



Monitoring the twin transition of industrial ecosystems

TOURISM

Analytical report

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Executive summary

Measuring performance and monitoring change within an industrial ecosystem are vital components that enable policymakers and industry stakeholders to track progress over time and obtain valuable feedback on whether the system is moving in the desired direction. This report is a contribution to the '**European Monitor of Industrial Ecosystems**' (EMI) project, initiated by the European Commission's Directorate General for Internal Market, Industry, Entrepreneurship, and SMEs, in partnership with the European Innovation Council and SMEs Executive Agency (EISMEA). Its primary objective is to present the current state and the advancements achieved over time in terms of the green and digital transition of the **Tourism** industrial ecosystem.

Tourism and travel have been **going through transformative times** including digitalisation, shift towards environmentally sustainable tourism, demographic changes all of which have been amplified by the severe shocks caused by the Covid-19 pandemic, geopolitical tensions and the most recent energy crisis. According to Eurostat data, the total number of nights spent at tourist accommodation establishments in the EU27 has reached 95% of pre-pandemic levels in 2022¹ and industry experts expect the ecosystem to grow further with a renewed wave of tourists in 2024. These are promising prospects, however, there are a range of key challenges on the front of sustainability and decarbonisation that the ecosystem has to address. It has to do so, while further embracing the impacts and opportunities of digitalisation and aim to deliver better value for their customers. In this context, the next two sections summarise the key findings of this study regarding the status and progress of the tourism ecosystem on its path towards digitalisation and a green 'modus operandi'.

Key findings about the green transition

The tourism industrial ecosystem has important environmental impacts that are linked to carbon emissions, disposable material and waste (more specifically food waste), unsustainable water use, and biodiversity loss as identified in this analysis. These environmental effects depend very much on the local context. The analysis of Exiobase data found that **tourism industrial ecosystem contributed to 10% of the total GHG emissions** of all industrial ecosystems (one of the highest among all) in 2021. Emissions have decreased over time since 2011, but they **show a renewed increase since 2021**. Tourism was responsible for **5.9% of all industrial material extraction in 2021**. Although material extraction declined between 2011 and 2017, it has risen since then. Tourism is a consumer of fresh water, and it is responsible for 5.7% of the total water consumption of all industrial ecosystems as concluded from Exiobase. The **tourism industrial ecosystem increasingly contributed to the damage to the natural ecosystem** over the past years.

The green transition of the tourism industrial ecosystem has become of vital importance and is addressed at several levels from policy, industry to local communities and environmental organisations. Tackling the potentially negative environmental impacts of tourism is important to preserve the attractiveness and value of nature and thus ensure the future of the industry.

One of the positive signs is an increasingly dynamic startup activity that aim at changing current practices. As the analysis of Crunchbase and Net Zero Insights data show, the number of newly created **environmental startups in tourism had increase dsince 2012 with a steady dynamic throughout the past years**.

Environmental startups in tourism are focused mainly on the sharing economy and rental services, waste management (solutions for food waste) and environmentally friendly tourism services. Travel services increasingly target a

¹ https://ec.europa.eu/eurostat/databrowser/view/TOUR_OCC_NIN2__custom_7525415/default/table?lang=en

specific customer segment and foster the social travel experience in the sense of connecting tourists, creating links to the local hosts, and aim at saving environmental resources. This creates a more personal and authentic exploration of the tourist destination and at the same time supports the circular economy. There is also a strong presence of startups that rely on digital technologies to deliver environmentally focused services in tourism, in particular based on new software applications, artificial intelligence and Internet of Things.

Regarding the adoption of green transition technologies and circular economy practices, a business survey with tourism SMEs was conducted as part of the project. The results reveal the following insights:

- 35% of the surveyed organisations adopted at least one form of technology or solution relevant for the green transition
- 44% of the respondents stated to have increased investments dedicated to the green transition and environmental sustainability during the past five years
- **30.6% adopted recycled materials** including also measures such as the use of recycled cups, bottles, or biodegradable packaging in hotels, restaurants, and tourist attractions (eg. museums or fairs). Other types of advanced materials that are bio-based/organic have been adopted by 21% of SMEs in the sample.
- **28% invested in energy-saving technologies,** with many SMEs highlighting the importance of energy-saving solutions and also implementing related measures.
- **26% adopted solutions to reduce food waste** including optimisation technologies of stock inventory, better food management (buying ingredients in a way that all can be used before their expiry dates), donation of food to local agriculture and systematically offering leftover to the client to take home. A further question shows that when recycling food waste, close to half of the respondents tackle between 20-50% of the food, however another 37% claims recycling less than 5%.
- 21.7% of the survey respondents answered that they have adopted an ecotourism, nature-based tourism or related ecological services.

One of the important pillar to underpin the green transition is skilled professionals with the necessary knowledge in the field of environmental protection and the circular economy. In this study, the supply and demand for environmental skills was investigated based on LinkedIn data and the analysis of online job advertisements obtained from Cedefop (the European Center for the Development of Vocational Training).

Within the registered professionals on LinkedIn employed in the tourism industrial ecosystem, 1.8% indicated to have one type of green skill that is a low result. Among the green transition related skills, we find most often environmental management competences and skills necessary to comply with environmental standards. Other skills that have been monitored include the circular economy that includes skills necessary for the management and recycling of waste - a particular concern for the industry. Other important green skills include the low carbon challenge and energy management.

With regard to demand for green skills, requirements related to the green transition appeared on 1.91% of online job advertisements in the field of tourism. Green skills that are required in job advertisements were most often related to sustainable transportation and waste management in 2022.

Key findings about the digital transition

Technology has transformed the tourism industry in several ways: it eases travel planning, allows the optimisation of operations, improves the travel experience and increases safety for example by using digital traveller identity. The emergence of the internet has enabled the development of a tourism market where travellers and tourists are more informed and

autonomous² and use digital information to take travel decisions³. The tourism industry has become more **digital, mobile and personalised**.

EU tourism stakeholders highlighted several of the key digital transformative trends in the co-creation process of the Transition Pathway for Tourism⁴. As part of digital trends, *online intermediation service platforms* have been pointed out as increasingly relevant and also playing a key role in the generation of data. *Sharing data* between the public and the private sector is considered to be instrumental in creating innovative tourism services and providing new opportunities for destination management. Digitalisation also makes booking and ticketing easy and developments are expected around *multimodal ticketing* of travelling. Particular to cultural heritage and museums, *virtual and augmented reality* services provide new ways to preserve natural and cultural resources and also enable real-like visitor experiences.

In this study, technological trends have been analysed based on startup data sourced from Crunchbase and Net Zero Insights. In the case of **digital tech startups in tourism, a marked increase can be noticed until 2017 with a further rise afterwards**. The following trends have been observed:

- The **travel and tourism experience becomes a combination of services provided physically and online** with new solutions increasingly available through mobile apps.
- **Digital technology follows the tourist journey** and emerging startups can be found basically at every stage. They aim at empowering the tourist starting from the search for information, comparing prices, booking flights, hotels, tours, and activities, planning their itinerary, accessing the hotel and tourist attractions close-by.
- **There has been a shift** from online (travel) platforms of simple booking to platforms that are **tailored, more personalised, and underpin the sharing economy**.
- There is a sharp rise in the number of **big data and AI applications** allowing new customer services and the analysis of tourism data. These developments are highly relevant for tourism flow and tourism destination management.
- **Immersive media, digital twins powered by augmented and virtual reality has started to emerge** that aim at creating new customer experiences.

The actual uptake of these new digital technical solutions is however still limited and depends very much on the segment of the value chain, the types of actors in the tourism ecosystem and their size. As a response to the survey conducted in the framework of this project 97% of the SMEs in the tourism ecosystem indicated that digitalisation has been already transformative for their business. More specifically the survey found that:

- 45% of the respondents stated to have increased investments in digital technologies.
- Using big data has been pointed out by 13% of the respondents.
- Artificial Intelligence has been adopted by 8% of the respondents.
- Digital twins are used by 5.8% of the respondents at the level of the ecosystem, often as a virtual model of the tourism facility or of the tourism destination.
- Augmented and virtual reality has been mentioned by a very low number, notably 3% of the respondents but some SMEs show an increasing interest in digital twins to directly engage with their customers.

² https://www.politesi.polimi.it/bitstream/10589/154284/3/Report_v08_DEFINITIVO.pdf

³ Attitudes of Europeans towards tourism - November 2021 - Eurobarometer survey

⁴ <https://ec.europa.eu/docsroom/documents/49498/attachments/1/translations/en/renditions/native>

- Robotics and blockchain technologies have been mentioned by a very small share of the respondents (by 1.7%). The use of robotics was pointed out for inventory management and self-services.
- Blockchain was assessed to be used in the field of secure payments and financial transactions.

Digital skills is a key compass reflecting about the progress of the ecosystem in the digital transition. Within the registered professionals on LinkedIn employed in the tourism industrial ecosystem, it was found that **15.4% had moderate digital skills and 2% advanced digital skills.** The most relevant digital skills that tourism employees cite on their LinkedIn profiles include digital marketing and online platforms. Among the advanced digital skills the most relevant are cloud technologies and big data.

Specific to the tourism industrial ecosystem, the share of online job advertisements that required any form of moderate digital skills (excluding basic IT office skills) was 34% over the period from 2019-2022, while this percentage was 17.09% for advanced digital skills. The most requested digital skills on online job advertisements included computer programming and database management. Although LinkedIn and Cedefop data cannot be compared directly, the analysis still points at an acute gap in the demand and supply for professionals with digital skills.

1. Introduction

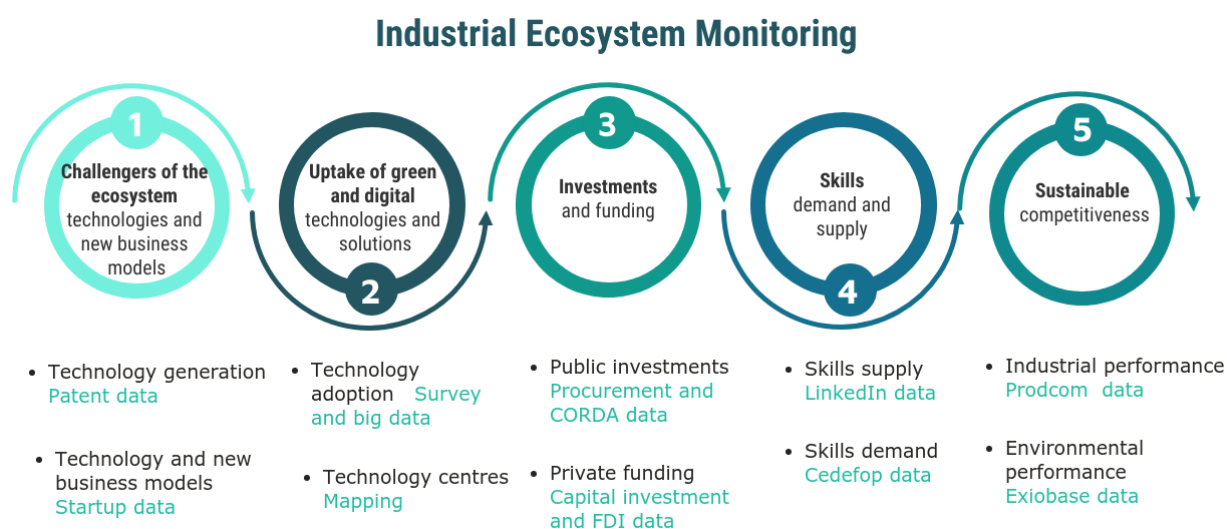
1.1 Objectives

This report has been prepared within the ‘**European Monitor of Industrial Ecosystems**’ project, initiated by the European Commission, Directorate General for Internal Market, Industry, Entrepreneurship and SMEs and the European Innovation Council and SMEs Executive Agency (EISMEA). The overall objective of the project is to **contribute to the analysis of the green and digital transformation of industrial ecosystems** and progress made over time.

The EU’s updated industrial strategy⁵ has identified 14 industrial ecosystems⁶ – one of them being ‘**Tourism**’ - that is in the focus of this report. The industrial strategy defined industrial ecosystems as encompassing all players operating in a value chain: from the smallest startups to the largest companies, from academia to research, service providers to suppliers. The notion of ecosystems captures the complex set of interlinkages and interdependencies among sectors and firms across the EU. Industrial transition is driven by technological, economic, and social changes, and in particular by green and digital technologies and the shift to the circular economy. The process is however characterised by complex, multi-level, and dynamic development. To make transition sustainable, technological change needs to be coupled with new business models, the necessary investments, skills, regulatory framework conditions and behavioural change.

Measuring performance and change is vital to allow policymakers and industry stakeholders to track progress over time and get feedback whether the system is moving in the desired direction. To measure performance, a dedicated **monitoring and indicator framework** has been set up for the purposes of this project with an aim to capture them in regular intervals (see the overview of the monitoring framework in Figure 1). These indicators will be used as one input source for developing the annual monitoring report of the Transition pathway for Tourism.

Figure 1: Overview of monitoring industrial ecosystems and relevant data sources



Source: Technopolis Group, IDEA Consult and Fraunhofer ISI

⁵ European Commission (2020). A New Industrial Strategy for Europe, COM/2020/102 final and European Commission (2021). Updating the 2020 New Industrial Strategy: Building a stronger Single Market for Europe’s recovery, COM(2021) 350 final

⁶ The 14 industrial ecosystems include: construction, digital industries, health, agri-food, renewables, energy intensive industries, transport and automotive, electronics, textile, aerospace and defense, cultural and creative culture industries, tourism, proximity and social economy, and retail

The indicator framework includes a **set of traditional and novel data sources that allow shedding new light on ongoing transformation patterns**. The novelty of the analysis lies in the exploratory and innovative data sources used across the different chapters. Due to its effort to analyse industrial ecosystems using a more or less standardised set of indicators, the study cannot address all aspects of the green and digital transition. Therefore, additional analysis and industry-specific data sources should be used to supplement a full assessment.

The **methodological report** that sets the conceptual basis and explains the technical details of each indicator is found in a separate document uploaded on the [EMI website](#). Moreover, some of the specific industry codes used throughout this analysis have been also included in Appendix B. The green and digital technologies that have been taken into account in this study are presented in Figure 2.

Figure 2: Main technologies monitored in the project

Green transformation	Digital transformation
Advanced Sustainable Materials	Advanced Manufacturing & Robotics
Biotechnology	Advanced Manufacturing
Energy Saving technologies	Robotics
Clean Production technologies	Artificial Intelligence
Renewable Energy technologies	Augmented and Virtual Reality
Solar Power	Big Data
Wind Power	Cloud technologies
Other (geothermal, hydropower, biomass)	Blockchain
Recycling technologies	Digital Security & Networks/ Cybersecurity
Circular business models	Internet of Things
	Micro- and Nanoelectronics & Photonics
	Online platforms

Source: Technopolis Group, IDEA Consult and Fraunhofer ISI

This report contributes to the [Transition Pathway for Tourism](#)⁷, which set concrete objectives and outlined actions that support the green and digital transition and improve the resilience of the tourism ecosystem, based on an 8-month long stakeholder co-creation process. It also complements the analysis of the **key pillars put forward in the 'Blueprint for the development of transition pathways'**⁸ of the Industrial Forum developed in 2022.

1.2 Definition of the ecosystem

Tourism covers economic activities providing goods and services demanded by visitors to support, directly or indirectly, their activity. As the Transition Pathway described in 2022⁹, the tourism industrial ecosystem gathers businesses from a range of sub-industries such as **hospitality services** (food and beverage, accommodation, **tourist information providers** (tourist offices, travel agencies digital platforms, travel technology providers), tour operators, destination managing organisations, **attractions** (museums, fairs, amusement parks) **and passenger transport** (airlines and airports, trains, and cruises).

The tourism ecosystem is directly connected to other ecosystems such as '**Cultural and creative industries**' (tourism based on cultural heritage, traditions, arts and authentic

⁷ [Transition pathway for tourism - Publications Office of the EU \(europa.eu\)](#)

⁸ <https://ec.europa.eu/docsroom/documents/49407/attachments/1/translations/en/renditions/native>

⁹ https://single-market-economy.ec.europa.eu/news/transition-pathway-tourism-published-today-2022-02-04_en

cultural experiences, sport tourism) '**Health**' (access to healthcare while travelling and health tourism), '**Mobility, transport and automotive**', (mobility for travellers and visitors).; '**Proximity, Social economy**' (local economy); '**Retail**' (opportunities for visitors and local residents to create new income); '**Aerospace**' (air travel, space data based services); '**Agri-food**' (food services); '**Construction**' (building and renovating tourism infrastructures); '**Digital industries**' (digital applications)¹⁰.

Following the Annual Single Market Report 2021, the tourism ecosystem includes various economic activities, although they are taken into account with different weights in the statistical analysis. The NACE rev.2 classifications relevant for tourism include H49 Land transport and transport via pipeline (with a weight of 0.45), H50 Water transport (with a weight of 0.22), H51 Air transport (0.91), I Accommodation and food service activities (1), N79 Travel agency, tour operator and other reservation service and related activities (1), N82 Office administrative, office support and other business support activities (1), R90-R92 Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities (0.66), R93 Sports activities and amusement and recreation activities (1).

Figure 3: Depicting the tourism ecosystem



Source: European Cluster Collaboration Platform

1.3 Industry state of play

The EU has been the most popular tourism destination worldwide, representing close to half of the global market share of international tourism¹¹.

The tourism industrial ecosystem was responsible for 7% of the EU value added and provided 20.3 million jobs in 2019 as indicated by the Annual Single Market Report (2021)¹². The ratio of international travel receipts relative to GDP is over 12% in some EU Member States such as Croatia, Cyprus and Malta. The industry has a large share of small and medium sized enterprises (99.8%), and more specifically micro and small enterprises generate about 64% of the value-added employing 84% of the industry professionals¹³. Regarding the analysis of the ecosystem, it is also important to keep in mind that a large

¹⁰ European Commission (2022). Transition Pathway for Tourism

¹¹ UNWTO (2021). International Tourism Highlights, 2020 Edition, January 2021

¹² https://commission.europa.eu/system/files/2021-05/swd-annual-single-market-report-2021_en.pdf

¹³ European Commission (2021). Scenarios towards co-creation of transition pathway for tourism for a more resilient, innovative and sustainable ecosystem, Brussels, 21.6.2021 SWD(2021) 164 final

part of the industry is composed of small local owners at tourist destinations (some being a franchisee of known brands)¹⁴.

The tourism ecosystem was among the most severely affected ecosystems by the COVID-19 pandemic when travel restrictions brought the industry to a halt. Nevertheless, tourism has proven its resilience and it recovered significantly during the summer travel season in 2021. It rebounded even more in 2022 and in 2023 reaching close to pre-pandemic level of tourist arrivals and in some destinations even being over pre-pandemic levels. The contribution of travel and tourism to EU gross domestic product (GDP) was €1.4 bn in 2021¹⁵.

According to the United Nations World Tourism Organisation's World Tourism Barometer the tourism industrial recovery was continued in 2023 and international arrivals reached close to pre-pandemic levels in the first quarter of 2023 in Europe¹⁶. This is also confirmed by Eurostat statistics.

Most recently, the industry experienced further challenges due to the war in Ukraine, the increase in energy prices, and the 'cost-of-living' crisis resulting in travel costs spiralling upwards.

The structure of this report follows the key pillars of the conceptual and methodological framework set up for the purposes of this project:

- Chapter 2 discusses trends in technological development and service innovation relevant for the green and digital transformation of the tourism industrial ecosystem.
- Chapter 3 presents the results of the business survey about the uptake of green and digital technologies and related service models and the analysis of company websites
- Chapter 4 analyses investments and funding
- Chapter 5 explores the development in the field of skills relevant for the green and digital transition of tourism
- Chapter 6 presents the findings from the analysis of the main environmental impact indicators of tourism.

¹⁴ European Commission (2022). Transition pathway for tourism

¹⁵ <https://www.statista.com/statistics/617528/travel-tourism-total-gdp-contribution-europe/>

¹⁶ <https://www.unwto.org/tourism-data/unwto-tourism-dashboard>

2. Challengers of the industry: green and digital technological trends

Key findings

The tourism industry has been moving on the one hand towards digital, mobile and personalised services, and on the other hand it has been increasingly recognising the importance of environmental sustainability. Transformative developments in tourism and more specifically digital and green transformation have been captured via the analysis of technology and innovation startups active in the tourism industrial ecosystem. These are mirrored against the key development areas recognised by stakeholders in the Transition Pathway for Tourism.

The analysis of technological trends and service innovation shows that both environmental sustainability and advanced digital technologies such as **big data, artificial intelligence, and augmented and virtual reality** gained more attention over the past three years compared to previous periods. Digital technologies allow the creation of novel connections among the stakeholders of the tourism ecosystem and redefine travel.

The **travel and tourism experience becomes a combination of services provided physically and online** with new solutions increasingly available through mobile apps. **Digital technology follows the tourist journey** and emerging startups can be found basically at every stage. They aim at empowering the tourist starting from the search for information, comparing prices, booking flights, hotels, tours, and activities, planning their itinerary, accessing the hotel and tourist attractions close-by.

Based on the analysis of startup data, we can observe various shifts of emphasis:

- from online (travel) platforms of simple booking to platforms that are **tailored, more personalised, and underpin the sharing economy**,
- increasing role of **mobile applications** that address the needs of tourists along their travel journey,
- from IT software to more specific **big data and AI applications**,
- emergence of **immersive media** and its use in creating new customer experience,
- towards startups that offer **environmental services** in the field of the sharing economy, recycling, waste management, sustainable mobility and ecotourism.

Environmental startups in tourism are focused on the sharing economy and rental services (provided via digital platforms). Travel services increasingly target a specific customer segment and foster the social travel experience in the sense of connecting tourists, creating links to the local hosts, and aim at saving environmental resources. This creates a more personal and authentic exploration of the tourist destination and at the same time supports the circular economy. An increasing number of startups fight the waste challenge and develop solutions for food waste reduction, elimination of plastics, waste management and foster recycling.

The digital transition of the tourism ecosystem has been determined by online platforms and mobile applications. Most recently, the number of digital tech startups offering big data and AI-powered solutions has been on the rise. The increasing amount of accessible data on tourist behaviour, transactions, features of tourism services has contributed to the creation of a range of startups with a data analytical focus. Several companies are developing travel intelligence and tourism management services based on big data to customers such as to traditional tourism service providers and destination management organisations.

Technology has transformed the tourism industry in several ways: it eases travel planning, allows the optimisation of operations, improves the travel experience and increases safety for example by using digital traveller identity. The emergence of the internet has enabled the development of a tourism market where travellers and tourists are more informed and autonomous¹⁷ and use digital information to take travel decisions¹⁸. The tourism industry has been moving on the one hand towards **digital, mobile and personalised services**, and on the other hand it has been increasingly recognising the importance of and attention to **environmental sustainability**.

EU tourism stakeholders highlighted several of the key digital transformative and environmental trends in the co-creation process of the Transition Pathway for Tourism. As part of digital trends, *online intermediation service platforms* have been pointed out as increasingly relevant and also playing a key role in the generation of data. *Sharing data* between the public and the private sector is considered to be instrumental in creating innovative tourism services and providing new opportunities for destination management. Digitalisation also makes booking and ticketing easy and developments are expected around *multimodal ticketing* of travelling. Particular to cultural heritage and museums, *virtual and augmented reality* services provide new ways to preserve natural and cultural resources and also enable real-like visitor experiences.

With regard to the green transition, the Transition pathway recognised several areas of policies, which will require active response from the tourism ecosystem stakeholders, such as *sustainable transport, protection of biodiversity, energy efficiency of buildings, reduction of food waste, plastic packaging and general waste, improving water efficiency, sustainable fuels and overall reduction of environmental footprint of tourism*. Moreover, it was highlighted that consumer demand for more sustainable tourism offer is on the rise, and this should be taken into account by tourism accommodation, service and attraction providers as well as by travel agencies.

2.1 Twin transition driven by technology startups

Providing a picture about technological trends in service industries and quantifying change beyond desk research and anecdotal evidence is not straightforward. In this report, we capture technological developments in tourism and more specifically digital and green transformation via the analysis of technology and service innovation startups active in the tourism industrial ecosystem. Uptake of technologies and new service provisions will be analysed in the next Chapter based on a dedicated survey conducted in the framework of this project.

Tourism tech startups have been instrumental for the tourism industry contributing to its development with a wide variety of solutions. The UN World Tourism Organisation has provided a mapping of the travel and tourism tech startup ecosystem and related investments¹⁹ in its recent report. Tech startups make travel and hospitality experience better and easier, but some of these technological changes, such as the ones related to platforms or AI, also cause disruptions to traditional business models.

In this analysis, digital and green transformation trends in tourism have been captured by analysing technology and innovative startups²⁰ based on data sourced from the Crunchbase

¹⁷ https://www.politesi.polimi.it/bitstream/10589/154284/3/Report_v08_DEFINITIVO.pdf

¹⁸ Attitudes of Europeans towards tourism - November 2021 - Eurobarometer survey

¹⁹ <https://www.unwto.org/travel-and-tourism-tech-startup-ecosystem-and-investment-landscape>

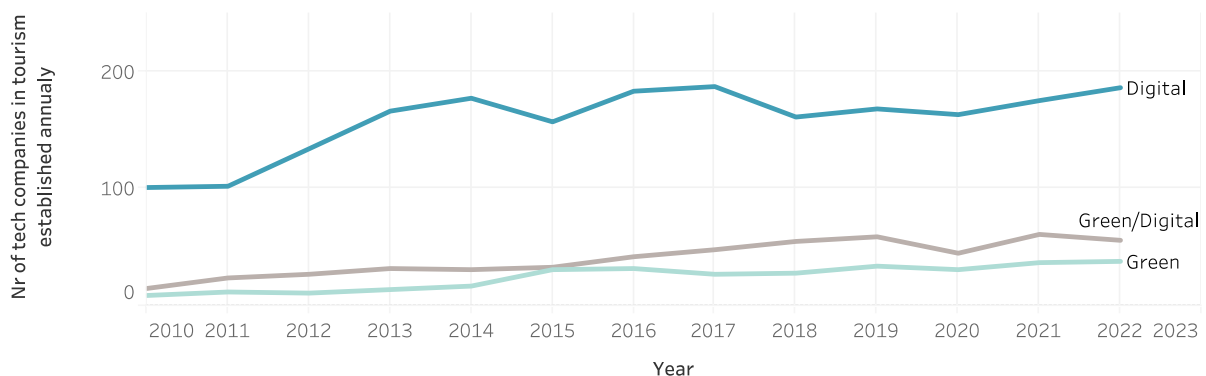
²⁰ In this study, startups are defined as 'young, innovative, growth-oriented businesses in search of a sustainable and scalable business model' (NESTA, 2015). Tech startups are technology-based startups. More specifically, digital tech startups do not simply develop or adopt digital technologies but digital is an inherent part of their value proposition (Oestreicher-Singer and Zalmanson, 2012; Griva et al, 2023). Environmental startups are another form of young, innovative business that develop and implement products, technologies and services that contribute to environmental sustainability, for example by reducing greenhouse gas emissions, improving energy efficiency, adopting a circular economy approach or providing a service that is ecological (see in Bergset et Klaus, 2015).

and Net Zero Insights²¹ databases. The detailed methodology is presented in the Methodological report of the project.

Figure 4 presents the evolution of digital tech startups and environmental startups in tourism established over time. The overview indicates that digital technologies have been much more prominent than environmental solutions (at least from the perspective of startups looking for venture capital investment), however the most recent years show a surge in startups with a focus on solving environmental challenges in the industry. There is also a strong presence of startups that rely on digital technologies to deliver environmentally focused services in tourism (indicated as green/digital in the Figure below).

The results indicate different patterns for the green and the digital transition. In the case of **digital tech startups in tourism, a marked increase can be observed until 2017 with a further rise afterwards**. This trend has been driven by online travel services as it will be further analysed in the sections below. It might also indicate an early interest in internet-based tourism startups and consolidation afterwards. The impact of the Covid pandemic can be also felt to some extent although digital solutions continued to emerge. The number of newly created **environmental startups in tourism started to increase since 2012 with a steady dynamic throughout the past years**. 2012 was also the year when the European Parliament addressed the food waste issue and put it as a priority. This momentum might be linked to a surge in food waste startups. Interestingly, green solutions kept on emerging also during the pandemic period. The exact evolution in the number of startups however must be interpreted with caution since there is a time lag in Crunchbase and some of the most recent developments about startup creation might not be known. As it is well-understood from other sources, the **size of the online travel market has a steady increase getting a further boost** during the pandemic. Allied Market Research estimated that this segment had a €300 bn market size in 2020 and will hit €800 bn in 2025 .

Figure 4: Evolution of digital and green tech startups in the tourism ecosystem in the EU27 over time



Source: Technopolis Group based on Crunchbase and Net Zero Insights data, 2023

The relative importance of different technologies and service models that these startups focus on allows to make further observations. As illustrated in the diagram below with the size and distribution of the blue shape, both **environmental and advanced digital technologies** such as artificial intelligence, augmented and virtual reality and blockchain gained more attention in the past three years compared to previous periods. More specifically we can observe various shifts of emphasis

- from online (travel) platforms of simple booking to platforms that are more personalised and underpin the sharing economy,

²¹ <https://netzeroinights.com/> and www.crunchbase.com

- from IT software to more specific big data and AI applications, appearance of virtual reality and blockchain
- shift towards **environmental services** including recycling, waste management, sustainable mobility and ecotourism.

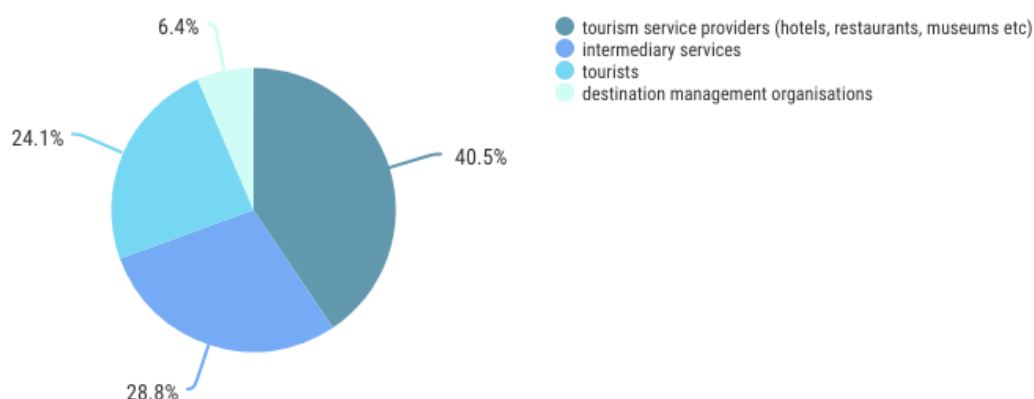
These technologies and service models will be further analysed in the following two sections.

Figure 5: Type of digital tech and environmental startups in the tourism ecosystem in the EU27 and shifts over time

Source: Technopolis Group based on Crunchbase and Net Zero Insights data, 2023

The digital tourism tech and environmental startups identified and analysed in this report serve different client groups, the largest share (40.5%) offer mostly digital technology based services to tourism service providers directly, and 28.8% are intermediary service providers within the space between original tourism businesses (such as hotels, airlines, restaurants) and the final customer. In this respect, they challenge most traditional travel agencies and tour operators. It is a more limited share (6.4%) that targets destination management organisations directly as the examples in the following sections will showcase.

Figure 6: Key target groups of tourism tech startups



Source: Technopolis Group based on Crunchbase and Net Zero Insights data, 2023

Green transformative trends

The green transition of the tourism industrial ecosystem can include a range of new activities and services that damage less the environment. Addressing the potentially negative environmental impacts of tourism is important to preserve the attractiveness and value of our nature and thus ensure the future of the industry. COVID-19 accelerated travellers' interest to consider the quality of tourism experience, and the Eurobarometer survey in 2021 showed that 82% of EU citizens are ready to change their habits to support more environmentally sustainable tourism (*"by consuming local products, choosing ecological means of transport or by paying more to protect the natural environment or to benefit the local community"*). As key areas for stakeholder action on the green transition, the co-creation process of the Transition Pathway highlighted the importance of accelerating the following issues:

Sustainable mobility

- Passenger transport companies to develop greenhouse gas (GHG) reduction plans
- Improving the appeal of railways for visitors

Circularity of tourism services

- Developing the use of locally supplied ingredients with low environmental footprint to reduce the environmental impact of food services
- Reducing food waste in the hospitality industry
- Reducing and separating overall waste of tourism services
- Increasing water efficiency, reducing water stress and pollution, and improving sanitation

Green transition of tourism companies and SMEs

- Tourism companies, including SMEs, to register to EMAS
- Tourism accommodations, including SMEs to apply for the EU Ecolabel or other ISO 14024 type I ecolabels or equivalent voluntary labels
- Tourism operators to use relevant EU green public procurement (GPP) criteria where applicable

R&I projects and pilots on circular and climate friendly tourism

- Tourism stakeholders engaging in public-private co-operation for circular tourism-related R&I projects and pilots
- Developing models and transferable practices for sustainable tourism

In this report the analysis of the green transformation in tourism has been based on **849 environmental startups active in the tourism industrial ecosystem, which have**

been collected through the Net Zero Insights and Crunchbase data source. Net Zero Insights is a database specialised in capturing sustainability driven startups and therefore covers widely the innovations that are being developed in the context of the green transition. These startups have been analysed with a focus on the green transition technologies and services identified as the most relevant to monitor industrial transformation as explained more in detail in the methodological report of the project (including the circular economy, low carbon, energy-saving and renewable energy technologies).

Within the group of environmental startups in tourism that are backed up by venture capital investment, we find the largest share linked to topics such as the **rental, the sharing economy, recycling and waste management** (and more specifically food waste). This is followed by **sustainable mobility** (also analysed as part of the report on the mobility industrial ecosystem) and ecotourism. The share of tourism specific environmental startups that provide energy services is very low, but this is also due to the fact that such services are usually not provided to the tourism ecosystem only but are more general. Biodiversity has not been an explicit core topic of the environmental startups captured, however, it is part of ecotourism depending on the case.

The environmental startups identified operate in the segment of **accommodation and food services, travel agency, tour operators, transport and mobility**, but much less so in the area of cultural services, museums or attractions.

Figure 7: Type of green technologies and solutions provided by tourism startups (as the share of all environmental startups in tourism)

Source: Technopolis Group based on Net Zero Insights, 2022

Sharing economy

This analysis identified an increasing number of tourism companies which operate on the premise of sharing such as shared mobility and accommodation (car sharing, house sharing, ride-sharing etc), peer-to-peer bookings, home swap, shared dining. Startups active in the tourism sharing economy usually rely on an online platform.

Peer-to-peer reservations allow users to connect and share meals in each other's homes. These startups can connect tourists with hosts and allow sharing accommodation.

Moreover, new service providers enable renting houses among a specific community such as an alumni school, club or association.

It is also evident from the data that more and more services target a **social travel experience** in the sense of connecting tourists, facilitating short-term rentals and thus saving environmental resources. This creates a more personal and authentic exploration of the tourist destination and at the same time supports the circular economy. Some offer a service to put together solo travellers in small groups to share not just the travel itself but also resources such as transport, accommodation etc.

Shared mobility services give a more affordable access to go around in tourist destinations and explore a city or a region. Examples include the Sevilla based MissCar (Spain)²² is a carpooling platform founded in 2020 which targets women and offers them to share a ride from one city to another and GreenMobility²³ that offers sustainable transport in shared electric cars.

Recycling, food waste, waste management

Recycling is transforming the tourism industry and several startups have an answer to tackle waste. There are several critical waste streams in hospitality that needs to be addressed including food waste, packaging waste, soap waste, wastewater/sewage and other consumer waste generated by tourists. Eurostat statistics (2022) shows that nearly 59 million tonnes of food waste are generated annually with an associated market value estimated at €132 bn . Recycling does not only allow environment protection but since the use of recycled materials require less energy, it helps save costs. Waste management is often supported by digital applications and software.

- Some of the food waste startups with the highest total funding include the Danish '**Too Good To Go**'²⁴. This startup established in 2015 fights food waste through an application that connects users with stores and restaurants that have unsold surplus food at the end of the day. For consumers, the app gives them access to surplus food at affordable prices and allows them to discover local restaurants and potentially new food products. For businesses, they can make money out of food that would be otherwise wasted (Zero Waste Europe, 2020).
- Reducing packaging waste is the focus of the French startup called **Pyxo**²⁵ that designed Pyxobox to minimise the environmental footprint of mobile catering.
- The Swedish **Karma**²⁶ is a mobile application for food rescue that allows restaurants to sell their surplus food to consumers at a lower price - instead of having food go to waste. The application informs customers about opportunities of take-aways and sends them to the restaurant directly. Via an additional online application restaurant can collect statistics about their patterns of using food ingredients and get recommendations how to better manager orders.

Soap recycling is yet less a standard in the EU and it is addressed by non-profit organisations. For example **Unisoap**²⁷ is a French association to recycle hotel soap and transform this waste into resources for those in need and to give access to hygiene to disadvantaged populations in France and abroad. Startups that deal with soap recycling include refillable packaging (such as the example Seifenbrause from Germany), from Switzerland (such as Sapocycle, Youth for Soap) or the USA (Clean the World).

Water management has been also addressed by some of the startups. For example, Optishower develops a water and energy management technology designed to increase operational performance and financial health of hotels.

²² <https://misscar.es/>

²³ <https://www.greenmobility.com/be/en/>

²⁴ <https://toogoodtogo.com/en-us>

²⁵ <https://www.pyxo.fr/>

²⁶ <https://old.karma.life/about>

²⁷ <https://www.unisoap.org/en/>

Other circular economy solutions include the use of biotechnology to create alternative, plant-based food and promote it in hotels and restaurants (however this activity overlaps with the agri-food ecosystem).

Ecotourism

Ecotourism is a further growing segment within the tourism ecosystem with an increasing number of startups backed up by venture capital funding. The number of ecotourism startups is most probably higher than captured by the data sources used in this project (the first momentum of ecotourism dates back to the 1990s), but it must be kept in mind that Crunchbase and Net Zero Insights have primarily focused on tech ventures and investment-backed startups. The fact that there is a surge in ecotourism startups captured in these data sources reflects a stronger recent acknowledgment of the market to back up such companies.

According to UNWTO²⁸, ecotourism is defined as all “*forms of tourism which have the following characteristics:*”

- All nature-based forms of tourism in which the main motivation of the tourists is the observation and appreciation of nature as well as the traditional cultures prevailing in natural areas.
- It contains educational and interpretation features.
- It is generally, but not exclusively organised by specialised tour operators for small groups. Service provider partners at the destinations tend to be small, locally owned businesses.
- It minimises negative impacts upon the natural and socio-cultural environment.
- It supports the maintenance of natural areas which are used as ecotourism attractions by:
 - Generating economic benefits for host communities, organisations and authorities managing natural areas with conservation purposes;
 - Providing alternative employment and income opportunities for local communities;
 - Increasing awareness towards the conservation of natural and cultural assets, both among locals and tourists.”

Ecotourism startups are on a mission to develop travel routes that have zero negative impact on nature. Their services can include community-oriented projects, wildlife protection, sustainable organic farming etc. New business models support ecological tourism such as channelling the price of the tour directly into local projects that help environmental protection.

Some of the examples include:

- **SeaCrush**²⁹ is a French travel agency founded in 2017 that targets divers with a concept to protect marine nature.

Educational tourism with respect to environmental issues

Tourism startups play an important role in calling the attention to environmental pollution and the need for more environmental action.

- **Green Fashion Tours**³⁰ is a project focusing on sustainable fashion, offering guided tours throughout Berlin which have the goal of educating the public about the environmental and social issues of the fashion industry, while presenting alternative options for an ethical consumption. Green Fashion Tours’ urban excursions lead the customers to the most exciting sustainable fashion spots in the city, discovering hidden gems and showing the behind the scenes of eco-friendly businesses and the stories of their creators.

²⁸ <https://www.unwto.org/sustainable-development/ecotourism-and-protected-areas>

²⁹ <https://www.seacrush.com/en/about>

³⁰ <https://greenfashiontours.com/>

- The **Disgusting Food Museum**³¹ started in 2018 to change people's views on what is considered to be disgusting or not by promoting environmentally sustainable protein sources such as insects and lab-grown meat. The museum started in Malmö, Sweden and had a popup in Los Angeles, USA the same year, in Nantes, France the year after and in 2021 a permanent exhibit opened in Berlin, Germany as well as a popup in Bordeaux, France.

Carbon footprint reduction

A modest share of startups is dedicated to foster the reduction of emissions in the tourism industry. Nonetheless, as pointed out above, this must be due to the nature of energy technology firms not to specialise in tourism as such but serve a broad range of industries. Startups that help the tourism industry save energy and reduce emissions are relevant and are often linked to sustainable mobility.

- **FairAway**³² is an SME organising sustainable travels. It collaborates with local agents and measures the carbon footprint and environmental impact of each travel package, hence supporting travellers to choose more environmentally friendly options.
- **Bob W**³³ is a technology-driven hospitality provider that offers an alternative to hotels and short-stay apartments. Interiors are created by local designers with climate-neutral approach and powered by renewable energy. The company was founded in 2018 and is headquartered in Helsinki, Finland.
- **Klimato**³⁴ is a developer of a carbon footprint calculation application intended to reduce carbon dioxide equivalent emissions by labelling meals for restaurants.

Sustainable mobility and alternative fuels

The green transition of tourism is strongly linked to environmental friendly transport choices. Sustainable transport is driven by a broad range of startups from vehicle- or aircraft engineering solutions, fleet management to novel mobility services. The use of sustainable transport modes to reach tourist destinations has been increasingly in the focus of new ventures. Moreover, sustainable mobility is fostered by sharing economy platforms that have been already presented above. Examples include the following:

- **r3charge**³⁵ is a travel platform dedicated to electric vehicle owners and providing reliable information about charging throughout the travel journey.
- **E-Go**³⁶ offers environmentally friendly transport solutions at tourist resorts by renting out electric cars.
- **Lilium**³⁷ is developing sustainable, high-speed air mobility through its electric vertical take-off and landing aircraft, vertiports and digital service.

³¹ <https://disgustingfoodmuseum.com/>

³² <https://fairaway.de/>

³³ <https://bobw.co/?lng=en-GB>

³⁴ <https://www.klimato.co/>

³⁵ <https://www.r3charge.com/>

³⁶ <https://e-go-mobile.com/en>

³⁷ <https://lilium.com/>

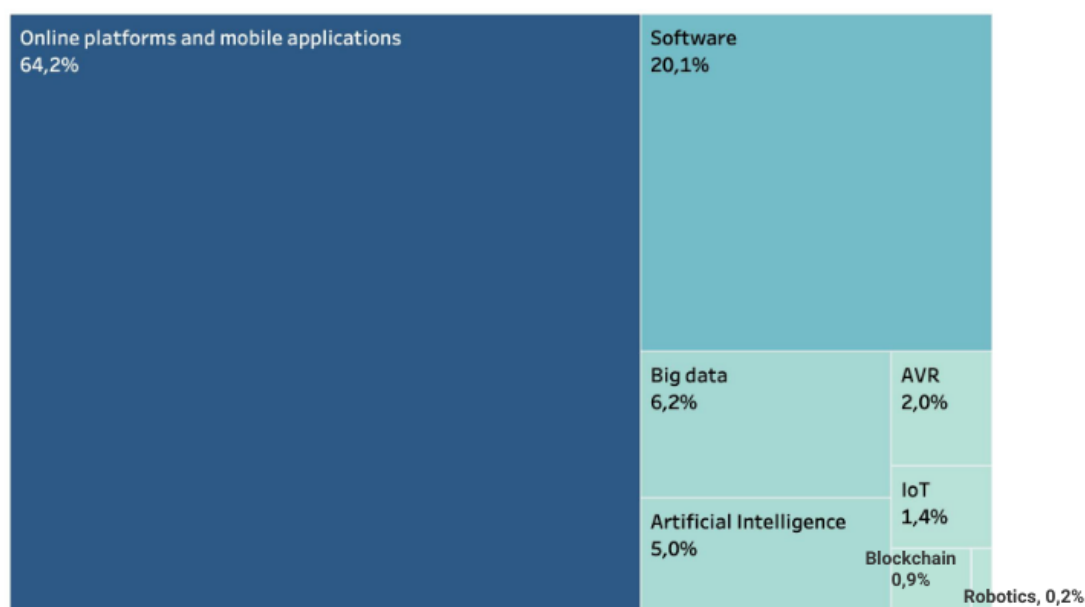
2.2 Digital transformation

Digital transformation in the tourism industry started back in the 1990s and over the 2000s with the shift of reservations and booking from brick-and-mortar travel agencies to the internet. Online travel aggregators (OTAs) and online search engines have redefined the value chain of tourism already in the past two decades. Digital technologies empower today tourists to search, compare and book touristic services online, opening up new scenarios for more personalised tourism services. At the same time, they also enable tourist businesses and destination management organisations to optimise their operations, reach out to customers and analyse tourist data. Demographic changes also drive digitalisation trends due to the fact that the largest share of tourists is more and more from the 'digital native' generation who demand online, cloud-based services, connectivity, and mobility³⁸.

Figure 8 below provides an overview of the key types of digital tech startups in tourism established after 2015, considering the types of digital technologies used (and in the focus of this project as explained in the methodological report). It is evident that **online platforms including online booking** have been the most popular activity. In this category we have also included mobile applications, since in most cases the technological solution is made available both through an online platform and a mobile application, or the online booking service is also provided in a mobile app format.

This has been followed by **software applications including management and analytics solutions that aim at improving efficiency, optimising workflows** and analysing available digital data. Increasingly, big data and data analytics started to dominate this space. Data-driven software solutions have been developed for various parts of the ecosystem such as hotels, restaurants, travel agencies, cultural organisations, but also in transportation. Artificial Intelligence represents an area with a growing share of startups addressing various challenges of the industrial ecosystem. The use of augmented and virtual reality and blockchain have also increased in importance over the past years. Startups in these areas create new virtual experiences and mixed reality applications and blockchain enables more transparency within the industrial value chain.

Figure 8: Type of technologies offered by digital tech startups in tourism in the EU27 (founded after 2015)



Source: Technopolis Group based on Crunchbase, 2023

³⁸ <https://www.unwto.org/investment/unwto-investment-guidelines-SA1>

As already highlighted above, key customers of digital tech startups in tourism are first of all tourism service providers. Online travel platforms occupy the space between tourists, tourism services and destination management and have been playing a key role in shaping the development of the industry. In most cases they have adopted a B2B2C - Business to Business to Clients – business model and reach out directly to the final users with a product that is based on partnerships with tourism businesses and create an end-to-end solution. Public authorities and destination management organisations are targeted directly only by a small share of the digital tech startups; however, they are considered as a relevant key customer group for these services.

As key areas for stakeholder action on digital transition, the co-creation process of the Transition Pathway of Tourism highlighted the importance to accelerate the following developments:

Data-driven tourism services

- Active sharing of tourism-related data in the European data space for tourism
- Developing personalised tourism services and destination management, monitoring and service provision, including the creation of new platforms among SMEs
- Use of artificial intelligence and data-based innovation, such as digital twins for predictive planning to accurately meet demand and increase resource efficiency of services

Improving the availability of online information on tourism offer

- Improving the online availability of validated information on sustainable, accessible or specifically targeted tourism offers
- Developing partnerships with online portals and booking platforms to provide more visibility to certified accommodation providers

R&I for digital tools and services in tourism

- Data-driven destination management models and mechanisms
- Innovative tourism services using advanced technologies and digitised cultural heritage

Online platforms - travel management, booking, intermediary services

Online travel agencies and online travel booking platforms have been instrumental in the digital transformation of the tourism ecosystem. With a growing population of digital natives and digital nomads, the internet and mobile phones will continue to be a key medium that augment services in travel and tourism. The latest online platforms target new customer segments such as business travellers, offer specific services such as multi-day tours and adventures and cover the whole travel journey digitalising booking, check-in, cleaning, customer service to invoicing. The shift towards personalisation is visible in the types of new online travel platforms.

An emergence of service integrators can be observed where new startups aggregate existing booking platforms, delivery apps. The new entrants further shape the tourism ecosystem by connecting even more elements of the tourist journey in new ways.

Some of the latest startups in the EU27 include the following:

Personalised booking:

- **TravelPerk³⁹** is a business travel booking and management platform for companies. It offers a centralised platform for booking, managing, and analysing business travel, with features such as real-time booking, expense management, and travel policy enforcement. TravelPerk is backed by investors such as Spark Capital, investors in Slack, Trello, and Twitter.

³⁹ <https://www.travelperk.com/>

- **Comtravo**⁴⁰ is a travel and tourism company that specialises in travel management, business travel, and online booking. It features machine learning and software platforms that help SMEs to book, manage, and expense their business travel. The company was founded in 2015 and headquartered in Berlin, Germany.

Special travel offers:

- **'I Like Local'**⁴¹ is an impact travel marketplace where users can directly book a travel experience with local people and community organisations in Africa and Asia.
- **Tourlane**⁴² is a platform for multi-day tours and offers curated trip itineraries and bookings to some 50 destinations worldwide.
- **Limehome**⁴³ is a hospitality startup that offers nightly stays for a weekend as well as discounted monthly rates for longer project stays or business trips.
- **TalkTalkBnb**⁴⁴ is a collaborative platform that combines travel and language-learning. The traveller can stay with a host and benefit from their mother-tongue and cultural knowledge.

Personalised travel:

- **Yookye**⁴⁵ is an online travel platform that creates tailored made holiday packages.
- **Destination Everywhere** is an online resource platform for people with disabilities for accessible travel. They are specialized in finding the best adapted and accessible experiences and services around the world - and making them available to travellers with disabilities and sector professionals. The platform focused mainly on activities and experiences for people with reduced mobility.

Box 1: Case of Kiwi connecting tourism service providers, destinations, and tourists

Kiwi.com⁴⁶ is a Czech online search engine for flights allowing price comparison. It gathers data from several airlines and service providers and redirects travellers to partner websites.

Among others, it offers the service of a digital marketing campaign to tourism boards and destination management organisations. The marketing campaign includes articles in travel magazines, sponsored posts on social media, email campaigns, and banners. The objective is to boost passenger traffic from promising source countries of tourists to selected destinations.

Mobile applications

Beyond booking services, mobile applications ease the travel experience in many other ways, as list of startups in this area indicates. There are a range of travel guides, catalogues of recommended tourist attractions, support to communication in a foreign country, assistance to luggage handling etc. provided via a mobile app.

⁴⁰ <https://www.comtravo.com/en>

⁴¹ <https://www.i-likelocal.com/en/>

⁴² <https://www.tourlane.com/>

⁴³ <https://www.limehome.com/>

⁴⁴ <https://www.talktalkbnb.com/>

⁴⁵ <https://yookye.com/>

⁴⁶ <https://www.kiwi.com/en/>

- **Welcome⁴⁷** is a Greek startups that aims to offer a personalised travel experience to travellers taking care of their transfer from and to the airport including a travel guide in the destination.
- **Mobile applications can ease the customer journey by providing quick access to hotels.** Instead of a key, they can open the door with their mobile phone directly and can register online instead of waiting at the reception desk. These digital keys are often linked to an **Internet of Things** enabled system. For example, 4SUITES⁴⁸ is a cloud-based IoT access solution for smart hotels. StayMyWay's was founded in 2014 in Murcia and developed a technology and mobile app for hotel guests to open their rooms without stopping at the front desk and taking up their keys or badges. In 2021 the company announced a partnership with Accor Hotels for the 'Accor Key' digital key programme⁴⁹. The company was acquired in 2022 by the Canadian Oporto.

Box 2: Digital and crowd-sourced tour guides

SmartGuide⁵⁰ is a digital solution developed in the Czech Republic available via a mobile app and helping tourists explore tourist destinations. The company allows anyone to develop local tourist guides and make them available for free or for fee. The company uses geolocation, recommendation engine, machine learning, and augmented and virtual reality technologies among others.

Their objective is to develop the existing product into a full virtual conversational guide with an augmented reality avatar and a chatbot. They also provide big data services for tourism destinations.

Further examples of mobile applications that are linked to environmental goals are presented under Section 3.3.

Software solutions

The tourism industrial ecosystem has been supported by software applications such as SaaS marketplace, flow management solutions, optimisation of operational performance, digital check-in-check out solutions and software that allows mobile payment. Although these general IT software solutions for the tourism industry sound less exciting than new personalised services or Artificial Intelligence-powered applications but are a strong building block among the digital tech startups identified in this report and a key element in the digital transition of SMEs (e.g. use of digital payments).

Some examples are presented below:

- **Combo (Snapshift)⁵¹** is a staff management web solution for restaurants. The company's software enables restaurant owners to make online scheduling and enter the information on contracts, endorsements, proofs, leave requests, time sheets which will be stored online, enabling restaurant owners spend less time on administrative tasks so they can focus on their customers.
- **Amenitiz⁵²** is an all-in-one platform to help owners grow and manage their vacation properties by making attracting guests, managing reservations and crafting experiences.

⁴⁷ <https://www.welcomepickups.com/>

⁴⁸ <https://www.4suiteshq.com/aboutus/>

⁴⁹ <https://boutiquehotelnews.com/news/supplier/operto-acquires-staymyway/>

⁵⁰ <https://www.smart-guide.org/>; smartguide pitch deck 2020 by Jan Dolezal

⁵¹ <https://combohr.com/fr/>

⁵² <https://www.amenitiz.com/en/>

Big data, Artificial Intelligence and cloud technologies

The Transition Pathway for Tourism recognised data sharing as a key enabler but at the same time a key challenge for the European tourism industrial ecosystem. The pathway addresses the European data space for tourism that aims to facilitate data sharing between various sources of data providers and data users, both for their own services development and intermediary analytic services.

Startup data analysed in this report shows that the increasing amount of accessible data on tourist behaviour, transactions, features of tourism services has contributed to the creation of a range of startups with a data analytical focus. Several companies are developing travel intelligence services based on big data to customers such as to hotel groups, and destination management organisations. Nevertheless, data access is a challenge and tourism bookings, and search-related data are mostly owned by multinational platforms, requiring establishing bilateral data purchase agreements which might be too costly for new startups.

Startups often combine big data, Artificial Intelligence and cloud technologies, but they can be specialised and more advanced in any of these separately. Cloud based platforms allow for quick access and more efficient analysis of big data, hence they are key pillars of the big data revolution.

Among the new products are dashboards that provide information about how destinations are viewed by customers from different countries, and which channels the customers prefer. These products are targeted both at tourism service providers and destination management organisations.

Some of the examples include:

- The **Data Appeal company**⁵³ combined geospatial data, sentiment intelligence and market trends and turned it to data insights for tourism service providers and tourist destinations among others. The territorial analysis allowed to predict demand, get updates about the latest trends and help investment decisions.
- The Spanish company **Bismart**⁵⁴ offers business intelligence and big data solutions. It develops smart city bots for both tourists and residents. The bot can assist a user through social media applications during various interactions with the city, including working hours of various sites, museums, and public infrastructure.
- **Mabrian**⁵⁵ is a travel analytics platform that helps the tourism industry get an understanding of their target markets. Mabrian relies both on big data, AI and machine learning to provide actionable insights and integrates transactional and behavioral data.

Box 3: Real time data for crowd management

Online aggregators of travel services generate data that can support the planning of tourist flows and improve the travel experience. With the use of sensors and generation of real time data, new applications can forecast waiting times and indicate congestion and crowd at museums and tourist attraction sites.

MUST SEE⁵⁶ is a Danish tourist platform that offers crowd control, and reservation system services to museums and tourist attractions that can become quickly crowded. They are regulating visitors through an online ticket reservation system.

⁵³ <https://datappeal.io/>, The Data Appeal Company was acquired by Almawave in 2022. See also <https://www.crunchbase.com/organization/travel-appeal>

⁵⁴ <https://bismart.com/en/home/>

⁵⁵ <https://www.crunchbase.com/organization/mabrian>, www.mabrian.com

⁵⁶ <https://www.mustsee.nl/>

Artificial Intelligence

Artificial Intelligence helps digital optimisation and personalisation, offering fast response times to customer queries, and tailoring recommendations. AI relies on large set of data and hence its first users have been the largest online travel agencies and the providers of global distribution systems. Large booking platforms have an advantage given their size and access to data.

Booking.com⁵⁷, one of the largest platforms, has been developing its own machine learning models to make recommendations to destination and accommodation options since the 2010s. In 2023, they announced to launch the AI Trip Planner partially powered by large language model technology from OpenAI's ChatGPT API to create a new conversational experience for people to start their trip planning process. Similarly, **Kayak**⁵⁸ (owned by the Booking Holdings) has rolled out a ChatGPT implementation on its platform. Kayak has deployed ChatGPT as a virtual assistant for its customers, delivering more intuitive and natural interactions via the site's search engine.

Nonetheless, there are a growing number of European AI startups that offer solutions to actors in the tourism ecosystem. Most importantly, they foster the development of the tourism industry from various perspective: 1) AI applications facilitate the travel booking process and build relations with customers 2) AI can help analyse customer behaviour and provide more personalised services in a more effective and efficient manner.

Startups with an AI-based product or service in tourism include the following:

- **MountLytics**⁵⁹ is an AI-driven customer relationship management tool that hotels can use to build relationships with their customers and increase loyalty and profit.
- **Mountain Maps**⁶⁰ provides AI-powered guided navigation, data and statistics about mountain routes and services in the form of a navigation app.
- **Laya**⁶¹ enables dynamic, automated vacation packages for travel brands.
- **Livdeo**⁶² provides inclusive and accessible digital solutions for cultural institutions by bringing storytelling scenario management and distribution to visitors' mobile devices. It relies on image recognition and other AI technologies. In addition, its mobile application offers inclusive art exploration and monetisation platform with a focus on persistent and shareable augmented exhibitions.
- **Seatris.ai**⁶³ is an AI-based reservation and revenue management assistant that supports restaurants to manage their bookings.

Many of the above-mentioned online platforms are already active users of AI, such as Kiwi relies on machine learning to evaluate connection times in airports and finetune the stopover time. Similarly, SmartGuide develops personal travel recommendations with the help of a machine learning algorithm.

Augmented and virtual reality and digital twins

Augmented reality (AR) allows to display historic sights of a city, provide interactive virtual tours and immersive experience for tourists, helping them plan their trips in a more efficient manner.

⁵⁷ <https://globalnews.booking.com/bookingcom-launches-new-ai-trip-planner-to-enhance-travel-planning-experience/>

⁵⁸ <https://www.kayak.com/news/kayak-chatgpt/>

⁵⁹ <https://www.mountlytics.com/>

⁶⁰ <https://www.mountainmaps.it/>, <https://www.crunchbase.com/organization/mountain-maps>

⁶¹ <https://www.laya.ai/>, <https://www.crunchbase.com/organization/laya-technologies>

⁶² www.livdeo.com, <https://www.crunchbase.com/organization/livdeo>

⁶³ <https://seatris.com/english>

- **AerinX**⁶⁴ is an aircraft inspection system with a smart technology that helps in reducing inspection time. The system supports the maintenance engineer while decreases the possibility of human mistake.
- **ShoreView**⁶⁵ is a 'Digital Nautical Guide' with augmented reality to locate tourists on the sea, explore the coast safely, and discover points of interest.
- **X-Plora**⁶⁶ is a startup that develops apps for interactive and immersive tours. It uses technology to drive users along with a visit in a totally interactive and immersive way. X-Plora is improving the storytelling, the engagement, and the overall experience. The company was founded in 2019 and is headquartered in Portugal.

Box 4: Digital twins in the hospitality industry – the case of Hotelverse

Digital technologies including AVR allow today the full digital replication of tourism sites such as hotels and tourism facilities. By creating a digital twin of a hotel customers can get a more personalised booking experience, check the facilities in advance and take a more accurate decision which room they want to book, what services they can expect in advance.

Hotelverse⁶⁷ is one example of a technology startup that offers a new immersive booking experience for travelers who can virtually enter into the hotel, explore its characteristics, hyper-customise a specific room, and book it. The value that this solution offers lies in a new service that is expected to lure customers directly on the hotel website to book their rooms instead of online platforms that sometimes offer unfavourable conditions for the accommodation providers.

Internet of Things

Internet of Things technologies are used to control noise and avoid unwanted behaviour in hotel rooms, to support the establishment of smart locks, enable the remote management of hotels, hostels, rural houses, and tourist apartments.

- **Resimator**⁶⁸ provides an integrated management solution to hotels and restaurants that would like to operate a self-service kiosk and digital signage solution. These kiosks are managed on mobile devices or via the internet using IoT technologies and sensors.
- **Traxit**⁶⁹ developed a multi-sensor device with IoT and AI solutions that enables tracking of checked-in luggage worldwide. It works with a M2M sim-on-chip connected to GSM network, with an app for smartphone, a desktop version for handlers and airports and an innovative travel insurance package.
- **Bevscale** is a IoT and AI driven inventory management solution for bars, restaurants, and corporate users. They utilise custom-build hardware for keeping track of the user's inventory in real-time.

Robotics

Despite the technological possibilities in robotics and service automation in the form of delivery robots or robot-concierge, **robotics is a less relevant field currently**

⁶⁴ <https://aerinx.com/>

⁶⁵ <https://www.shoreview.app/index-en.html>

⁶⁶ <https://www.goxplora.com/>

⁶⁷ <https://www.hotelverse.tech/>

⁶⁸ <https://resimator.fi/en>

⁶⁹ <http://traxit.it/>

addressed by tourism tech startups. This shows that these technologies do not yet find their real application value in the tourism industry.

The robotics technology examples that can be highlighted include the following:

- **MIXARTISTA is a robotic barman** with an innovative liquid dispenser, designed to prepare cocktails for the luxury market. The machine allows to install up to 12 bottles and the robot is able to create the most complex recipes. MIXARTISTA relies on specific algorithms that guarantees a precise dosage of the cocktail's ingredients.
- **The Spanish Remy Robotics is a food robotics company** specialised in delivery through autonomous kitchens and combining adaptive robotics with culinary engineering.

Nevertheless, there are more international examples in this area:

- Tailos from the USA helps bridging the gap between robots and humans offering a housekeeping robot for hotels and commercial buildings. Like a self-driving car, Rosie navigates intelligently through the space while cleaning floors and collecting invaluable operational and environmental data.
- The Chinese Star Speed Store is a delivery robot provider. Star Speed Store provides hotels with delivery robots for delivering food, packages, and room service within eight minutes – a typical last-mile journey on the premises.
- A famous example is the "robot hotel" in Japan. A nearly fully automated robotic hotel: <https://group.hennnahotel.com/>.

2.3 Digital technologies supporting the green transition

Digital technologies are becoming a key enabler behind environmental solutions in the tourism ecosystem as the growing number of startups demonstrate.

Online platforms, mobile applications and digital software can support the circular economy. Under this category, further startups have been included that offer an online platform for booking, ordering, information sharing, discovery and at the same time they encourage environment-friendly travel and consumption choices.

- **Tripdoodler**⁷⁰ is a dedicated platform to empower travellers to create environmentally sustainable travel adventures. With the application, they can find, validate, rate, and share verified sustainable travel options through a searchable database of user ratings.
- **Glooby**⁷¹ is a travel search engine to find and compare prices on airplane tickets and hotels, while indicating the most fuel-efficient flights and eco-labelled hotels.
- The **Choco** app⁷² is an ordering platform connecting restaurants and their suppliers. Their service allows a better planning and more accurate supply of necessary ingredients and contributes to the reduction of food waste.
- **MyTwinPlace**⁷³ is a collaborative travel startup that connects travellers with hosts without money exchange. Its members accommodate their guests in their homes in exchange for free accommodation when they travel later themselves.

Mobile applications that offer a service to find environmentally friendly vacation planning or finding **nature-based tourist routes** have been also identified:

- **Hiiker**⁷⁴ developed an online platform and a mobile application for hikers and hiking trails providing information for vacation planning.

⁷⁰ <https://www.tripdoodler.com/about-us>

⁷¹ <https://www.glooby.com/>

⁷² <https://choco.com/fr>

⁷³ <https://www.crunchbase.com/organization/mytwinplace>

⁷⁴ <https://hiiker.app>

- **Adventurer**⁷⁵ provides a mobile app that is a unique helper in planning outdoor activities and hike orientation with a database of hikes, treks, and nature trips.

Artificial Intelligence for green transition

Artificial Intelligence is not only transforming the tourism industry in terms of optimisation of business processes as it will be presented in the next section, but it also enables more environmentally sustainable tourism choices. AI startups in tourism are limited (4% of startups are dedicated to AI or use AI to address environmental challenges in tourism). Although AI can also be used to monitor the carbon footprint of tourists and create a picture of tourist behaviour, interestingly this has not been an activity of recent tech tourism startups.

- **Smartvel**⁷⁶ is a developer of AI-empowered travel content technology intended to provide information about the destination and the latest restrictions to travel.
- **Heyyo.ai**⁷⁷ is an AI and SaaS-driven room automation solutions for hotels. The solution includes an electronic water control system, cloud bed, in-room streaming, dining table, multi-functional wall, intelligent lighting system, mirror with sound system, and more.
- **HelloEarnest**⁷⁸ is an AI-based virtual travel manager with focus on business travels.

IoT for environmental sustainability

The analysis identified also a couple of examples of environmental startups, where IoT technology and cloud-based software solutions have been applied to allow a more efficient use of natural resources such as water and energy.

⁷⁵ <https://adventurerapp.cz>

⁷⁶ <https://www.smartvel.com/>

⁷⁷ <https://www.heyyo.ai/>

⁷⁸ <http://hello-ernest.com/fr/>

3. Uptake of green and digital technologies and business models

Key findings

A business survey was conducted as part of the project about the status in the uptake of digital and green technologies and circular economy practices by SMEs operating in the tourism ecosystem. The results reveal the following insights:

- 35% of the surveyed organisations adopted at least one form of technology or solution relevant for the green transition
- 44% of the respondents stated to have increased investments dedicated to the green transition and environmental sustainability during the past five years
- 30.6% adopted recycled materials including also measures such as the use of recycled cups, bottles, or biodegradable packaging in hotels, restaurants, and tourist attractions (eg. museums or fairs). Other types of advanced materials that are bio-based/organic have been adopted by 21% of SMEs in the sample.
- Energy-saving technologies were adopted by 28% in tourism
- 26% adopted solutions to reduce food waste including optimisation technologies of stock inventory, better food management (buying ingredients that can be used before their expiry dates), donation of food to local agriculture and systematically offering leftover to the client to take home. A further question shows that when recycling food waste, close to half of the respondents tackle between 20-50% of the food, however another 37% claims recycling less than 5%.
- 21.7% of the survey respondents answered that they have adopted an ecotourism, nature-based tourism or related ecological services.

In the case of digitalisation, the tourism industrial ecosystem has been making overall a good progress with 97% of the respondents indicating that digitalisation has been already transformative for their business.

- Close to half of the respondents invested less than 5% in revenue in digital technologies, which is however still low.
- Using big data has been pointed out by 13% of the respondents.
- Artificial Intelligence has been adopted by 8% of the respondents.
- Digital twins are used by 5.8% of the respondents at the level of the ecosystem, often as a virtual model of the tourism facility (eg. hotel, bar, museum etc) or of the tourism destination as indicated by some of the SMEs.
- Augmented and virtual reality has been mentioned by a very low number, notably 3% of the respondents.
- Robotics and blockchain technologies have been mentioned by a very small share of the respondents (by 1.7%). The use of robotics was pointed out for inventory management and self-services.
- Blockchain was assessed to be used in the field of secure payments and financial transactions.

As it is known, the tourism industrial ecosystem is highly fragmented with a diverse set of activities such as transport, hotels, restaurants, tour operators, leisure activities that are all face different challenges both in terms of the green and the digital transition⁷⁹. When analysing the transformation of tourism, the interlinkage across value chains and flows of materials and assets should be kept in mind such as with agriculture, food production, construction (the built environment) and transport.

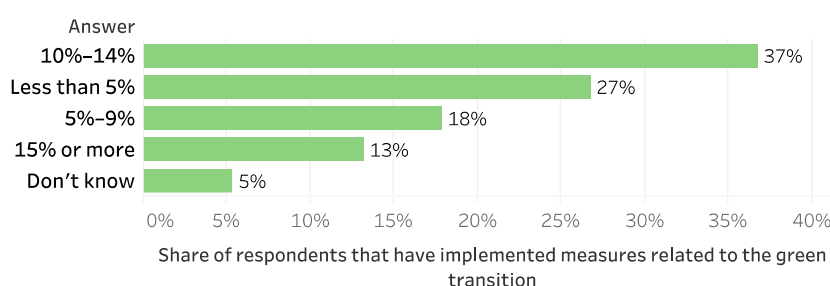
With the objective to monitor the status in the uptake of digital and green technologies, a large-scale business survey has been implemented in the framework of this study. The survey was based on using **Computer Assisted Telephone Interviewing (CATI)**. The final sample included 8 987 companies in all industrial ecosystems and in particular **836 for tourism**. The mainstage fieldwork was conducted between 15 January and 15th May 2023. A prerequisite for each reach-out and interview was to have a respondent with adequate capacities and knowledge to answer the questionnaire (for more details please see the methodological report of the project).

The results of other existing surveys have been also taken into account such as the Flash Eurobarometer 498 on SMEs, green markets and resource efficiency, and the ICT-usage in enterprises survey⁸⁰. The different time of the field work for each survey can give some insights about progress even if the questions were not exactly the same. The Flash Eurobarometer 498's field work took place in November-December 2021. The last ICT usage survey results date from 2020.

3.1 Green transformation of SMEs

Overall, the survey results indicate a relatively high interest in environmental sustainability. It was found that **35% of the surveyed organisations adopted at least one form of technology or solution relevant for the green transition as identified below**. The majority of the respondents adopted more than one green technology or solution⁸¹. Tourism SMEs were asked whether they had increased their investments dedicated to the green transition and environmental sustainability during the past five years. The results show that 44% of the respondents answered positively. A further question was related to the percentage in terms of revenue that the tourism enterprise had invested in green transformation on average annually that is presented in the Figure below.

Figure 9: Share of revenue invested in green transformation by SMEs in the tourism industrial ecosystem on average annually



Source: Technopolis Group and Kapa Research, 2023

⁷⁹ Dredge, D., Phi, G., Mahadevan, R., Meehan, E. & Popescu, E.S. (2018) Digitalisation in Tourism: In-depth analysis of challenges and opportunities. Low Value procedure GRO-SME-17-C-091-A for Executive Agency for Small and Medium-sized Enterprises (EASME) Virtual Tourism Observatory. Aalborg University, Copenhagen.

⁸⁰ https://ec.europa.eu/eurostat/cache/metadata/en/isoc_e_esms.htm

⁸¹ The list of technologies has been set up as a result of expert consultations about the main environmental technologies (directly used or embedded in a product) relevant for the 12 industrial ecosystems included in the full survey and specifically for tourism enterprises.

Similarly, the Flash Eurobarometer in 2021 found that tourism was among the industrial ecosystems most concerned about the environment as **24% of the SMEs surveyed in the tourism ecosystem had a concrete strategy in place to reduce their carbon footprint and become climate neutral** or negative, although 23% was planning to prepare one.

Resource efficiency

The detailed results demonstrate that SMEs in the tourism industrial ecosystem switched most easily to the use of **recycled materials with a share of 30.6%** adopting this green solution. Some of the interviews cited measures such as the use of recycled cups, bottles, or biodegradable packaging in hotels, restaurants, and tourist attractions (eg. museums or fairs). Other types of advanced materials that are bio-based/organic have been adopted by 21% of SMEs in the sample. The Flash Eurobarometer 498 in 2021 found that **41% of the SMEs switched to greener suppliers of materials** overall.

Energy-saving technologies came as second with 28% of tourism SMEs adopting these solutions. This finding is not a surprise since energy-saving has become very important since the start of soaring energy prices in 2021. According to the results of the Flash Eurobarometer 498, **61% of the SMEs in the tourism industrial ecosystem undertook actions to save energy** (including non-technological). The least cited technologies include carbon-capture and hydrogen technologies. The share of those respondents that have not yet adopted these technologies but planning to do so is relatively low.

Figure 10: Adoption of green technologies or solutions within the tourism industrial ecosystem

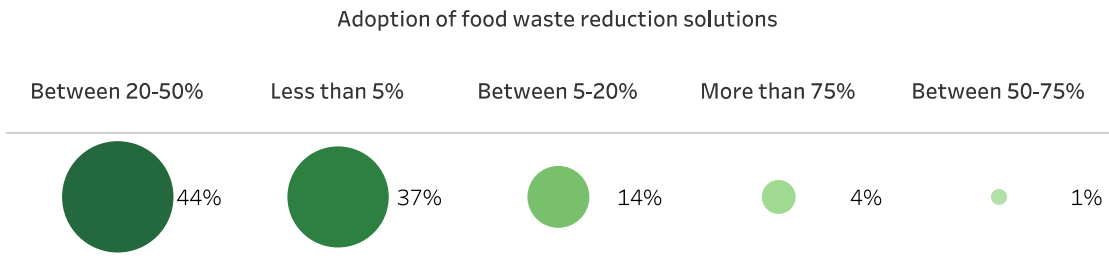
Green	Status	
	Already using	Planning to adopt
Recycled materials	30,6%	1,0%
Energy-saving technologies	28,6%	1,6%
Food waste reduction technologies	26,1%	2,0%
Water reduction/optimisation technologies	23,9%	2,5%
Renewable energies	23,9%	2,8%
Advanced materials (including organic, bio-based, biodegradable)	21,4%	3,3%
Waste reduction (other than food waste)	19,4%	5,1%
Circular design	17,5%	2,8%
Sustainable fuel	11,8%	2,9%
Carbon capture technologies	10,8%	1,6%
Hydrogen	5,4%	1,3%

Source: Technopolis Group and Kapa Research, 2023

Food waste reduction was the third preferred choice, indicated by 26% of the respondents. This activity can include optimisation technologies of stock inventory, better food management (buying ingredients that can be used before their expiry dates), donation of food to local agriculture and systematically offering leftover to the client to take home. A further question shows that when recycling food waste, close to half of the respondents handle between 20-50% of the food, however another 37% claims recycling less than 5% (see Figure 11).

Other waste reduction methods or technologies have been cited by 19% of the respondents, which share is relatively low, compared to the importance of this activity for the industry. Nevertheless, the share of those who plan to adopt it in the future is relatively high (the highest among all technologies and solutions), which can reflect the ongoing changes in regulation and the revision of the EU Waste Framework Directive⁸² as also some respondents pointed out.

Figure 11: Share of food waste that has been reused by respondents adopting such measures

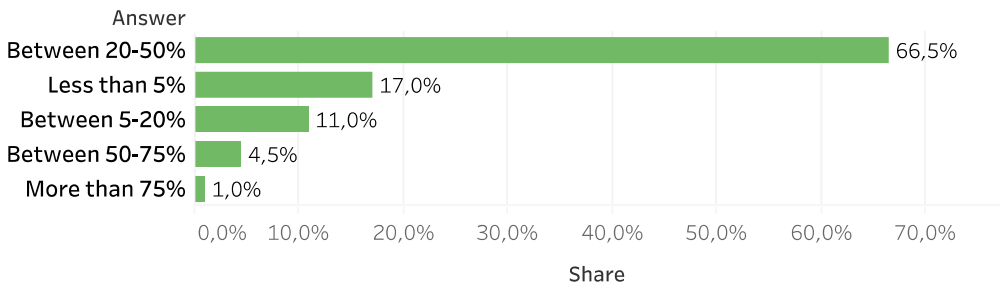


Source: Technopolis Group and Kapa Research, 2023

Renewable energy

Renewable energies have been taken up by 23% of the respondents. The results also indicate that 66.5% of those that responded positively, cover between 20-50% of their total energy consumption by renewable energies.

Figure 12: Share of renewable energy use within total energy consumption

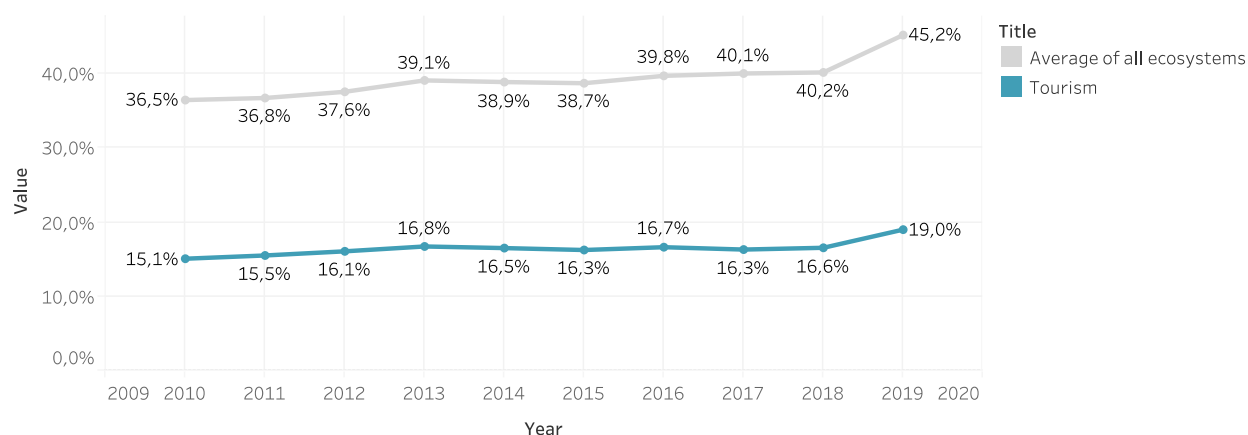


Source: Technopolis Group and Kapa Research, 2023

The renewable energy share of the tourism industrial ecosystem can be also monitored by relying on the statistics from Eurostat. Although the last available year of this statistics is before the pandemic notably 2019, it demonstrates the evolution over time (see Figure 13). The data indicate that 19% of the total energy consumption of the tourism industrial ecosystem (including passenger transport) was covered by renewable energies in 2019. There is a gap between the tourism industrial ecosystem and the industry average of 26 percent points. The top countries by share of renewable energy use in the tourism ecosystem during the 2010 – 2019 period were Cyprus, Netherlands, Bulgaria, Austria, Romania and Italy.

⁸² https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en

Figure 13: Evolution of the share of terajoules of renewable energy use by the tourism ecosystem and the total EU27 IEs (2010 – 2019)

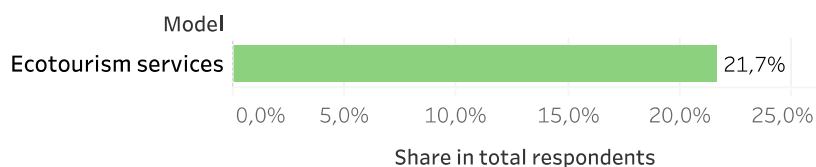


Source: Technopolis Group, 2022, based on Eurostat [ENV_AC_PEFASU]

Ecotourism and nature-based tourism

The growing importance of ecotourism was highlighted by several interviewees in this study. It was noted that there is an increasing demand by tourists to prefer tourism experiences that are nature-based and environmental-conscious. Overall, **21.7% of the survey respondents answered that they have adopted an ecotourism, nature-based tourism or related ecological service model**. The advantages of ecotourism for the local host communities were emphasised, where the objective is to conserve and protect nature while providing economic benefits for local people.

Figure 14: Adoption of ecotourism



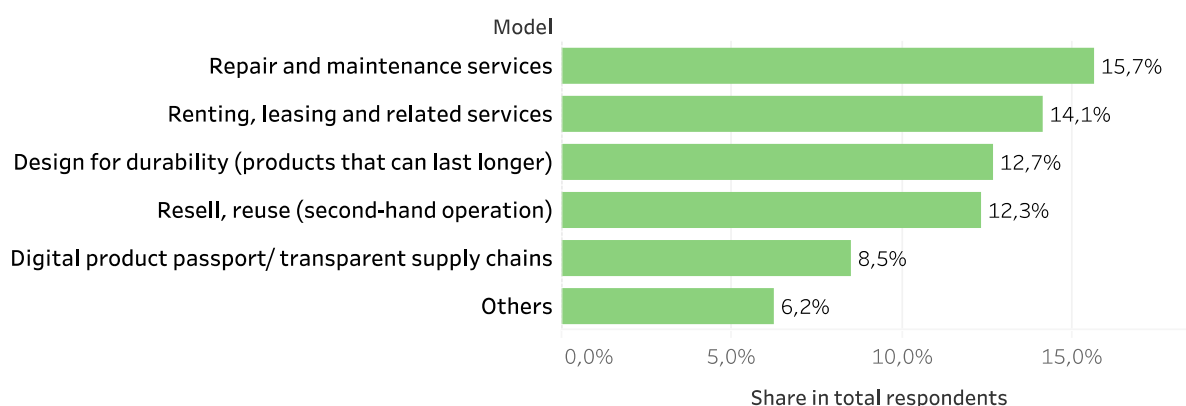
Source: Technopolis Group and Kapa Research, 2023

Circular business models and service models

Tourism enterprises were also surveyed about the **adoption of circular business models** and other environment-focused service models. The results indicate that 15% of the respondents adopted repair and maintenance services and 14% renting and leasing business models. Nevertheless, the results also hide the diversity of the tourism industrial ecosystem notably the different options that hotels, restaurants, museums with assets and tangible products have on the one hand and travel agencies, attractions and tourism service operators with more non-tangible services have on the other hand⁸³.

⁸³ See also this distinction made in the report CE360 Alliance (2020). Circular economy in travel and tourism

Figure 15: Adoption of green business models and non-technological solutions within the tourism ecosystem

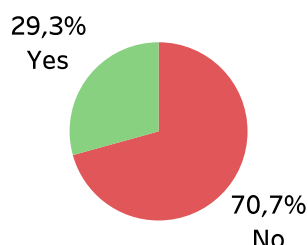


Source: Technopolis Group and Kapa Research, 2023

Environmental standards

When asked about the certification on any environmental standards, 29% of the respondents indicated that they had been certified by a third party (see Figure 16). The tourism industry has several sets of definitions and guidelines for the environmental impact of services including ISO standards, the EU Ecolabel of environmental excellence, or the EU Eco-Management and Audit Scheme (EMAS). The EU Ecolabel is awarded to products and services that meet the strictest environmental standards throughout their life cycle. In the tourism industry, over 500 hotels and campsites across Europe have been awarded the EU Ecolabel⁸⁴.

Figure 16: Share of organisations indicating that they have obtained an environmental certificate by a third party



Source: Technopolis Group and Kapa Research, 2023

ISO 14001 is a set of standards that any company can follow to implement an effective environmental management system. By adopting the good practices suggested by the standard, firms can set their objectives and monitor the reduction of their environmental footprint. The number of environmental ISO 14001 certificates issued for the tourism industry indicates the progress towards the application of environmentally friendly business practices and production methods. For the purposes of this report, ISO 14001 data were accessed via the ISO survey of certifications to management system standards⁸⁵. Besides ISO 14001, tourism companies can also apply for the EU Eco-Management and Audit

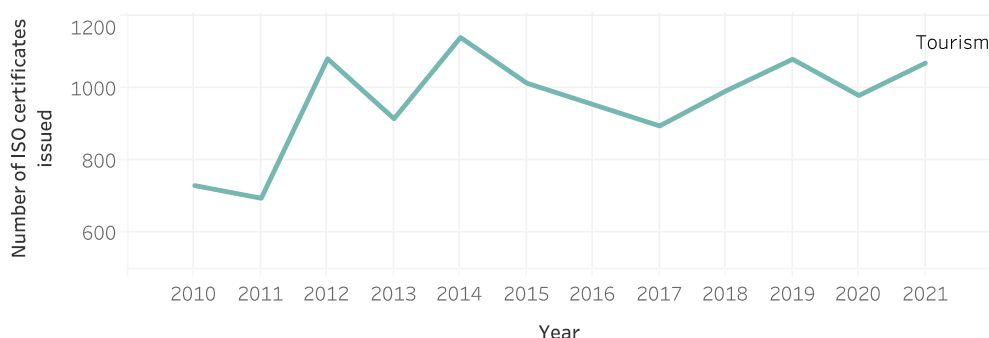
⁸⁴ https://environment.ec.europa.eu/topics/circular-economy/eu-ecolabel-home/eu-ecolabel-tourist-accommodation_en#:~:text=In%20the%20tourism%20industry%2C%20over,emissions%20while%20you're%20travelling.

⁸⁵ ISO (2022) ISO Survey of certifications to management system standards. Accessed on <https://isotc.iso.org/livelink/livelink?func=ll&objId=18808772&objAction=browse&sort=name&viewType=1>

Scheme (EMAS), the EU Ecolabel or the European Union label of environmental excellence. The Transition pathway for tourism recognised as key action for the ecosystem to increase the number of SMEs with registration to EMAS, and accommodations with EU Ecolabel, or other ISO 14024 type I ecolabels or equivalent voluntary labels, which are independent, multi-criteria based and third party verified.

The annual ISO survey indicates that there were 1 070 certificates issued to tourism companies in the EU27 in the year 2021, which number increased over the years since 2010.

Figure 17: Number of environmental certificates issued



Source: Technopolis Group, 2022, based on ISO

3.2 Digital transformation of SMEs

The tourism industry has been making relatively good advancements on the digital scene over the past two decades. It was among the first industries to harness the potential of the Internet at its dawn with the launch of web-based reservation systems to facilitate business transactions and the use of websites for marketing purposes⁸⁶. Most recent Eurostat data show that the share of companies that have a website has been increasing both in the case of accommodation and food services (75.4% of enterprise that employed 10 persons or more had a website in 2021) and the travel agency, tour operator and other reservation service and related activities (92.3% of enterprises that employed 10 persons or more had a website in 2021)⁸⁷. As pointed out in the Annual Single Market Report 2021, the market share of traditional travel agencies has been decreasing steadily with the development of online entrants.

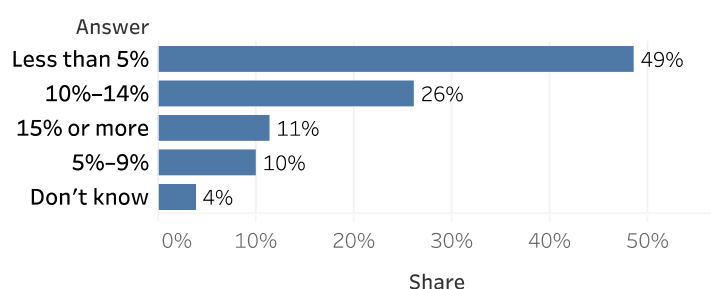
Nonetheless, **the path of digital transformation is very different for the various sub-industries and among small and large organisations**. For example, restaurants face a different challenge than hotels, travel agencies, or destination management organisations.

The survey conducted in the framework of this project confirms this status, **since 97% of the respondents said that digitalisation has been important for their business**. When asking tourism SMEs, whether they had increased their investments dedicated to the digital technologies during the past five years, 45% responded positively. A further question was related to the percentage in terms of revenue that the tourism enterprises had invested in digital transformation on average annually. The responses show that close to **half of the respondents invested less than 5% in revenue** in digital technologies and altogether 86% invested less than 15%.

⁸⁶ Dredge, D., Phi, G., Mahadevan, R., Meehan, E. & Popescu, E.S. (2018) Digitalisation in Tourism: In-depth analysis of challenges and opportunities.

⁸⁷ https://ec.europa.eu/eurostat/databrowser/view/ISOC_CIWEBN2__custom_7450779/default/table?lang=en

Figure 18: Share in revenue is invested in digital transformation on average annually



Source: Technopolis Group and Kapa Research, 2023

The adoption of specific digital technologies is shown in Figure 19. The detailed results demonstrate that **tourism SMEs adopted cloud technologies most often (25%)**.

Figure 19: Adoption of digital technologies within the tourism industrial ecosystem

Technologies	Status	
	Already using	Planning to adopt
Cloud technologies	25,24%	1,79%
Big data	13,16%	2,27%
IoT	9,81%	2,03%
AI	8,01%	2,51%
Digital twin	5,81%	3,11%
AVR	3,59%	2,03%
Robotics	1,79%	1,56%
Blockchain	1,79%	1,56%

Source: Technopolis Group and Kapa Research, 2023

Tourism enterprises have been increasingly realising the potential of **cloud computing** and storage for their business as measured by Eurostat in its indicator called 'Use of cloud computing services, by economic activity'⁸⁸. This data shows that the adoption of cloud services has increased over the period increased from a share of 16.4% in 2018 to a share of 32.1% in 2021 in the case of accommodation and food services⁸⁹. The use of cloud computing based on Eurostat statistics was mostly for e-mail and storage of files. The results of this survey are somewhat lower; however, the measurement is different given the focus on SMEs and on the broader tourism industrial ecosystem.

Using **big data has been pointed out by 13%** of the respondents. The survey results indicate that big data analytics was used most often in order to gain intelligence about tourists and analyse the market. As digitalisation creates more and more data about various dimensions of the industry, data analytics is becoming more and more popular. Eurostat⁹⁰ concluded that 12.3% of the companies in accommodation and food services (10 persons or more) and 27.5% in travel agency, tour operator and other reservation service and related activities analysed big data internally from any data source or externally in 2020. Increasing the opportunities to use of big data by SMEs in tourism is

⁸⁸ https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Cloud_computing_-_statistics_on_the_use_by_enterprises

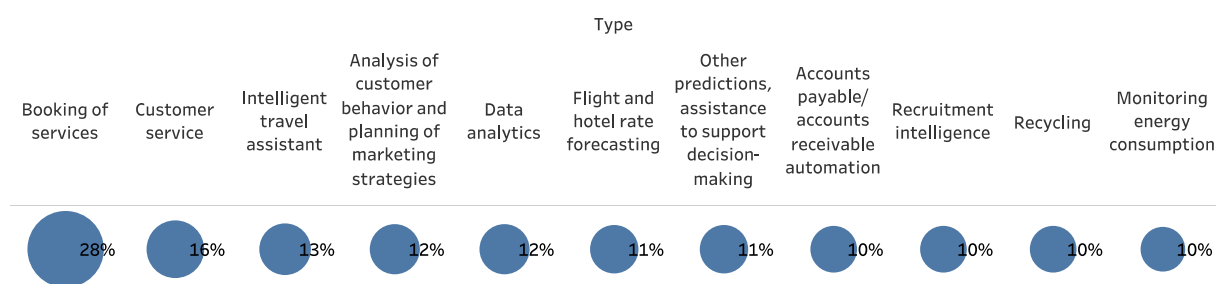
⁸⁹ https://ec.europa.eu/eurostat/databrowser/view/ISOC_CICCE_USEN2__custom_7522792/default/table?lang=en

⁹⁰ https://ec.europa.eu/eurostat/databrowser/view/ISOC_EB_BDN2__custom_7152869/default/table?lang=en

addressed by the upcoming European data space for tourism⁹¹ that is expected to fill the current gap in the data market for tourism and generate innovative services and economic value.

According to the survey results, **Artificial Intelligence has been adopted by 8% of the respondents.** The related indicator in Eurostat⁹² that measures the use of AI by enterprises by economic activity found that **3.6% of enterprises in accommodation and food service activities** (10 persons or more) adopted at least one Artificial Intelligence technologies in 2021. The same Eurostat indicator was **8.6% in the case of travel agency, tour operator and other reservation service and related activities.** Additional questions revealed the areas where Artificial Intelligence have been focused on along the tourism industrial value chain. Respondents that have specified these technologies include travel agencies, tour operators, reservation services followed by accommodation and restaurants. Most importantly, AI technologies have been adopted with the objective to support booking services, improving customer services and gathering insights about clients. From the feedback of tourism SMEs, we see the use cases of AI by hotels and travel agencies to analyse market trends and forecast customer behaviour. In addition, AI-based personalisation and recommendations (including virtual agents and chatbots) have been also pointed out. According to Eurostat, 5.4% of the companies in accommodation and food services (with 10 persons or more) used a chat service where a chatbot or a virtual agent replies to customers in 2020⁹³.

Figure 20: Use cases of AI and big data of tourism SMEs



Source: Technopolis Group and Kapa Research, 2023

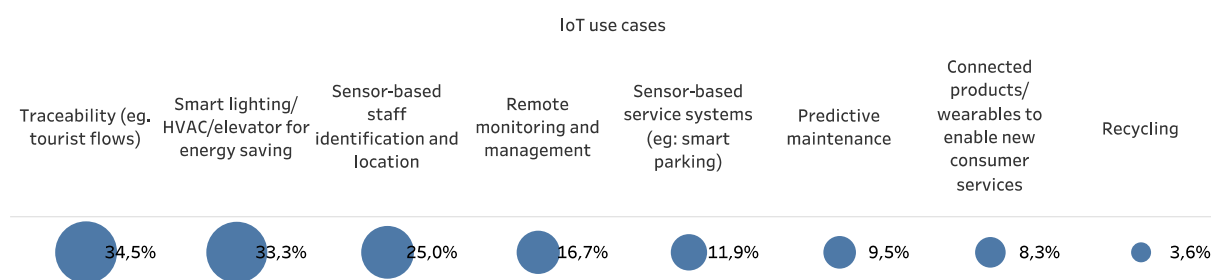
Digital twins are used by 5.8% of the respondents at the level of the ecosystem, often as a virtual model of the tourism facility (eg. hotel, bar, museum etc) or of the tourism destination as indicated by some of the SMEs. The advantage in digital twins is that it can provide a three-dimensional representation of the physical environment and thus a real-like indoor navigation experience. In contrast with manufacturing industries, the digital twin is less used for maintenance or operations but rather instead its role is to enhance guest experience, personalised services, and smart room features. As the technology is becoming more accessible, this innovation is used more and more with the objective to better engage users and increase bookings as pointed out. The adoption of the **Internet of Things** follows closely digital twins with a share of 9.8%. IoT has been used most often for the purposes of monitoring tourist flows, followed by the use of IoT-based products for energy saving. For example, it was pointed out that hotels plan to use IoT to support the check-in process with electronic key cards and automatic check-in process via a mobile application.

⁹¹ https://single-market-economy.ec.europa.eu/system/files/2023-07/C_2023_4787_1_EN_ACT_part1_v4.pdf

⁹² https://ec.europa.eu/eurostat/databrowser/view/ISOC_EB_AIN2__custom_7451808/default/table?lang=en

⁹³ https://ec.europa.eu/eurostat/databrowser/view/ISOC_CIWEBN2__custom_7451813/default/table?lang=en

Figure 21: Use cases of Internet of Things of tourism SMEs

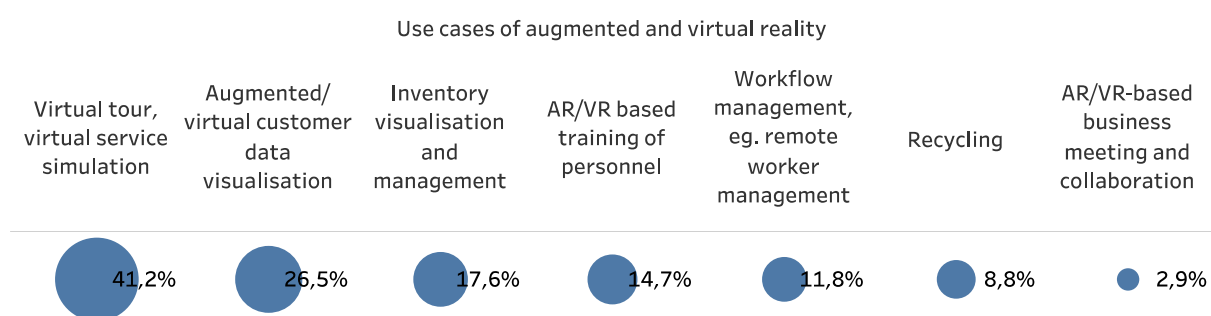


Source: Technopolis Group and Kapa Research, 2023

Smart room technology has been also cited as a promising area of future development that is enabled by IoT and other technologies including voice control, automation and energy efficiency.

Augmented and virtual reality has been mentioned by a very low number, notably 3% of the respondents. Although there are a lot of future opportunities in developing virtual tourism or the metaverse, this has not been considered as a priority or area that tourism SMEs are concerned with. Those very few that responded yet, pointed out the use of virtual reality for virtual tours (virtual service simulation also linked to digital twins), followed by data visualisation and inventory management use cases.

Figure 22: Use cases of augmented and virtual reality of tourism SMEs



Source: Technopolis Group and Kapa Research, 2023

Robotics and blockchain technologies have been mentioned by a very small share of the respondents (by 1.7%). The use of robotics was pointed out for inventory management and self-services.

Blockchain was assessed to be used in the field of secure payments and financial transactions.

3.3 Technology centres supporting technology uptake

Innovation actors are at the core of industrial ecosystems and gathering and sharing information about them in a structured way is crucial to detect gaps, improve collaboration, foster innovation, and strengthen innovation ecosystems. The [Technology Centre Mapping](#) conducted in the framework of this project comprises information on technology centres that are key actors in innovation ecosystems due to their technical expertise and their ability to bring together and steer collaboration among various types of actors in their own ecosystems and beyond. SMEs in industrial ecosystems are supported in their twin transformation efforts by other hubs and networks such as the European Digital Innovation Hubs and cluster organisations, nonetheless, in this study we present the results of the technology centre mapping more in detail given its direct link to the project.

The results of the technology centres mapping show that 10 technology centres are active in the tourism industrial ecosystem as so far registered in the mapping database. Six technology centres are located in Spain, and one technology centre respectively in Czechia, Estonia, Finland and Ireland. Countries might host additional technology centres active in tourism, which are currently not registered to the technology centres mapping.

The following examples serve to illustrate the activities and scope of technology centres active in tourism, their links with the broader ecosystem as well as examples of recent activities in which they are involved. They include the following three cases: STACC (EE), TIDES - The University Institute for Tourism and Sustainable Economic Development (ES), Helsinki XR Center (FI).

Box 1 : Example Technology Centre: STACC (EE)

Name of the Centre	STACC (EE)
Location and scope	
<p>STACC (Software Technology and Applications Competence Center) was founded in 2009 by the University of Tartu, Tallinn University of Technology, Cybernetica AS, Regio AS (now Reach-U AS), Webmedia AS (now Nortal AS), Logica Eesti AS (now CGI Eesti AS) and Quretec OÜ.</p> <p>SACC works in the field of data science and machine learning with the objective of developing artificial intelligence to help customers find data driven solutions for their business problems. It does this in multiple sectors such as tourism, telecommunications, consumer goods, and education, among others.</p>	
Main services and equipment	
<p>STACC provides data analytics and IT solutions in different fields:</p> <ul style="list-style-type: none"> • E commerce: STACC offers recommendations systems to increase the turnover, personalised email campaigns and different machine learning solutions such as supply chain management, demand forecasting and credit scoring. • Online media: The Centre provides services to help companies increasing their competitiveness in online media with tools like text analytics and machine learning feasibility analysis. • Manufacturing: STACC helps to analyse and optimise the manufacturing process. • E-government: STACC helps processing data volumes and developing innovative solutions in the public sector. Therefore, it has created the so-called X-Road, a software platform that allows Estonian private and public sector institutions exchange data in a smooth way. • Personalised medicine: The Centre provides services for a preventive, predictive and participatory health system which involves conducting epidemiological studies, developing the necessary software and IT components, and creating safe and well-structured data analytics. • Start-ups: STACC offers start-ups services for conducting applied research, product, or service development, conducting feasibility studies and protection of their intellectual property. <p>Among its equipment, STACC has an IT Laboratory with computing and database servers, a secured network, and a functional office space in Tartu.</p>	
Recent projects related to the green and digital transition in tourism	
<ul style="list-style-type: none"> • The National Heritage Board is the agency of the Estonian government that protects the country heritage by supervising monuments and heritage conservation areas, keeping a register of the cultural monuments and managing the property export applications. Within this context, STACC conducted an analysis based on the data entered into the museum 	

information system called MuIS. The analysis allowed an overview of the materials, its dimensions and the number of objects planned for the repositories

- In the **Kratt Säili*** project STACC helped the Estonian National Heritage Board to create an artificial intelligence solution for the preservation of museum objects.⁹⁴

Source: Advanced Technologies for Industry Technology Centre Mapping, 2023 and STACC, 2023 <https://stacc.ee/>

Box 2: TIDES - The University Institute for Tourism and Sustainable Economic Development (ES)

Name of the Centre	TIDES - The University Institute for Tourism and Sustainable Economic Development (ES)
Location and scope	
<p>The University Institute of Tourism and Sustainable Economic Development (TIDES) was created in 2010 as an initiative of a group of research teaching staff of the University of Las Palmas de Gran Canaria (ULPGC). Therefore, the University Institute of Tourism and Sustainable Economic Development (TIDES), belongs to the ULPGC and has the support of the main Public Administrations of the Canary Islands, town halls and companies, as well as the support of different international centres in tourism research at a worldwide level.</p> <p>The aim of the Centre is to do research in the fields of tourism innovation, tourism cooperation and sustainable economy by carrying out research activities in collaboration with other public and private entities, circulating research studies, establishing links with other research institutions, and promoting trainings and seminars, among other activities.</p> <p>In order to achieve its objectives, the Institute is divided into divisions such as Business and Tourism Management, Cooperation for Sustainable Development, and Market and Tourist Experiences, among others.</p> <p>In addition, the TIDES University Institute has a presence, mainly in Africa, Latin America and Europe and it was placed by the ranking of Shanghai (ARWU) among the 23 best centres in the world in the field of Tourism.</p>	
Main services and equipment	
<p>TIDES provides two main services:</p> <ul style="list-style-type: none"> • The climate service. This service operates through the “Regional Exchange Information System -REIS” platform, which offers: <ul style="list-style-type: none"> - The assistance and advice from an expert panel formed by a multidisciplinary group of scientists, policy makers, sector rulers and practitioners experienced in the impacts of climate change in islands, who work collaboratively and exchange new ideas. - The so-called Adaptation Support Tool, which is a practical guide to familiarise with the Climate Change impacts in the context of European Islands and outermost regions. • The Digital Lab, to better understand social behaviour by using neuromarketing techniques. This analysis can be done with tourists, companies, and the society, as a whole. The Lab includes the EMOFOODLab to get a deeper idea of the influence of gastronomy in tourists at the time of choosing their destination or the type of experiences. This can also be used for other types of touristic activities such as commerce, public services or museums. 	

⁹⁴ See <https://stacc.ee/our-work/>

TIDES has equipment consisting of Eye Tracking Heatmap, face readers, virtual reality consumables and coding software, among others

Recent projects related to the green and digital transition in tourism

- The Government of La Palma, through the Department of Tourism, presents the Global Sustainability Fellows Programme promoted by the Sustainability Laboratory of New York, the UNESCO Chair of Economic Development and Sustainable Tourism, the TIDES Institute of the University of Las Palmas de Gran Canaria (ULPGC) and the Ashotel – Caja Canarias Chair of Tourism of the University of La Laguna (ULL). The Global Sustainability Fellows Program is focused on a training-learning process, theoretical and in the field, tackling real problems, under the axis of sustainability.
- The Erasmus + **CLIMAR** project intends to strengthen research, innovation, and knowledge transfer on Climate Change & Tourism in Higher Education Institutions in Latin America.
- **Euro-Emotur** is a COSME project that seeks to foster the adoption of digitisation and innovation by tourism SMEs through transnational cooperation and capacity building.⁹⁵

Source: Advanced Technologies for Industry Technology Centre Mapping, 2023 and TIDES, 2023 <https://tides.ulpgc.es/>

Box 3: Example Technology Centre: Helsinki XR Center

Name of the Centre	Helsinki XR Center (FI)
Location and scope	
<p>Helsinki XR Center is running since 2019. It is located in Arabia, Helsinki, and it is part of the Metropolia University of Applied Sciences' Creative Campus. It works in close cooperation with the Finnish Virtual Reality Association (FIVR) and is supported by the City of Helsinki.</p> <p>It is dedicated to virtual reality, augmented reality and mixed reality technologies and it works as an incubator and a cultural hub which connects industries, entrepreneurs, start-ups, students, scientists, and artists for co-creation and learning of XR.</p>	
Main services and equipment	
<p>Helsinki XR:</p> <ul style="list-style-type: none"> • Supports Finnish XR startups by offering office space and equipment, mentoring and access to the Finnish XR community, coaching, and facilities for teams, companies, and individuals in their early phase of development of virtual reality, augmented reality, and mixed reality projects. These facilities include Green screen & MultiCam studios, Photography studios, and a Motion Capture Studio. • Organises various XR events for networking purposes. • Carries out different kinds of Research Development & Innovation projects with universities and other organisations. Furthermore, it offers the so-called XR Research Indexes, which is a compilation of several indexes that include data related to Finnish XR research. These indexes serve to help people to find important research data and possible partners for collaboration in XR related projects. • Offers XR Workshops for companies and organisations, special facility renting, venue services and business coaching for early-stage startups in Helsinki Arabia district. Moreover, the HXRC Showroom serves to test state-of-the-art XR devices, experience applications of different fields and industries, and get a front row view of Finnish XR expertise. 	

⁹⁵ See <https://tides.ulpgc.es/proyectos/>

- Provides **free work space** and hardware, mentoring and networking opportunities.

Recent projects related to the green and digital transition in tourism

- The **PARK project** is aiming to develop the practices of businesses and create product and business blanks using gamification and service design. The PARK-project picks good practices from the gaming industry, and applies these on other fields of business.
- The aim of the **Vevent** project is to develop models that will strengthen the knowhow of using XR technologies in creative industries and give tools for future employment and new innovations.⁹⁶

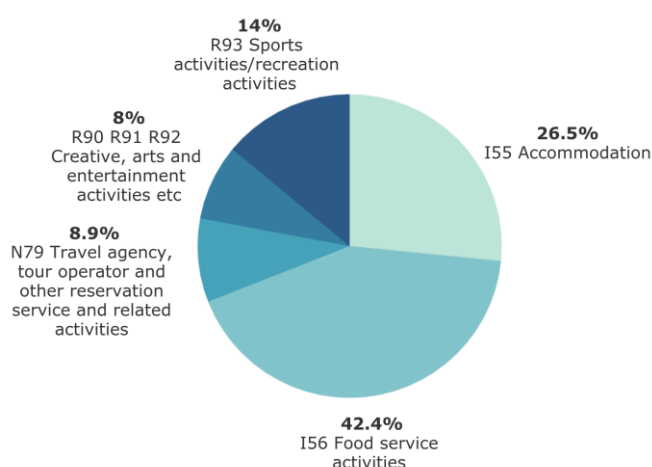
Source: Advanced Technologies for Industry Technology Centre Mapping, 2023 and Helsinki XR Center, 2023 <https://>

3.4 Textmining of tourism company websites

Scraping and analysing company websites can provide valuable insights about how companies behave. Websites contain a lot of publicly available information about companies, such as press releases, business news, product information, and public reports. By mining this information, we can gain insights into the actions and decisions companies are taking in the areas of digitalisation and environmental sustainability. The objective of this big data exercise is to provide empirical evidence on how companies in the tourism industry are adopting digital technologies and implementing measures to protect the environment. The analysis is based on a large number of company websites, which allow us to regularly and accurately monitor the adoption of sustainable practices and innovations using digital technologies.

This analysis conducted as part of the project relied on the OPIX⁹⁷ platform, which includes models designed for the tourism industrial ecosystem and the related technologies selected to be monitored. The analysis focuses on the green and digital transition aspects of the ecosystem, based on a review of policy documents, scientific literature, and industry practices related to this transition. The analysis included tourism organisations from various NACE codes obtained from business registers. The data was collected and analyzed between September 2023 and November 2023.

Figure 23: Distribution of the big data sample across sub-NACE within tourism



Source: Opix platform

Note: Please note that we have excluded transport from the sample

⁹⁶ See <https://helsinkixrcenter.com/projects/>

⁹⁷ <https://www.opix.ai/>

The sample was further divided into **2% large companies and 98% SMEs from the tourism industrial ecosystem**. Within the SME category, 91% of the organisations are micro-enterprises employing less than 10 people.

The presence of tourism companies on online platforms and whether or not they have their own website provides an initial understanding of the companies' digitalisation journey.

Our assessment first of all shows:

- **84% of companies in the tourism ecosystem and included in a business register have an own website**
 - More specifically, **100% of the large tourism companies had an own website** and **83% of SME tourism companies had an own website**
 - Eurostat data⁹⁸ shows 75.4% in 'I55-56 Accommodation and food services' and 92.3% in the field of 'N79 Travel agency, tour operator and other reservation service and related activities' had a website in the EU27 in 2021.
- **98% of companies captured within our sample in the tourism ecosystem and included in the business register have been present at least on one online platform** (OTAs included in the analysis are: booking, airbnb, trivago, kayak, expedia, Orbitz, Hotels.com, tripadvisor, ortharize, oyorooms, igms.com, agoda.com, ctrip.com, roverpass.com, hostaway.com, klook.com, priceline.com, us.trip.com, uber.com, illusions-online.com, hometogo.com, tashi.travel, hospitable.com, okarito.io, casy.ch, hotelasp.com, bestrez.com, brillianthospitality.com, ratehawk.com, ownerreservations.com, hotelbee.co, mybookingpal.com, good.travel, bookingforce.io, roomranger, trivo.in, webbookingpro, lodgeline.com, roomstay.io, revelex, vamoos).
- Zooming into hotels and the use of online platforms, our estimate indicates that **88% of large accommodation establishments have been included on booking.com** (the ones that are not included are large vacation centres, youth vacation groups). Nevertheless, they sell usually fewer rooms via OTAs than do smaller establishments. Existing academic research indicates that hotels remained dependent on OTAs, although this is more the case for small than large establishments⁹⁹¹⁰⁰.
- Overall, our analysis found that **there are more establishments present on online booking platforms than included in business registers**. More specifically, in the field of accommodation, our analysis found that there are **1.7% more accommodation** offered on OTAs than companies included in business registers. The analysis shows that in many countries the number of accommodations in booking.com exceeds the number of accommodations as reported by Eurostat's Structural Business Statistics.
- With regard to referencing and including a link to online platforms from the own website of the companies, we find that only **7.97% of those with an own website indicated a direct link to an online booking platforms**. Nevertheless, this is not surprising given the fact that companies prefer to direct customers to their own websites rather than external booking platforms.

98 https://ec.europa.eu/eurostat/databrowser/view/isoc_ciwebn2__custom_8273600/default/table?lang=en

99 See the analysis of Hotrec (2022). European Hotel Distribution Study 2022

100 Martin-Fuentes, E. and Mellinas, J.P. (2018), "Hotels that most rely on Booking.com – online travel agencies (OTAs) and hotel distribution channels", *Tourism Review*, Vol. 73 No. 4, pp. 465-479. <https://doi.org/10.1108/TR-12-2017-0201>

- **67.3% of the companies in the tourism ecosystem had a link or reference to a social media account**¹⁰¹ (in Eurostat it is indicated that 52.9% in 'I55-56 Accommodation and food services' and 70.3% in 'N79 Travel agency, tour operator and other reservation service and related activities' had a website with links or references to the enterprise's social media profiles in 2021 in the EU27)

Green transition

The green transition of companies in the tourism ecosystem (excluding transport) has been analysed in terms of their use of environmental certifications and secondly their claims of environmental practices.

Environmental certifications/labels are formal recognitions that a company has met specific environmental standards and criteria set by certifying bodies. Examples include certifications like ISO 14001 (Environmental Management), Green Key (for eco-friendly hotels), or EarthCheck (for sustainable tourism). Obtaining such certifications requires a company to adhere to established environmental guidelines and practices. These certifications can serve as concrete evidence of a company's commitment to environmental sustainability. We present the list of environmental labels used in this analysis in Table below.

Table 1: Environmental labels addressed in the analysis

Hotels	Restaurants
EMAS	EMAS
ISO 14001	ISO 14001
EU Ecolabel for tourist accommodations	Green Restaurant Association
BIO HOTELS	Ocean Wise
ECOCAMPING	Certified Organic
EarthCheck	Fair Trade Certified
Good Travel Seal	Slow Food
Green Globe	LEAF (Leaders in Environmentally Accountable Foodservice)
Green Key	Zero Waste Certification
Green Lodge	Michelin Green Star
Leadership in Energy and Environmental Design	Plant-Forward Certification
Travelife	Local Food Certifications
TourCert	https://www.ecolabelindex.com/

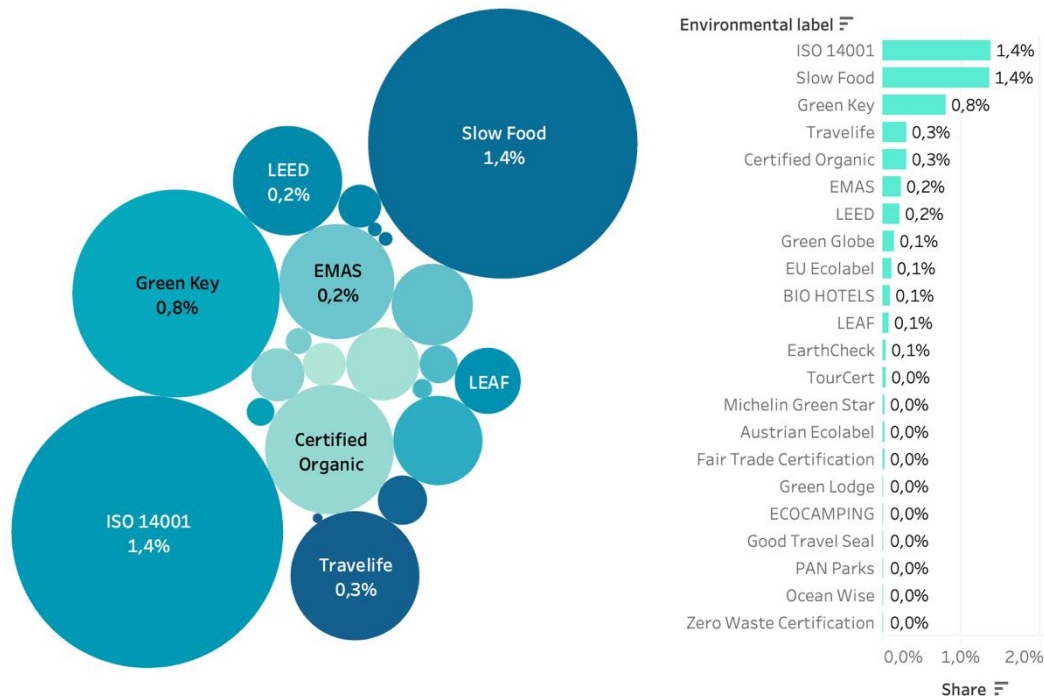
Source: Technopolis and Opix

The results indicate that **3.1% of companies in the tourism ecosystem** had at least one environmental certificate/label referenced on their website, however, this is the average including all the sub-activities. More precisely, **4.5% of the accommodation establishments and 2.3% of food services/restaurants** mentioned at least one environmental label on their website.

¹⁰¹ Social media included in the analysis are: facebook, instagram, linkedin, pinterest, reddit, skype, tiktok, twitter, weibo, youtube

The Figure below indicates the share of accommodation and food service establishments that had an environmental label on their website. The ones referenced the most often include Slow Food, ISO, Green Key, Travelife and Certified Organic.

Figure 24: Share of accommodation and food services (155-56) referencing an environmental label on their website



Source: Technopolis Group and OPIX, 2023

Besides environmental labels, we have further screened tourism company websites in terms of their environmental measures.

References to environmental practices on websites mean basically self-declared statements about their environmental efforts. While they can provide insights into a company's intentions and its positioning in the ecological tourism niche, they are not as concrete as formal certifications. It has to be highlighted that claims can be used for marketing and greenwashing, where companies overstate their environmental efforts to attract environmentally conscious consumers. We have investigated the following references:

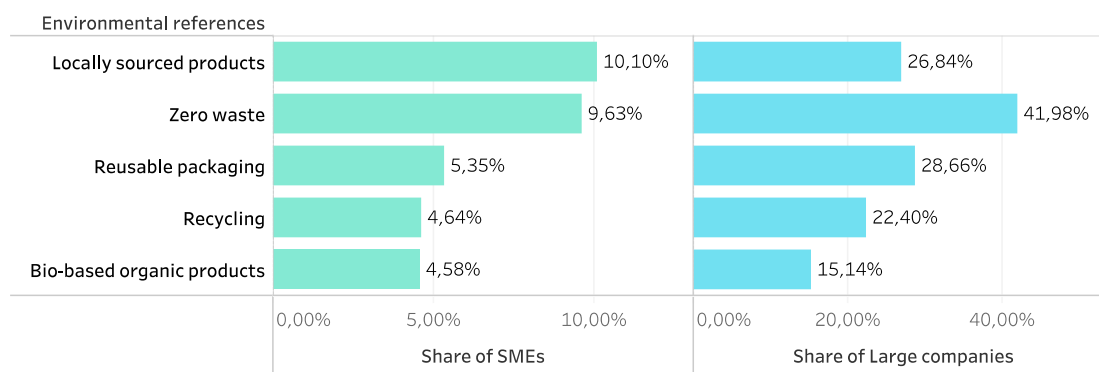
- offering bio-based, organic products
- locally sourced products, short supply chain
- use of waste management, zero waste, reusable packaging,
- recycling measures.

The findings of the data analysis show that:

- **18.7% of SMEs and 59.3% of large companies** in the tourism ecosystem has referenced environmental practices and measures that they have implemented on their website.

Figure 3 displays some of the more concrete environmental practices that have been referenced on company websites.

Figure 25: References to environmental practices on tourism company websites



Source: Technopolis Group and OPIX, 2023

Digital transition

In the process of digital transition, this report uses statistics from Eurostat's annual survey on ICT usage and e-commerce in enterprises to supplement the analysis of big data, when applicable. There are two main differences between the two approaches. Firstly, the report takes an ecosystem approach and covers all relevant tourism activities. Secondly, Eurostat's survey includes enterprises with at least 10 employees, while the big data analysis also includes micro enterprises.

First, we investigated what is the share of tourism companies in our sample that have an own booking or reservation option on their own website. The findings show that **10.76% of the tourism companies in general and 12.2% of accommodation and food service establishments** offered such a service for their customers. These values are much lower than indicated in Eurostat¹⁰² where the share of organisations in 'I55-56 Accommodation and food services' that had online ordering, reservation or booking was 45.9% in 2021. Nonetheless, the Eurostat figure refers to organisations with 10 employees or more and the big data analysis in this project includes micro companies in majority.

Regarding the use of mobile applications that can be downloaded either from an apple store or from android, our data analysis shows **that 4.1% of the websites had a link to android mobile applications and 2.8% a link to applications to be downloaded from the apple store.**

Chatbots have been used in a very low number of websites, notably below 0.8% as found in this analysis. This value is also much lower as indicated in Eurostat with regard to the share of tourism organisation with an AI chatbot to engage with customers (4.1%), but again the difference in terms of the organisational size has to be kept in mind.

The share of tourism organisations that had an **augmented or virtual reality, 3D view, immersive experience presented on their websites** was below 1%, with a large difference between large companies (5%) and SMEs (0.5%).

The **share of accommodation and food services that offered any further advanced digital service** such as connected room, voice control, digital room/food service was found to be very low notably 0.0791%.

¹⁰² https://ec.europa.eu/eurostat/databrowser/view/isoc_ciwebn2__custom_8273600/default/table?lang=en

4. Investment and funding

Key findings

The tourism ecosystem has a **dynamic investment landscape** with both the private sector and public actors (authorities, agencies etc.) actively engaged.

Venture capital investment has become pronounced in the tourism and travel tech segment and has been growing over the last decade. Tech firms that provide an **environmental service or green technology** to the tourism industry **attracted an estimated €319 m venture capital and private equity investment in 2022**. Over the same period, **digital technology firms specialised in tourism had received and estimated €1 bn** according to the analysis of Crunchbase and Net Zero Insights data.

Regarding foreign direct investment (FDI), in the period from 2015 to 2022, the EU27 had a volume of **€18.4 bn intra-EU, €18 bn inward and a much higher volume of €44 bn outward FDI**. A low number of projects notably only **23 were related to research, development and ICT**. These projects include digitalisation of services at new headquarters or offer new online travel services. Again, a **very low but growing number of the projects are related to the green transition**. This group includes projects that invest for instance in new hotels that comply with the specifications of a sustainable building or deliver organic food.

Public funding plays a key role in fostering the twin transition of the tourism ecosystem at national, regional and EU level. One of the important instruments is the **Recovery and Resilience Facility (RRF) that helps also developing the tourism industry by fostering both green and digital investments**.

The results of the analysis show that public procurement in the tourism industrial ecosystem in the EU27 from 2014 to 2023 amounted to approximately €92.94 bn with traditional procurement notices on supplies and services being the primary focus. **Green and digital public procurement had limited representation, with only 2.93% (€2.7 bn) of the total tourism procurement value related to the twin transition**.

The Horizon 2020 programme funded **544 projects** with direct linkages to tourism and had a total funding of **€2.12 bn** in the period **2014-2020**. More specifically, €228 m was spent on the green transition and €873 m on the digital transition of tourism related activities.

Public and private funding plays a key role in enhancing the competitiveness of the tourism industry and facilitate a positive transformation influenced both by digital technological trends and environmental challenges as presented in the previous chapters. Company investments are instrumental in order to secure appropriate infrastructure and develop new services. At the same time active policies are needed to set the requirements towards environmental objectives and enhance the business environment for sustainable tourism.

The tourism industry has been increasingly investing in new services that address changing consumer behaviours¹⁰³ and besides hard investment in accommodation infrastructure targeted also digital solutions and support services around experiences and sustainability.

Most tourism businesses saw a great challenge in continuing investments during the tough years of the Covid-19 pandemic and the geographical tensions arisen in 2022. As a result of the various recent constraints¹⁰⁴, industrial stakeholders are currently rethinking their operating models creating a momentum for change.

¹⁰³ <https://www.unwto.org/investment/unwto-investment-guidelines-SA1>

¹⁰⁴ European Commission (2022). Tourism transition pathway

In this report, investment data have been captured from various sources. On the side of private investments, we present data on private equity and venture capital investment and foreign direct investment. Public investments are analysed based on public procurement data and investigating Horizon R&D funding. The scale of venture capital and private equity investment in green and digital tourism startups has been calculated using data from the Net Zero Insights and Crunchbase sources already presented above¹⁰⁵.

4.1 Venture capital and private equity investment

Venture capital (VC) investment has become more and more pronounced in the tourism and travel tech segment over the last decade¹⁰⁶ despite the fact that tourism startups in general are much less targeted by VCs than other economic segments such as automotive or retail. The analysis of Net Zero Insights and Crunchbase allows to capture investment information and funding rounds of startups and innovative companies active in the tourism industrial ecosystem. Tech firms that develop digital technologies and environmental sustainability solutions have been linked to the tourism industrial ecosystem following their industrial classification and key words-based search within the business descriptions. The investment figures presented in this section refer only to the funding rounds where a value has been disclosed.

Tourism and travel tech companies with an environmental focus had a sharp increase in terms of venture capital and private equity investment with a total amount of €3.8 bn between 2015-2022. Sub-fields that attracted the largest investment include green transport solutions, food waste recycling, and booking of sustainable tourism services. Some examples are presented below. Investments into green technology peaked in 2021 and venture capital funding in the early stage shows continuous growth.

Examples include Lilium that develops emissions-free regional air mobility service, and raised a total of €890m in funding over 8 rounds; TravelCar that offers parking, rentals and car sharing for travellers and raised a total of €20.8 m. Another interesting example in the field of mobility is the German Volocopter, an urban air mobility service provider that develops battery-powered, zero-emission electric air taxis. With VoloCity, the company is developing the fully electric vertical take-off and landing aircraft that can transport passengers within cities.

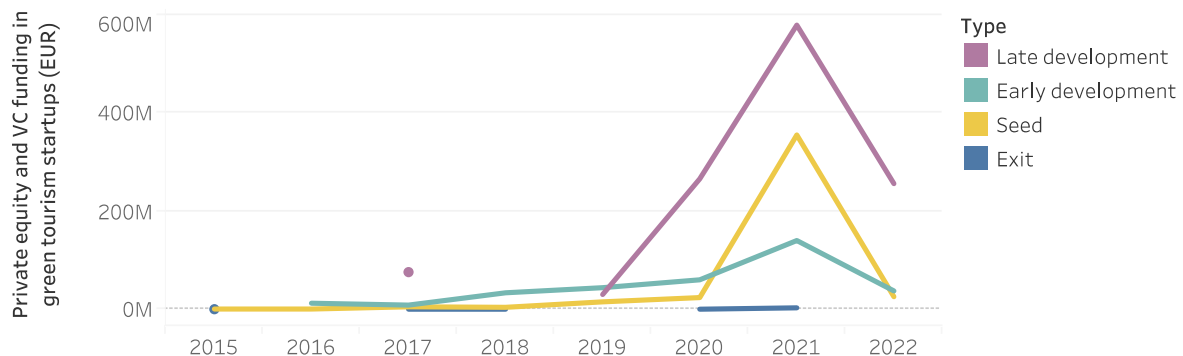
Besides transport, other VC deals included the one into Campspace¹⁰⁷, a Dutch startup that created an online platform for environmentally sustainable outdoor stays. It enables the sharing of outdoor space with a new generation of conscious travellers. A further example in the field of food waste is VersTrade¹⁰⁸ that an online food marketplace connecting food suppliers and food professionals, thus facilitating a short food supply chain. VersTrade has raised a total of €2 m in 1 Series A round in 2021.

¹⁰⁶ <https://www.unwto.org/investment/unwto-investment-guidelines-SA1>

¹⁰⁷ <https://campspace.com/en>

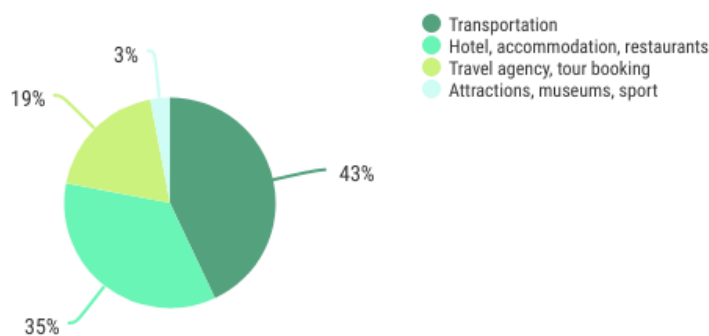
¹⁰⁸ <https://www.verstrade.nl/>

Figure 26: Annual venture capital and private equity investment into tech firms with an environmental focus active in tourism



Source: Technopolis Group calculations based on Net Zero Insights, 2023

Figure 27: Share of VC investments into the green transition per industry within the tourism ecosystem



Source: Technopolis Group calculations based on Net Zero Insights, 2023

Digital technology-based companies active in tourism received €6.1 bn venture capital and private equity investment between 2015-2022 as indicated by the analysis of Crunchbase. With a new peak in 2021, VC into the tourism industry and more specifically in digital technologies has slowed down. The most dynamic segment has been online travel booking, ticketing and online marketplaces that ease travel planning. Smart ticketing eases the use of travel services and access to tourist attractions including mobile payments and transparent ticket validation. Investment into the tourism industrial ecosystem has included several recent mega rounds and unicorn valuations most of them in transportation¹⁰⁹.

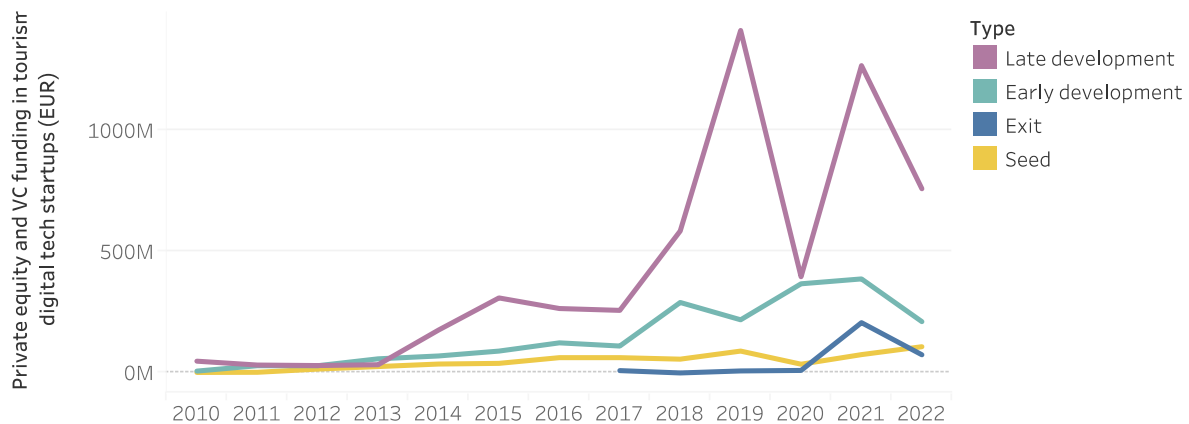
Examples of some of the highest investment rounds between 2015-2022 include the following:

- FlixBus has raised a total of €1.1 bn in funding over 7 rounds. Their latest funding was raised in 2021 from a Series G round.
- GetYourGuide has raised a total of €828 m in funding over 12 rounds. Their latest funding was raised in 2021 from a Debt Financing round.
- Omio offers a multi-mode search tool that compares and combines rail, air, bus, and car for destinations. It raised a total of €400 m in funding over 10 rounds. Their latest funding was raised in 2022 from a Series E round.
- TravelPerk has raised a total of €390 m in funding over 9 rounds. Their latest funding was raised in 2022 from a Series D round.

¹⁰⁹ See also the analysis of UNWTO, World Tourism Organisation (2021). Travel and Tourism Tech Startup Ecosystem and Investment Landscape

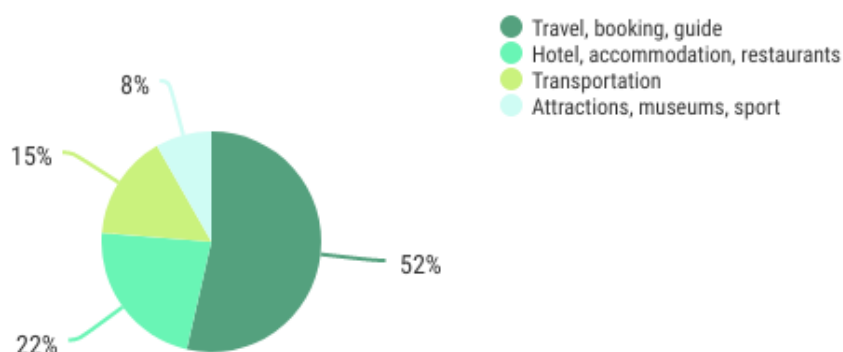
The investment landscape is also affected by global distribution systems that allow transactions between travel service providers and connect hotels, airline-, railroad- and public transportation, car rentals, and tourist attractions. In the EU, Amadeus provides such a transaction processing power and technology solution to both service providers and travel agencies¹¹⁰. Amadeus went public in 2010 and since then made 9 investments in a diverse set of companies ranging from food services to digital identity.

Figure 28: Annual funding of digital tourism tech startups since 2010



Source: Technopolis Group calculations based on Crunchbase and Net Zero Insights data, 2023

Figure 29: Share of VC investments into the digital transition per industry within the tourism ecosystem



Source: Technopolis Group calculations based on Crunchbase and Net Zero Insights data, 2023

4.2 Intra EU and extra EU foreign direct investment in tourism

fDi intelligence¹¹¹ tracks cross-border greenfield investment¹¹² both intra EU, extra EU and globally, covering the tourism industrial ecosystem among other industries. It provides real-time monitoring of investment projects, capital investment and job creation with powerful tools to track and profile companies that are active investors in the field. The data source tracks projects that are expected to create new jobs and do not cover merges and acquisitions (already part of the venture capital data analysis above).

¹¹⁰ <https://www.crunchbase.com/organization/amadeus>

¹¹¹ <https://www.fdiintelligence.com/>

¹¹² "A green-field (also "greenfield") investment is a type of foreign direct investment (FDI) in which a parent company creates a subsidiary in a different country, building its operations from the ground up." Investopedia

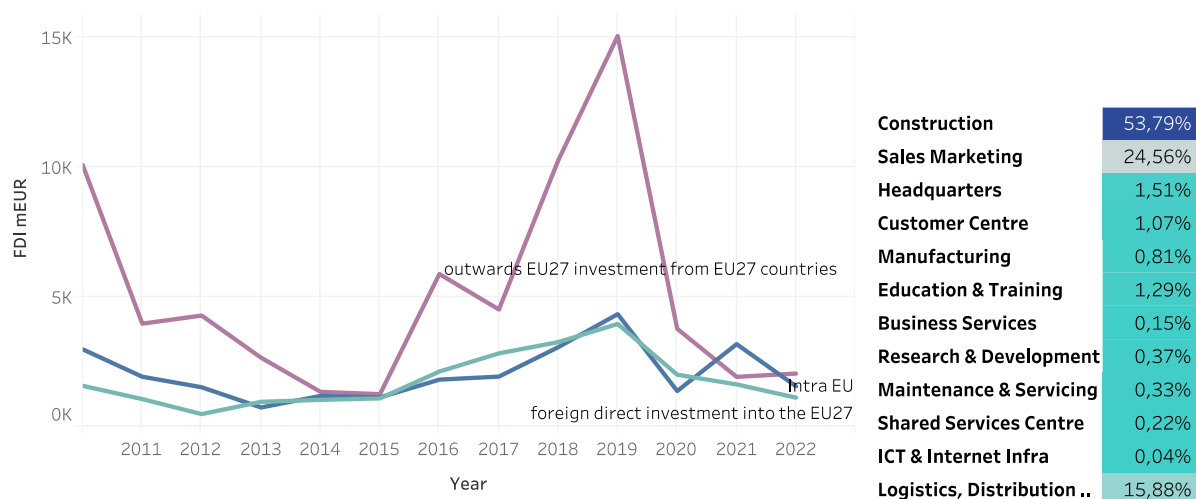
In the period from 2015 to 2022, the EU27 had a volume of **€18.4 bn intra-EU, €18 bn inward and a much higher volume of €44 bn outward foreign direct investment**. Until 2019, the ecosystem had a high FDI going out from the EU27 into third countries that dropped drastically with the start of the Covid-19 pandemic. Since then, investment levels have been slowly recovering, in particular intra-EU trade saw a relatively stronger increase in 2021. The EU27 countries' outward foreign investments has stayed so far significantly below the level of the past decade's average.

The investment projects include various activities: **54% of the projects are related to hotels, 23% to transportation** (including land, water and air), **13% to travel arrangement, 5.2% to food services and 3.8% to leisure activities** (3.2% performing arts and sports and 0.6% museums and historic sites). More specifically, 55.18% of the projects include construction of tourism infrastructure, 23% sales and marketing and 16% are about logistics. It can be observed that the majority of FDI projects are new, while only a lower share related to expansion.

A low number of projects notably only **28 were related to research, development and ICT**. These projects include digitalisation of services at new headquarters or offer new online travel services.

Again, a **very low but growing number of the projects (15) are related to the green transition**. This group includes projects that invest for instance in new hotels that comply with the specifications of a sustainable building or deliver organic food.

Figure 30: Foreign direct investment in the tourism industrial ecosystem



Source: Technopolis Group based FDIIntelligence data, 2023

Some of the recent FDI investment projects have been the following:

- 'Zleep Hotels', a hotel management company and a subsidiary of Germany-based Deutsche Hospitality, has announced the creation of jobs in 2022 to operate the new 'Zleep Hotel Madrid' in Spain. The hotel's core value is sustainability with various service offers from reduction of food waste, abandoning the use of plastic bottles, to sustainable building.
- France-based 'Le Collectionist' is an online vacation rental platform for homes. It will expand its team based in Barcelona (Spain) as announced in 2022. This follows a €60 m funding round from several VC and angel investors, targeting expanding the company's headcount by 120 people in 2023.
- Poland-based Restaumatic provides an online food ordering system and has opened a new office in Berlin, Germany in 2022.
- Netherlands-based Tiqetsn offers a global online ticketing platform for cultural venues and attractions and the company invested in Spain.

Within the EU, **Spain has been the most important source and also destination of investment within the EU**, attracting €7.9 bn in capital investment into tourism and investing €19.2 bn in other countries between 2015 and 2022, followed by Germany and Italy.

4.3 Public investments

In the field of tourism, public investments are instrumental. At EU level, the **Recovery and Resilience Facility** (RRF) helps developing the tourism industry fostering both green and digital investments. As presented in the Guide on EU funding for tourism¹¹³, several EU funding programmes such as Horizon Europe, Creative Europe, Digital Europe etc. support tourism development, sometimes with shared management with national and regional authorities. The **European Regional Development Fund** supports tourism via its operational programmes available in each country also co-financed by national and regional funding. Countries also have their own national budgets (or regional/federal budgets depending on the institutional governance of countries) for tourism to encourage investments and innovation. Within the recovery and resilience plans, several examples can be highlighted:

- The Italian RRF allocated €6.7 bn¹¹⁴ to the objective of tourism and culture 4.0 and more specifically €500 m to a thematic fund for tourism¹¹⁵. The objective is to facilitate digitalisation and sustainability. Investments include green building and energy-efficient modernisation of facilities and infrastructure, innovation and digitalisation projects including also sustainable mobility.
- France plans to spend €1.9 bn of its Recovery and Resilience Funds for tourism in collaboration with industry professionals and local authorities¹¹⁶. €50 m are made available for a dedicated sustainable tourism programme¹¹⁷.
- Croatia earmarked €292 m for the development of sustainable, innovative and resilient tourism that represents 4.6% of the national Recovery and Resilience Plan¹¹⁸.
- Spain set up the so-called 'Tourism Modernisation Plan' with an envelope of €3.4 bn¹¹⁹. The Spanish sustainable tourist destination programme 2021-2023 is a mechanism set up between the Government of Spain and the European Commission to support tourist destinations in their transformation towards environmental, socio-economic and territorial sustainability, and to help them develop resilience strategies against new sector challenges, such as climate change, excess tourism demand or health and safety crises.
- Bulgaria supports the energy transition of the tourism industry via its Recovery and Resilience Plan measure called 'Support for sustainable energy renovation of the non-residential building stock – including buildings in the tourism sector'. The planned resource envelope is €315 m (BNG 617.7 m)¹²⁰.

¹¹³ https://single-market-economy.ec.europa.eu/sectors/tourism/eu-funding-and-businesses/funding-guide_en

¹¹⁴ [https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/698847/EPRS_BRI\(2021\)698847_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/698847/EPRS_BRI(2021)698847_EN.pdf)

¹¹⁵ <https://www.eib.org/en/press/all/2023-102-pnrr-il-ministero-del-turismo-e-la-bei-lanciano-il-fondo-tematico-per-il-turismo>

¹¹⁶ https://www.diplomatie.gouv.fr/IMG/pdf/destinationfrance_cle0f5dc4.pdf

¹¹⁷ https://medblueconomyplatform.org/wp-content/uploads/2022/10/2022_handbook_eu_funding_sustainable_tourism_2022.pdf

¹¹⁸ [https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/733580/EPRS_BRI\(2022\)733580_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/733580/EPRS_BRI(2022)733580_EN.pdf)

¹¹⁹ https://www.lamoncloa.gob.es/temas/fondos-recuperacion/Documents/160621-Plan_Recuperacion_Transformacion_Resiliencia.pdf

¹²⁰ https://commission.europa.eu/business-economy-euro/economic-recovery/recovery-and-resilience-facility/recovery-and-resilience-plan-bulgaria_en

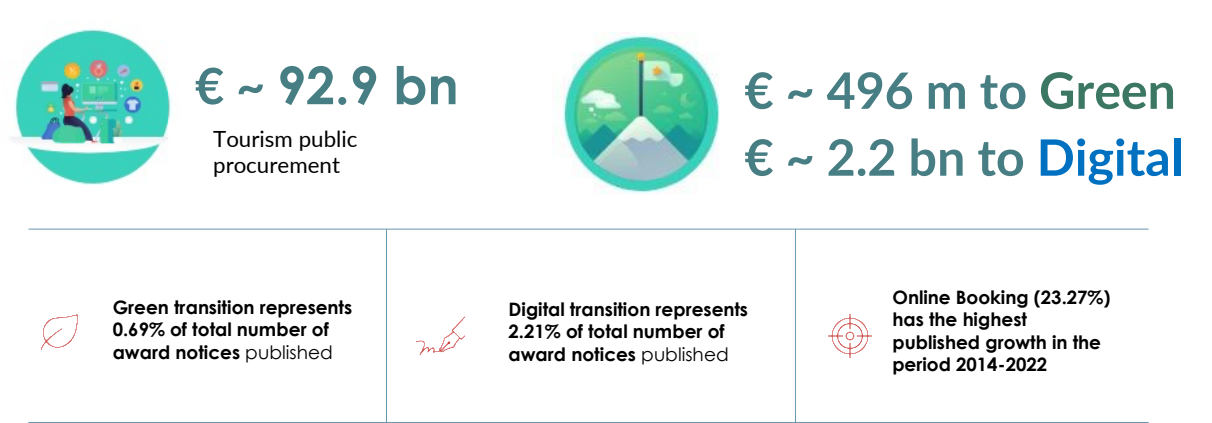
4.4 Public procurement increasingly used to support the twin transition of tourism

A specific form of public funding that has a potential to foster innovation is public procurement. Public procurement can drive demand for eco-friendly products and services that respect the environment, as well as foster the digital transition by procuring digital services. In tourism, destination management organisations - often including public authorities and government agencies - have a decisive role in the future development of a tourist destination. They can drive the green and digital transition by procuring efficient electrical appliances, sustainable and organic food and beverages, items made of recycled plastics instead of a single use, data analytics services just to highlight some examples. They can also procure training and capacity building activities for local tourism professionals that enhance local skills in digital applications or about the circular economy.

To monitor the twin transition in public procurement, the procurement awards of relevance to the tourism industrial ecosystem and specifically the green and digital products, goods and services procured have been filtered for. The approach was based on a combination of the Common Procurement Vocabulary (CVC) classification system and a selection of key-terms (see Appendix B). The main source for this analysis has been the Tenders Electronic Daily, the online version of the 'Supplement to the Official Journal' of the EU, dedicated to European public procurement. The period in focus has been 2015 until today (May 2023) which allowed an analysis over time including up to date information.

The results of the analysis show that public procurement in the tourism industrial ecosystem in the EU27 from 2014 to 2023 amounted to approximately €92.94 bn with traditional procurement notices on supplies and services being the primary focus. Green and digital public procurement had limited representation, with only 2.93% (€2.7 bn) of the total tourism procurement value related to the twin transition.

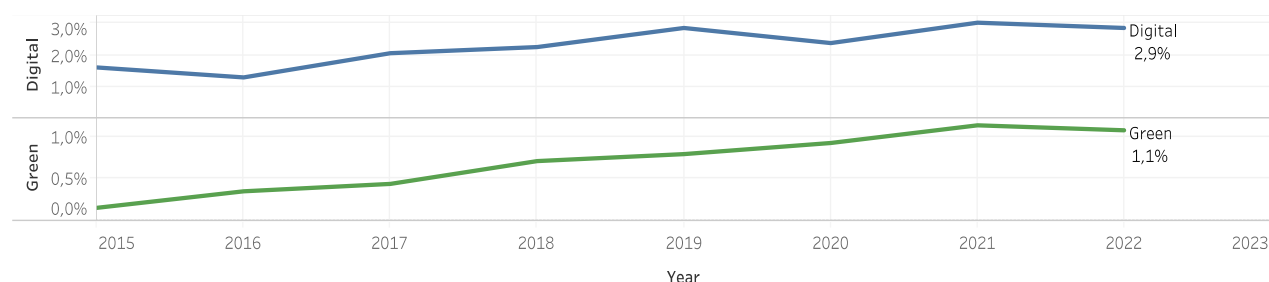
Figure 31: Public procurement in the tourism industrial ecosystem and related to the green and digital transition



Source: Technopolis Group, May 2023 based on analysis of TED

The data shows that transition award notices' value have grown on an annual average at 8.09% between 2014 to 2022, (digital at 5.09% and green at 58.02%).

Figure 32: Share of procurement notices with a green or digital transition related objective within total public procurement of the tourism industrial ecosystem



Source: Technopolis Group, May 2023 based on analysis of TED

The procurement notices indicate that the green transition is mainly driven by local and regional authorities, while the digital transition by public destination management organisations:

- Local or regional authorities have procured the highest value within the green transition related award notices with €163.2 m (30.24%), followed by bodies governed by public law.
- Bodies governed by public law such as public destination management organisations libraries, museums have procured the most digital transition related goods and services, with €1.4 bn (36.21%), followed by central government authorities at €1.3 bn (34.01%).

In the green transition award notices, procurement of services related to waste management, energy-efficiency and renewable energy to be implemented by companies in the tourism industry are the most prominent. For example, procuring training services in renewable energy is one way to promote the green transition in tourism. Procurement practices that address the circular economy have been also increasing. This includes services for shared transport services and waste management facilities with take-back provisions.

It is also evident that procurers put a high value on tools and certificates available for public procurers in the green public procurement process (as part of green public procurement manual), with the value of award notices standing at 26.19% and 10.86% of the green award notices. More specifically, **eco-certifications (ISO, EMAS and Eco-label) when procuring hotel, accommodation and catering services** were specifically requested in 7.49% of the green award notices. Other tools, such as life cycle costs and assessment only account for 1.24% of the green award notice value and are required as a qualification in 3.37% of the green award notices.

When analysing the digital transition related award notices, the findings provide evidence that procurers request most often **online software programming and consultancy services and data services**.

They are also interested in services for tourism with online booking (8.49%), online platforms (3.08%), mobile apps (2.43%) and online multimedia (0.19%) accounting for approximately 14.19% of digital award notices between 2014-2023 and approximately 32.59% of the value.

Table 2: Public Procurement – examples of green and digital transition procurement notices

Green Transition

Archipelago National Park, Tuscany Italy

The national park procured the management of environmental education services and sustainable tourism services.

Hotel accommodation services, Italy –Rome

Assignment in multi-service concession (guesthouse, restaurant, bar, pizzeria, cleaning of premises, reception, entertainment etc.). A specification to be able to apply is that they have the EMAS certification or ISO 14001.

Department of Culture, Heritage & the Gaeltacht, Ireland

Procurement for a natural resources management and conservation strategy in species and habitat management

Digital Transition

Library and archive services for the National Library of Ireland: The National Library of Ireland procured for web archiving of items through gathering, safeguarding, and provide access to the documented history of Ireland, encompassing various materials such as books, manuscripts, newspapers, prints and drawings, ephemera, photographs, maps, music, and born digital collections.

Travel agency and similar services for Adetef, France: A procurement for services that include air and rail ticket reservation and delivery, travel insurance, visa issuance, accommodation reservation, seminar and conference room rental, airport transfer services, insurance coverage for in-patriates and repatriation, vehicle rental, taxi reservation, restaurant reservation, online booking platform setup, and the implementation of a mission management tool.

Technical Museum Vienna, Austria: Procurement for the planning and implementation of the robotics and artificial intelligence museum exhibition.

Source: Technopolis Group, based on TED, 2023

It should be noted, that while the approach and tools used are robust in being able to scrape the information off the main publication of the contract award notice, we are not able to access the specifications of the award notices that are usually provided in further documents. Given this, we expect that the volume and value of the contract award notices to be higher in reality. A survey conducted by the College of Europe in 2012 found that at least 26% of procurement notices contain at least one criteria of Green Public Procurement,¹²¹ one could safely assume that the number has grown since then.

4.5 EU research and development funding in tourism

The Transition Pathway of the Tourism industrial ecosystem highlighted the need for research and innovation that can boost the circular tourism economy. It also pointed out the role of Horizon Europe funding that provides support for the green and digital transition of the ecosystem. Horizon 2020 was the European Union's multiannual research and innovation programme for the period 2014-2020 followed by Horizon Europe and it plays an important role in fostering technology development and innovation. In this report, Horizon 2020 data has been analysed regarding R&D investments into the digital and green transition of the tourism industrial ecosystem based on the programme's data from the Community Research and Development Information Service (CORDIS).

In the analysis only projects with a direct link to tourism were selected as a result of the participation of a tourism stakeholder or due to the application of the technology in the tourism industry or because of the industrial ecosystem definition which includes transport (air, water, land).¹²² To analyse the relevant projects from the Horizon 2020 projects, a

¹²¹ <https://ec.europa.eu/environment/gpp/pdf/CEPS-CoE-GPP%20MAIN%20REPORT.pdf>

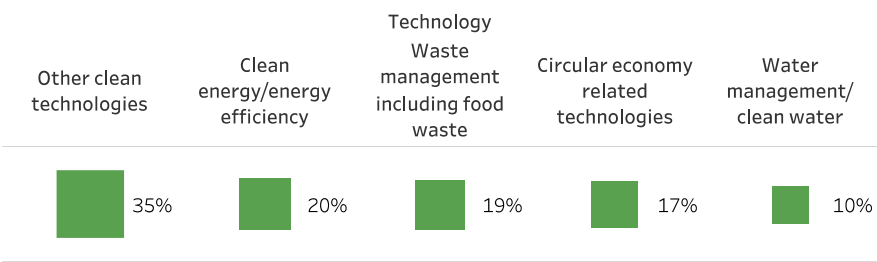
¹²² For the complete definition of the Tourism industrial ecosystem see section 2.1.

search based on a selection of key words were applied in the abstracts of the projects, for further detail please see the Appendix B and the methodological report). The identified projects target explicitly tourism, cultural heritage, tourist attractions or transport.

This analysis found that the Horizon 2020 programme **funded 524 projects** with direct linkages to tourism and had a total funding of €2.12 bn in the period 2014-2020. More specifically, **€228 m was spent on the green transition and €873 m on the digital transition of tourism related activities.**

Regarding the green transition, Horizon 2020 projects supported the development of clean energy, energy efficiency, waste management, the circular economy, and other clean technologies.

Table 3: Horizon 2020 - green transition related projects



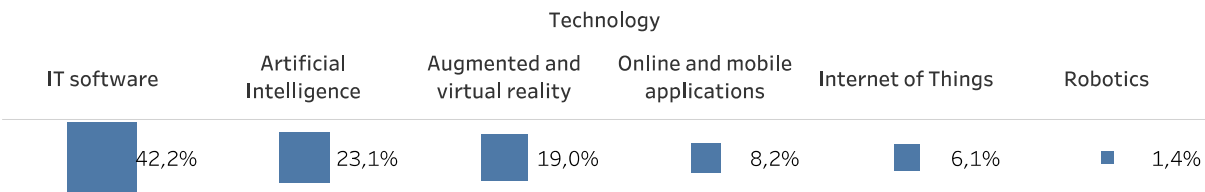
Source: Technopolis Group based on CORDA, 2023

Examples on green transition include:

- Projects on renewable energy include the example of SnowRESolution, a green snowmaker powered by renewable energy sources. SnowRESolution addresses the market of ski resorts that want to guarantee the production of snow also when ambient temperature is above 0°C.
- Projects on sustainable technologies relate to waste management practices. An example is the application of a holistic waste management methodology demonstrated in touristic coastal cities.
- Food waste is also a topic such as the development of a technology that transforms used cooking oil to advanced biofuel or aeroponic technology eliminating food waste.
- Several projects address marine waste. The development includes unmanned marine litter collection and treatment vessel that treats waste thermally with plasma technology without harmful emissions.
- Other, non-technology related projects include awareness-raising and strategy development around sustainable and circular tourism. The objective is to move away from a “stop-and-go” consumer-oriented approach and focus on nature, communities and cultural diversity.

In the field of the digital transition, the most common technologies found are artificial intelligence and IoT.

Table 4: Horizon 2020 - digital transition related projects



Source: Technopolis Group based on CORDA, 2023

Examples of digital transition related projects include:

- **Online platforms for hospitality** that integrate smart room solution and a mobile application and thus offering improved customer service. Projects of online applications also include travel booking systems that guarantee accessibility also to people with disabilities.
- Projects in **artificial intelligence** have various applications in tourism ranging from **cultural heritage** (through a user-centred co-creation setup for analysing and linking music data at scale with festival visitors giving feedback on algorithmic results, and annotating the data according to their personal expertise) to **navigating tourists to a desired location in a museum or a church** (through algorithms which allow one to recover the motion of a camera and a 3D reconstruction of the observed environment at unprecedented precision, robustness and large-scale capability) and to **addressing understaffing** in hospitality or airports (through a robot able to autonomously approach and engage in conversation, reacting to emotions).
- Projects in **connectivity** with direct impact on tourism include for instance those related to installation of Wifi/5G on public transport for tourists or improving safety on public transport.
- **Robotics technology** has been developed in the framework of a project supporting rescue organisations in mountains and increase the safety of mountain tourism. Robotic aerial technologies can help localise persons buried by avalanches.
- Projects related to **destination management** are limited but an interesting example includes a decision support system technology which aims to provide a comprehensive measurement framework for supply, demand and impacts. The system is developed for wide-scale monitoring purposes across European regions and synthesizes both traditional and non-traditional data sources, the latter particularly related to big data analytics, thereby assisting smart regional development.

5 Skills demand and supply

Key findings

The tourism industry is a labour-intensive industry requiring a combination of organisational, communication, management skills but also increasingly digital and environmental skills from the employees.

Within the registered professionals on LinkedIn employed in the tourism industrial ecosystem, **1.8% indicated to have one type of green skill, 15.4% to have a moderate digital skill and 2% advanced digital skills. Among the green transition related skills**, we find most often environmental management competences and skills necessary to comply with environmental standards. Other skills that have been monitored include the circular economy that includes skills necessary for the **management and recycling of waste** - a particular concern for the industry. Other important green skills include the low carbon challenge and energy management. The most relevant digital skills that tourism employees cite on their LinkedIn profiles include digital marketing and online platforms. Among the advanced digital skills the most relevant are **cloud technologies and big data**.

Specific to the tourism industrial ecosystem, **the share of online job advertisements that required any form of moderate digital skills (excluding basic IT office skills) was 34% over the period from 2019-2022, while this percentage was 17.09% for advanced digital skills**. Requirements related to the green transition appear less often on the advertisements notably in **1.91% of the cases**.

Figure 33: Share of online job advertisements requiring a skill relevant for the green and digital transition



Source: Technopolis Group calculations based on Cedefop data, 2023

The most requested digital skills on online job advertisements included computer programming and database management, while green skills were related to sustainable transportation and waste management in 2022.

Although comparing LinkedIn and the Cedefop data is not possible due to the different classifications and approach applied, nevertheless the findings suggest that **there is a particular gap in the demand for moderate digital skills and the actual number of professionals possessing such skills**.

The 'Transition pathway for tourism' recognised four key groups of skills necessary for the green and digital transitions and improving resilience of the tourism ecosystem:

- Green skills (elements of environmental sustainability, policy requirements, methods for resource efficiency)
- Digital skills (ICT user skills, ICT business innovation skills, and ICT developer skills including data skills)

- Entrepreneurship skills (marketing, budgeting, innovation)
- Governance and strategic skills (administration, strategy development, human resources)

These skills are intertwined, and tourism organisations and competitive companies need them all to be able to face our changing global socio-economic and climate context. Efforts to increase digital and green skills are challenged with the highly seasonal character of the sector where employees are hired for short-term contracts and small and micro companies are common¹²³. In addition, Cedefop¹²⁴ analysis of job advertisements highlighted the importance of soft skills (teamwork, communication, adaptability) which are needed to innovate new service offerings and environmental-friendly business models, stay resilient and adopt a system-approach towards sustainability where collaboration is key. Moreover, local and regional measures towards skills development will be crucial due to the fact that tourism jobs are locally anchored¹²⁵. In order to add further insights to the discussion about skills in tourism, this report explores the results from LinkedIn and online job advertisement data. These data sources have been analysed to reflect about skills supply and demand in the field of the twin transition.

5.1 Skills supply for the green and digital transition

This section aims at analysing trends in the supply of skilled professionals relevant for the green and digital transition based on LinkedIn data. LinkedIn is the largest professional network platform with rich information like profile summary, job title, job description and field of study, which can be used for the identification of skilled professionals in advanced technologies and both in digital and green transition. It represents the single most comprehensive source currently available for technology-specific skills related indicators. To harvest the data from LinkedIn, keywords capturing skills by advanced technology have been defined and reviewed by technology experts. Queries have subsequently been constructed to filter the database by location and industry. For the skills analysis of the tourism industry the following LinkedIn tags have been used: 'Hospitality', 'Restaurants', 'Recreational Facilities & Services', 'Gambling & Casinos', 'Leisure, Travel & Tourism', 'Museums & Institutions', 'Airlines/Aviation'. In order to capture the number of professionals working in the sector, occupations related to the tourism industrial ecosystem have been taken into account. In 2023 there were 3 985 406 professionals registered on LinkedIn and belonging to the tourism industrial ecosystem in the EU27.

Green transition related skills follow the definition of Cedefop and mean “*the knowledge, abilities, values and attitudes needed to live in, develop and support a sustainable and resource-efficient society*” (Cedefop, 2012). In this study, green skills have been defined as skills related to environmental protection, environmental services, resource efficiency, biodiversity, low carbon technologies, renewable energy, the circular economy, waste management, management of food waste, and clean production technologies and business models related skills (the list of keywords that have been used and are possible to track with the algorithm of LinkedIn is included in Appendix B).

Moderate digital skills include the monitoring of basic and other digital skills. Cedefop distinguishes “*five types of skills under the digital skills umbrella such as information processing (e.g. using a search engine and storing information and data); communication (including teleconferencing and application sharing); content creation (such as producing text and tables, and multimedia content); security (e.g. using a password and encrypting files); and, problem solving (e.g. finding IT assistance and using software tools to solve problems)*”. Specific for tourism, we included a list of skills that are related to data analytics, tourism flow management, online platforms, digital payment systems and

¹²³ <https://www.oecd.org/coronavirus/policy-responses/tourism-policy-responses-to-the-coronavirus-covid-19-6466aa20/>

¹²⁴ https://www.cedefop.europa.eu/files/3072_en.pdf

¹²⁵ Transition Pathway for Tourism - European Commission

delivery systems. (The list of keywords that have been used and are possible to track with the algorithm of LinkedIn is included in Appendix B).

Advanced digital skills have been defined as a specific group of digital skills in the context of the main digital technologies captured in this project notably in artificial intelligence, cloud computing, connectivity, robotics, Internet of Things, augmented and virtual reality and blockchain (the list of keywords that have been used and are possible to track with the algorithm of LinkedIn is included in Appendix B). LinkedIn data have to be interpreted in the light of its representativeness for tourism and across the EU. An analysis of representativeness is provided in Appendix B and in the related methodological report.

Based on the analysis of LinkedIn data, Figure 31 provides a picture about the supply of professionals with green and digital technological skills relevant to the tourism industrial ecosystem.

Within the registered professionals on LinkedIn employed in the tourism industry, this analysis found that

- **1.8%** professionals in tourism indicate to have one type **of green skill**
- 15.4% a moderate digital skill and
- **2% advanced digital skill** (including AI, big data, cloud IoT, robotics, augmented and virtual reality, blockchain and cybersecurity).

The share of professionals with green skills is particularly low compared to other industrial ecosystems. This confirms the statement made in the scenarios towards the co-creation of transition pathway for tourism¹²⁶ that *"there is a lack of sufficient skills and resources to develop business innovations around sustainability objectives"*. **Top green transition skills are related** first of all to the circular economy that includes skills necessary for **the management and recycling of waste** - a particular concern for the industry. Other important green skills include the **low carbon challenge and energy management**. A key skill group for green transition in tourism are business innovation skills for developing environmentally friendly and attractive tourism service models.

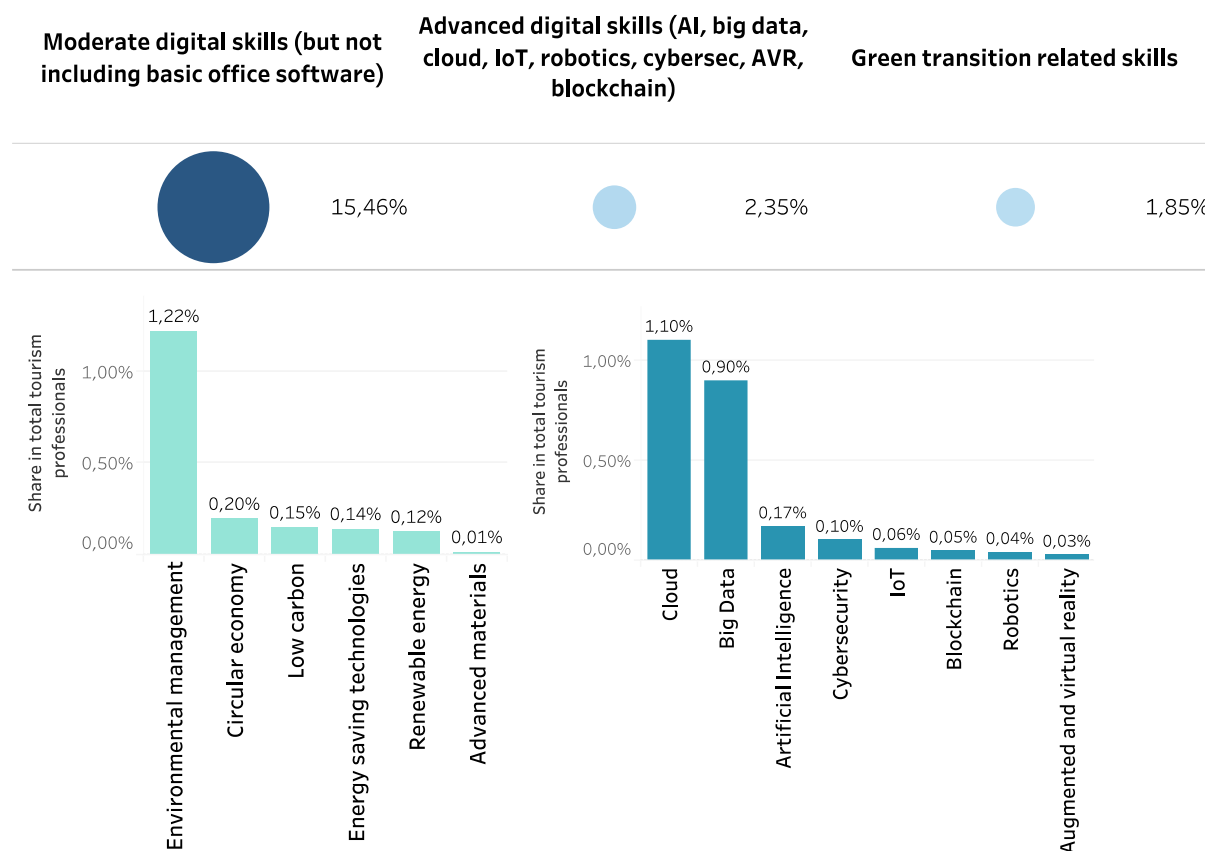
The detailed analysis per technology/green transition related skills is presented in the Figure below.

With regard to the green transition, the most wide-spread skill referenced on LinkedIn profiles was related to a more general category called 'environmental management' including environmental standards, environmental engineering, environmental protection, environmental impact assessment etc. **Circular economy related skills are also very low and appear only on 0.2% of the profiles**. As a further example, ecotourism was referenced on 0.03% of the profiles which is insignificant. Even if we keep in mind that not all tourism professionals are on LinkedIn or update constantly their profiles, these low shares are of concern.

Capacities in the field of digital technologies are higher but are still among the lowest compared to other industrial ecosystems. The most relevant digital skills that tourism employees cite on their LinkedIn profiles are **advanced software and cloud technologies**. Advanced digital technologies such as AI, IoT or robotics related skills are very low among tourism professionals, although their adoption could automate existing processes and free up time for higher-value interactions.

¹²⁶ <https://ec.europa.eu/docsroom/documents/45977>

Figure 34: Share of professionals with green and digital skills within the tourism industrial ecosystem in the EU27 and with a profile on LinkedIn

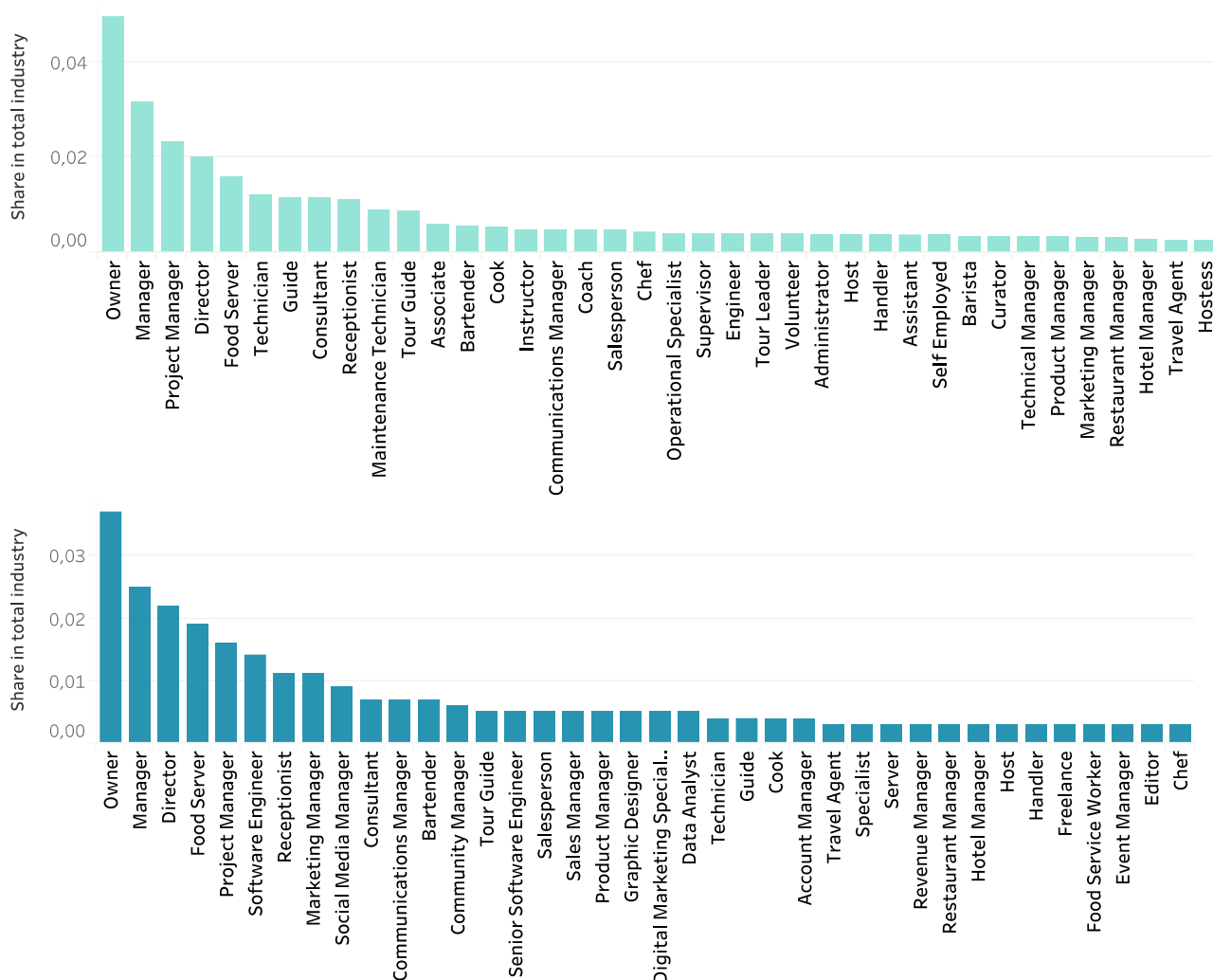


Source: Technopolis Group calculations based on LinkedIn, December 2023

Eurostat data provide further insights into the share of enterprises that employ ICT specialists, although it has to be noted that Eurostat captures the share of enterprises with and ICT specialist profile, while LinkedIn data above captures the share of employees with digital skills within the total number of employees in tourism that are two different metrics. Having said that, Eurostat shows that in accommodation and food services activities **8.1% of firms with 10 employees or more had ICT specialists in 2022**, while this share was **34.6% in the case of travel agency, tour operator** and other reservation service and related activities. Indeed, although green and digital skills are important not necessarily all types of employees need advanced skills in all domains especially in the field of advanced digital technologies (where just certain positions fill in this role) or as in the case of green skills, companies might not hire professionals but instead engage third-party environmental service providers.

In order to nuance the picture as presented above from LinkedIn, we provide below an analysis also at the level of the types of positions. Figure 32 indicates which are the positions with the highest share of professionals in green or digital skills as captured via LinkedIn data.

Figure 35: Type of positions with green transformation and digital transformation skills in tourism in the EU27



Source: Technopolis Group calculations, 2022

The total number of professionals in tourism and with a profile on LinkedIn has decreased over time and in particular during the pandemic period, which is in line with official statistical figures. LinkedIn suggests that there were 1% less professionals in tourism registered on their platform in 2023 than in 2022. Compared to this, the share of professionals with digital or green skills has witnessed a steady growth in the past two years.

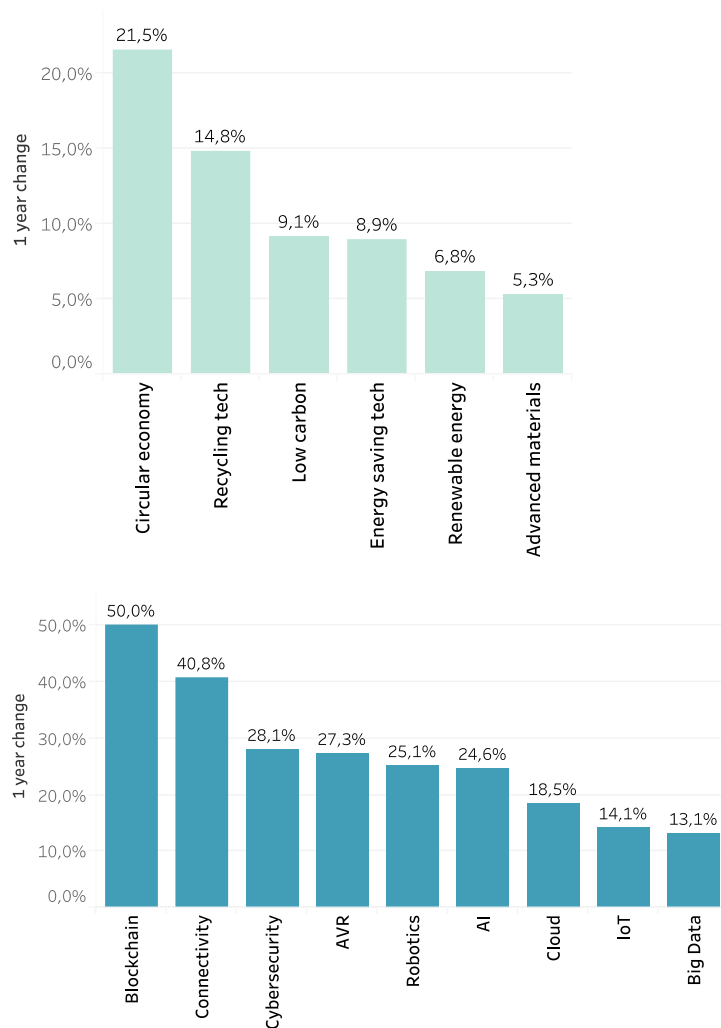
There have been 20% more professionals in the tourism industrial ecosystem claiming to have an advanced digital skill and 17% more with a green transformation skill in 2022 than in 2021. In a broader context, available Eurostat figures show that the number of ICT specialists in the EU grew somewhat between 2017 to 2022 in the field of 'Accommodation and food services' (from 7.7% in 2015 to 8.1% in 2022) and remained more or less constant in the field of 'Travel agency, tour operators'¹²⁷ (employed in companies with 10 persons or more).

¹²⁷

https://ec.europa.eu/eurostat/statistics-explained/index.php?title=ICT_specialists_in_employment,
https://ec.europa.eu/eurostat/databrowser/view/ISOC_SKE_ITSPEN2_custom_7446783/default/table?lang=en

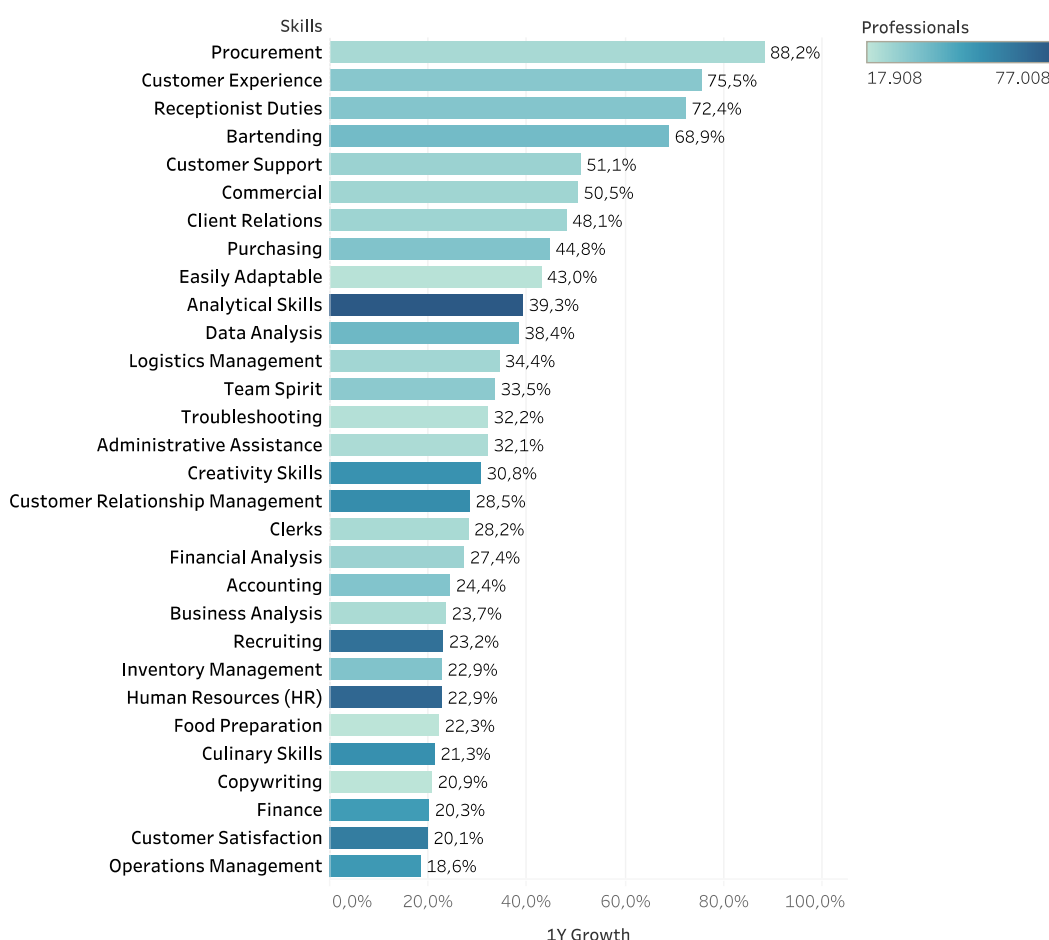
Figure 33 visualises the green and digital skills that showed the highest growth over the period from 2021 to 2022 among EU27 countries. In the field of digital technologies, we see augmented and virtual reality on top followed by big data and artificial intelligence related skills and also to some extent the Internet of Things. In the field of green skills, the broader category of the circular economy has witnessed an increase driven by patterns in recycling and waste management. In the case of energy saving technologies and renewable energies there is a sharp increase to be observed from 2018-2022.

Figure 36: Trends in the number of professionals with green and digital skills employed in the tourism industrial ecosystem and with a profile on LinkedIn over the period from 2020 to 2022



Source: Technopolis Group calculations, 2023

Figure 37: Most growing skills among professionals employed in the tourism industrial ecosystem in the EU27



Source: Technopolis Group calculations, 2023

5.2 Demand for green and digitally skilled employees

Skills demand in the tourism industrial ecosystem has been analysed following the skills intelligence insights of Cedefop, the European Centre for the Development of Vocational Training¹²⁸. This dataset covers the EU27 Member States (plus the UK) and is based on the collection and analysis of more than 530 online job advertisement sources (424 distinct websites) which are open-access sites. The dataset provides information on most requested occupations and skills across European countries based on established international classifications, e.g., ISCO-08 for occupations, ESCO for skills, and NACE rev. 2 for sectors.

Specific to the tourism industrial ecosystem¹²⁹, there were **13 900 296 unique job advertisements** from companies between 2019-2022 in the EU27. When filtering for accommodation, restaurants, travel and tourism services, and cultural activities we find 6 699 607 job advertisement over the same period. Job advertisements range from customer service, logistics and entertainment roles, travel agents, chefs in restaurants, housekeepers, managers, sales coordinators to tour guides. Although they offer also full-time jobs, a large share concerns **part time and seasonal occupation**.

¹²⁸ <https://www.cedefop.europa.eu/en/tools/skills-online-vacancies>

¹²⁹ In the case of the tourism industrial ecosystem the dataset was filtered for the NACE industries as defined in the Annual Single Market Report: H49, H50, H51, I55, I56, N79, N82, R90, R91, R92, R93).

These job advertisements have been text-mined and the required skills analysed from the perspective of the green and digital transitions. The green pre-defined skills are from ESCO v1.1 and the digital are predefined from ESCO v1.1.1 which is currently being updated.

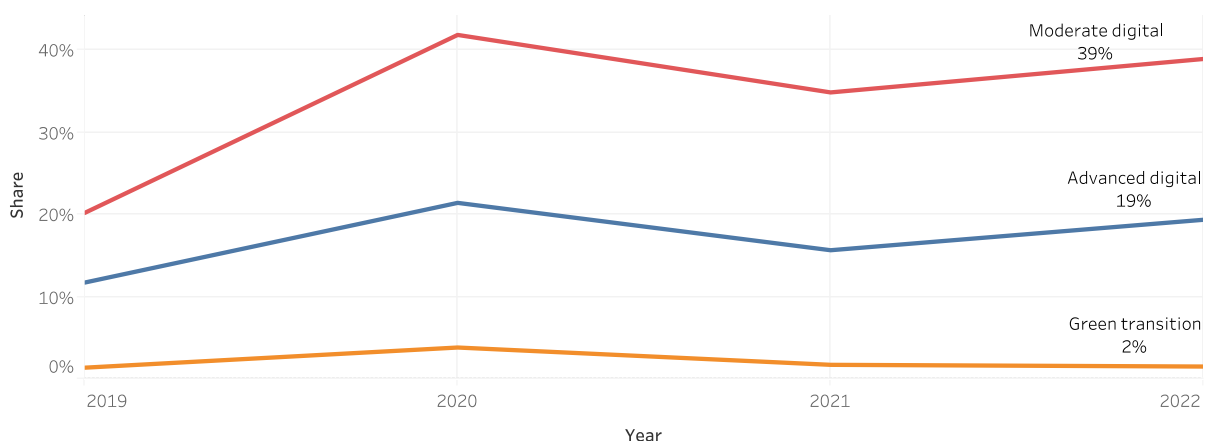
The European multilingual classification of Skills, Competences, Qualifications and Occupations (ESCO) is used as follows:

- **Green transition related skills** (ESCO v1.1.) are those knowledge and skills which reduce the negative impact of human activity on the environment (see also above the definition in the case of LinkedIn).
- **Moderate and Advanced Digital skills** (ESCO v1.1.1 which is currently being updated) are competences which involve the confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society. Within digital skills, we distinguish between moderate digital skills (that do not include basic Microsoft office skills but include specialised software used in the industry, the use of statistical software etc) and advanced digital skills (a category that is filtered for digital technologies highlighted in the methodological report including AI, big data, robotics, IoT, cloud, augmented and virtual reality, blockchain).

The results show that the share of online job advertisements that required any form of **moderate digital skills (excluding basic IT office skills) was 34%** over the period from 2019-2022 (and 39% in 2022), while this percentage was **17.09% for advanced digital skills (19% in 2022)**. Requirements related to the **green transition** appear less often on the advertisements notably in **1.91%** of the cases (increased to 2% in 2022).

It is interesting to observe that the share of digital transition related job ads had a surge in 2020 most probably an effect of the Covid-19 pandemic and continue to grow further. The evolution of green transition related skill requirements is more modest, however, some of the skills relevant for environmental management might not appear directly on the job advertisement.

Figure 38: Share of online job advertisements that demand digital and green transition related skills within the total number of job advertisements in the tourism industrial ecosystem in the EU27



Source: Technopolis Group calculations based on Cedefop data, 2023

The analysis of online job advertisements show that the most demanded digital skills included the following:

- Classification of databases (their purpose, characteristics, terminology, models and use, document-oriented databases and full text databases)

- Business ICT systems (The tools used to transform large amounts of raw data into relevant and helpful business information)
- Social media marketing techniques (digital marketing)
- Computer programming

The low level of green skills appearing on job advertisements might also reflect that business in the tourism industry do not necessarily employ professionals with green skills, but buy environmental services from specialist service providers in the field, hence green transition does not become visible in job advertisements. It is however interesting that we do not even find a relatively large share of 'green' titles with specific environmental position. For example, a further sub-analysis of tourism related job advertisements in Spain, shows that only 2 job advertisements out of 609 (captured in a certain period of time) included an explicit environmental position such as ecological tour guide or sustainability manager. Nonetheless, the analysis of job titles would need a further, more detailed investigation. Biodiversity has been found to be highlighted in a very limited number of job advertisements, for instance as part of looking for a biodiversity officer.

Having said that, within the 1.9% of green transition related job advertisements in tourism the more sought-after green skills included the following:

- Application of transport industry management concepts in order to improve transportation processes, reduce waste, increase efficiency, and improve schedule preparation
- Corporate social responsibility in terms of economic responsibility towards shareholders as equally important as the responsibility towards environmental and social stakeholders. This is probably linked to snippets of company advertisements where the company values are described.
- Energy efficiency
- Environmental legislation
- Emission standards
- energy performance of buildings

In terms of geographical coverage, the top countries are also the ones having the highest share of online job advertisements that contain transition skills. **Both in the field of the green and digital transition France is leading (41% - 47%) followed by Netherlands (17%), Italy (11%) and Germany (8%).**

6 Sustainable competitiveness: the green performance of the ecosystem

Key findings

The most important environmental impacts of the tourism industrial ecosystem are linked to **carbon emissions, disposable material and waste (more specifically food waste), unsustainable water use, and biodiversity loss** as identified in this analysis and presented later on.

When assessing the green performance of the industry, it has to be kept in mind that the environmental effects very much depend on the local context. Increased construction of tourism and recreational facilities can destroy complete local environments and damage biodiversity, overtourism can damage historical sites and living environments of local residents, hence **besides monitoring global figures data about local impact are as important and needs to be systematically collected**. National averages can hide important regional and local differences, therefore combining global values with exploration approach such as EU Tourism Dashboard¹³⁰ which shows indicators on regional level down to NUTS 3 regions is important.

The analysis of Exiobase data found that **tourism contributed to 10% of the total GHG emissions of all industrial ecosystems (one of the highest among all) in 2021**. Emissions have decreased over time since 2011, but they show a renewed increase since 2021. Particulate matter emissions show a similar pattern. Within this share, the contribution of 'accommodation and food service activities' and air transport are the highest.

Tourism relies on a wide range of materials that are typically obtained through material extraction mostly related to the construction of tourism infrastructure and related facilities. The Exiobase analysis shows that tourism was responsible for **5.9% of all industrial material extraction in 2021**. Although material extraction declined between 2011 and 2017, it has risen since then.

Tourism is a **major consumer of fresh water, and it is responsible for 5.7% of the total water consumption of all industrial ecosystems** as concluded from Exiobase. Although water consumption in tourism has decreased over time and it is below the average of all industrial ecosystems monitored in this project, the impact on water can be significant in regions where water is scarce.

The tourism industrial ecosystem **increasingly contributed to the damage to the natural ecosystem over the past years**.

Tourism can create a significant burden for the environment as a consequence of overconsumption of local resources and production of waste and pollution if not well managed. Uncontrolled tourism can result in noise, food waste, littering, sewage, the release of dangerous oil and chemicals, traffic congestion and increased car use, which become even more burdensome in overcrowded destinations¹³¹. Negative impacts also arise from land uptake, and wildlife and biodiversity disruption. Rapid growth of tourism

¹³⁰ <https://tourism-dashboard.ec.europa.eu/>

¹³¹ See in Baloch, Q.B., Shah, S.N., Iqbal, N. et al. Impact of tourism development upon environmental sustainability: a suggested framework for sustainable ecotourism. Environ Sci Pollut Res 30, 5917–5930 (2023). <https://doi.org/10.1007/s11356-022-22496-w>; European Commission (2018). A European Strategy for Plastics in a Circular Economy, Brussels, 16.1.2018 SWD(2018) 16 final; European Environmental Agency, <https://www.eea.europa.eu/soer/2015/europe/tourism>

activities and the spread of second homes increased pressure on the environment¹³² in the past decade, especially in coastal and mountain zones. The term 'overtourism' was coined to describe *the impact of tourism, when at certain times and in certain locations, exceeds physical, ecological, social, economic, psychological, and/or political capacity thresholds*¹³³.

With the aim to measure the trends in the above-mentioned environmental impacts, this report draws upon the data sources of Eurostat and Exiobase. The green transition impacts are sourced from Eurostat and Exiobase 3.8¹³⁴. Whilst Eurostat represent the official statistics, Exiobase is a legitimate source of information referred to for example by the European Environmental Agency¹³⁵, the EC/JRC community¹³⁶, Eurostat¹³⁷, and by the European Commission to propose the regulation on carbon border adjustment mechanisms¹³⁸. Pressure to environments refer to trade-embodied resources utilisation, and trade-embodied impacts. Resources utilisation is captured with four main dimensions are considered for cross-industry comparisons: embodied Land use, embodied Water consumption, embodied Materials Consumption, and Energy mix supplied to the industrial activity. In terms of impacts, there are three dimensions monitored: Air emissions (incl. GHG), waste generation, water consumption and damage to the ecosystem. In the calculations, the sub-industries were taken into account with the weights identified in the Annual Single Market Report 2021.

Table 42 on the next page shows the summary of green performance indicators at EU level and its change from 2010 to 2021. Overall, the analysis suggest that the most relevant environmental challenges of tourism are related to greenhouse gas emissions, where the ecosystem has one of the highest contribution among all ecosystems following agriculture and energy-intensive industries. Damage to the environment and biodiversity loss is also significant showing a steady increase.

The following table shows the summary of above-mentioned green performance indicators at EU level and their change from 2010 to 2021. These indicators do not therefore yet reflect any impacts of the Transition pathway for tourism, published in 2022. Overall, the analysis suggest that the most relevant environmental challenges of tourism are related to greenhouse gas emissions, where the ecosystem has the second highest contribution among all ecosystems following agriculture. Damage to the environment and biodiversity loss is also significant showing a steady increase. These are in line with the trends and actions recognised in the Transition pathway for the tourism ecosystem.

Emissions

In terms of greenhouse gas emissions of CO₂, the tourism ecosystem' outputs are above the average of all the industrial ecosystems monitored in the framework of this project for the most part originating from accommodation and food services and air transport. **Tourism contributes to 10% of the total GHG emissions of all industrial ecosystems (one of the highest among all industrial ecosystems).** Comparing the emissions of the last ten years, although overall emissions have decreased, the volume is high. Interestingly, the data suggest a sudden jump from 2020 to 2021 across some of the

¹³² <https://www.eea.europa.eu/soer/2015/europe/tourism>

¹³³ [https://www.europarl.europa.eu/RegData/etudes/STUD/2018/629184/IPOL_STU\(2018\)629184_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/STUD/2018/629184/IPOL_STU(2018)629184_EN.pdf)

¹³⁴ Exiobase is a time series of environmentally extended multi-regional input-output (EE MRIO) tables. Its coverage is by country and industry from 1995 to 2021 and has EU and extra rest of the world coverage. Source: Stadler, Konstantin, Wood, Richard, Bulavskaya, Tatyana, Södersten, Carl-Johan, Simas, Moana, Schmidt, Sarah, Usubiaga, Arkaitz, Acosta-Fernández, José, Kuenen, Jeroen, Bruckner, Martin, Giljum, Stefan, Lutter, Stephan, Merciai, Stefano, Schmidt, Jannick H, Theurl, Michaela C, Plutzar, Christoph, Kastner, Thomas, Eisenmenger, Nina, Erb, Karl-Heinz, ... Tukker, Arnold. (2021). EXIOBASE 3 (3.8.2) [Data set]. Zenodo. <https://doi.org/10.5281/zenodo.5589597>

¹³⁵ EEA 2022. Visit 12/10/2022. <https://www.eea.europa.eu/data-and-maps/data/external/exiobase>

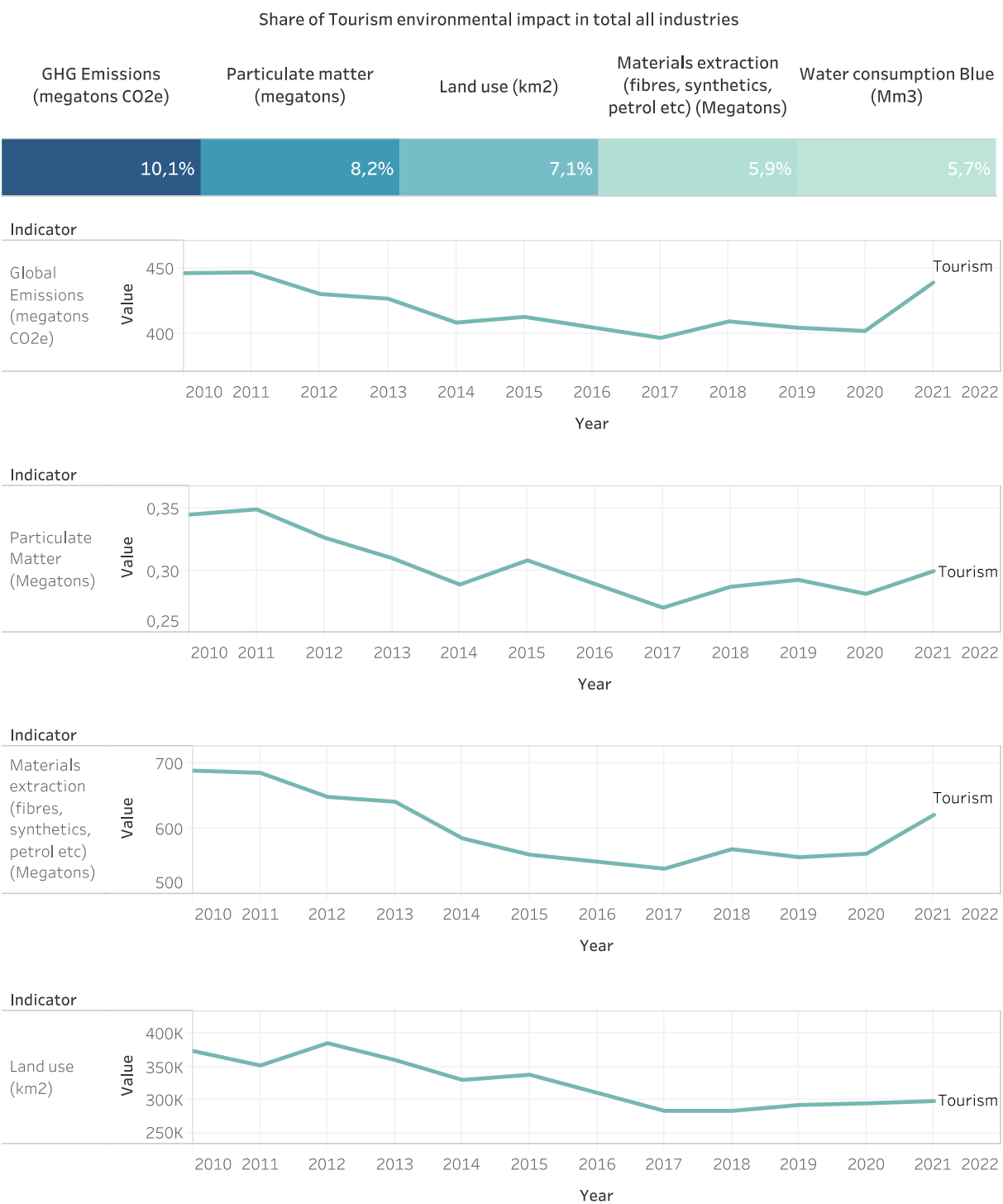
¹³⁶ Beylot, A., Secchi, M., Cerutti, A., Merciai, S., Schmidt, J. and Sala, S., 2019. Assessing the environmental impacts of EU consumption at macro-scale. Journal of cleaner production, 216, pp.382-393. <https://doi.org/10.1016/j.jclepro.2019.01.134>

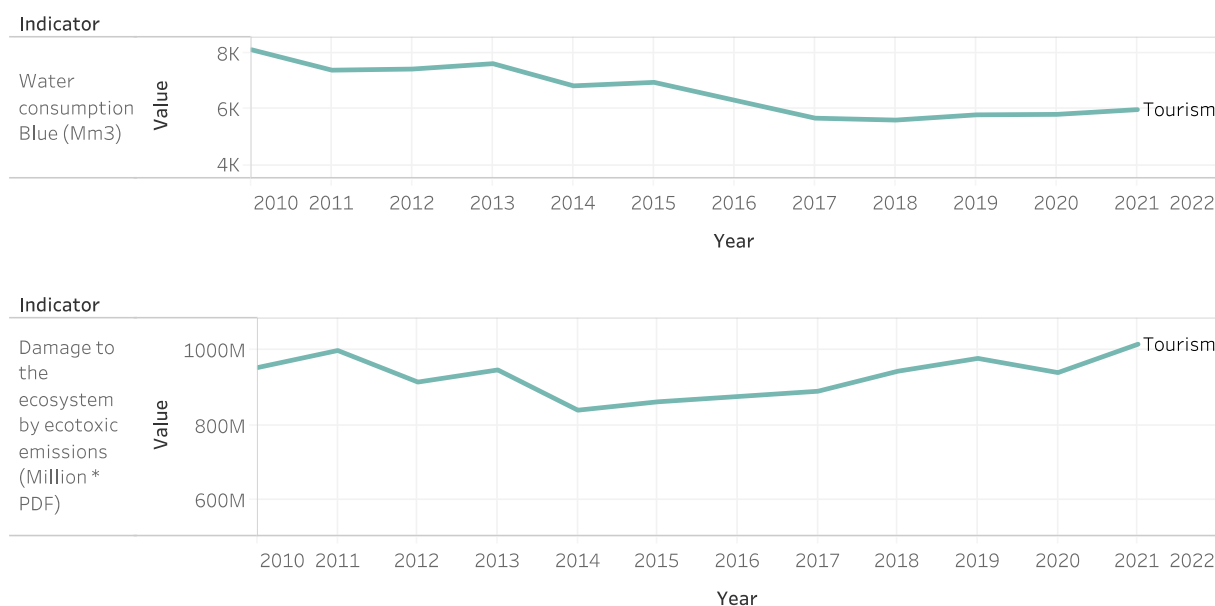
¹³⁷ Remond-Tiedrez, I. and Rueda-Cantuche, J.M. eds., 2019. EU Inter-country Supply, Use and Input-output Tables: Full International and Global Accounts for Research in Input-output Analysis (FIGARO). Luxembourg: Publications Office of the European Union.

¹³⁸ EC (2021) REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL. Establishing a carbon border adjustment mechanism. COM(2021) 564 final.

environmental indicators. Particulate matter emissions show a similar pattern, notably, they have been decreasing since 2011, but demonstrate a renewed surge in 2021.

Figure 39: Environmental impact of the tourism industrial ecosystem including both production and consumption accounts, Exiobase, 2022 (following the ecosystem definition)





Source: Technopolis Group, 2022, based on Exiobase data

Resource use

Tourism relies on a wide range of materials that are typically obtained through **material extraction mostly related to the construction of tourism infrastructure and related facilities**. When concentrated in small areas, tourism creates pressure on local resources like energy, food, and other raw materials. The Exiobase analysis shows that although material extraction declined between 2011 and 2017, it **has risen since then**, however it has been lower in tourism than the average of all industrial ecosystems.

Tourism has been blamed for destroying important freshwater ecosystems and contributing to drying out wetlands. As found by the analysis of the European Environmental Agency and indicated by data on water abstraction by source, one of the most significant pressures on freshwater originated from tourism¹³⁹. Indeed, in this analysis tourism has been found to be a **major consumer of fresh water, and it is responsible for 5.7% of the total water consumption of all industrial ecosystems** as the analysis of Exiobase data suggests. Although water consumption has decreased over time and it is below the average of all industrial ecosystems, tourism's impact on water can be still significant especially depending on the water scarcity in the local context. Water use is expected to remain a key challenge for the industry especially in dryer regions like the Mediterranean, where climate change is already heavily impacting the availability of water resources¹⁴⁰.

In terms of **land use**, the tourism industrial ecosystem has been lower than the global average of all industrial ecosystems monitored in this project and **contributes 7.1% to the global values**. Land use of the tourism industrial ecosystem decreased gradually until 2017 and has remained more or less at a constant level over the past years. Data however indicate an increasing trend since 2021 that should be further monitored when more recent data become available. Issues arise from the construction of tourism and recreational facilities that can have detrimental effects on landscapes. The pressure on local land use that is exploited for tourism destinations is a further driver behind this indicator.

¹³⁹ European Environmental Agency (2022). Water abstraction by source and economic sector in Europe', <https://www.eea.europa.eu/ims/water-abstraction-by-source-and>) accessed December 9, 2022

¹⁴⁰ See the analysis of the European Environmental Agency that concluded that "in 2019, Cyprus, Malta, Greece, Portugal, Italy and Spain faced the most significant water scarcity conditions in the EU27 on the seasonal scale" <https://www.eea.europa.eu/ims/use-of-freshwater-resources-in-europe-1>

Industrial drivers

The break-down at the level of sub-industries within the tourism ecosystem shows that **accommodation and food services are responsible for most of the emissions, material extraction, land use, and blue water consumption**. The need to supply services such as rooms, laundry, meals, swimming pools, etc. drive the resource consumption (notably the use of materials, land, and water) of the ecosystem. Restaurants and food services are also one of drivers of negative environmental impact and they use substantial energy for cooking, refrigeration, and lighting. Some studies showed that restaurants use several times more energy per square meter than any other type of commercial building¹⁴¹.

A comparative life-cycle study of Greek hotels¹⁴² indicated substantial environmental impacts in terms of resources consumption induced by hotels sustainability management practices and characteristics. For instance, the location of the hotel implies also different transportation needs (eg. by road, sea, water), which in turn leads to high consumption of fuel with impact on more resource consumption. The life-cycle impacts of all related items used such as for electricity, pellet for hot water, or gas and electricity in cooking need to be also taken into account in the case of accommodation's environmental impacts.

Air transport is another impactful driver of the GHG emissions of the ecosystem¹⁴³. It has been widely documented since the report of the Intergovernmental Panel of Climate Change (IPCC), in 1990 indicated the impacts of air travel on GHG emissions, even if there are observed efficiencies in air transport^{144,145,146,147}.

Water transport is a further contributor to the damage caused to the environmental ecosystem. The study of the mid-term review of the EU Maritime transport strategy¹⁴⁸ discussed the need of addressing multiple sources of damage to the ecosystem, (in particular the marine ecosystem) maritime environmental impacts, such as oil spills, noxious liquid substances, sewage, garbage, air pollution¹⁴⁹. It had been documented that cruises are drivers of several environmental impacts, including: solid waste, wastewater and ballast water; transfer of species; antifouling coating, scrubber discharge, heavy metals from ship dismantling/building/repair, collision with marine animals, light and noise pollution (disturbance to marine life)¹⁵⁰.

The environmental impacts are also very much seasonal pressures that can result in a potentially unmanageable stress at certain periods such as for example handling of excess waste by the local waste management systems, or treat waste water or manage increased air pollution caused by transport.

¹⁴¹ Wang, Y. F., Chen, S. P., Lee, Y. C., & Tsai, C. T. S. (2013). Developing green management standards for restaurants: An application of green supply chain management. *International journal of Hospitality management*, 34, 263-273. <http://dx.doi.org/10.1016/j.ijhm.2013.04.001>

¹⁴² Michailidou, A. V., Vlachokostas, C., Moussiopoulos, N., & Maleka, D. (2016). Life Cycle Thinking used for assessing the environmental impacts of tourism activity for a Greek tourism destination. *Journal of Cleaner Production*, 111, 499-510. <https://doi.org/10.1016/j.jclepro.2015.09.099>

¹⁴³ Soratana, K., Landis, A. E., Jing, F., & Suto, H. (2021). Supply chain management of tourism towards sustainability. Cham: Springer. <https://link.springer.com/book/10.1007/978-3-030-58225-8>

¹⁴⁴ IPCC (1999) Aviation and the Global Atmosphere. <https://www.ipcc.ch/report/aviation-and-the-global-atmosphere-2/>

¹⁴⁵ Somerville, H. (2004). Travel, tourism and the environmental challenges. *Tourism and Hospitality Research*, 5(1), 65-71. <https://doi.org/10.1057/palgrave.thr.60400>

¹⁴⁶ Gössling, S., Peeters, P., Ceron, J. P., Dubois, G., Patterson, T., & Richardson, R. B. (2005). The eco-efficiency of tourism. *Ecological economics*, 54(4), 417-434. <https://doi.org/10.1016/j.ecolecon.2004.10.006>

¹⁴⁷ Gühnemann, A., Kurzweil, A., & Mailer, M. (2021). Tourism mobility and climate change-A review of the situation in Austria. *Journal of Outdoor Recreation and Tourism*, 34, 100382. <https://doi.org/10.1016/j.jort.2021.100382>

¹⁴⁸ Artuso, Borbon-Galvez, Ferencz, Langeveld, Sys, Vanelslander, Zondag (2019) Evolution of the EU and international shipping: drivers, challenges, and scenarios. In Photis M. Panayides (Ed) *The Routledge Handbook of Maritime Management*. ISBN: 978-1-315-61713-8

¹⁴⁹ For information on the international convention to address environmental impacts of maritime transport, see the MARIPOL convention at [https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-\(MARPOL\).aspx](https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx)

¹⁵⁰ Lloret, J., Carreño, A., Carić, H., San, J., & Fleming, L. E. (2021). Environmental and human health impacts of cruise tourism: A review. *Marine pollution bulletin*, 173, 112979. <https://doi.org/10.1016/j.marpolbul.2021.112979>

The Table below summarises the share of contribution of the different sub-industries of the tourism industrial ecosystem to the overall environmental impacts (as captured by the five dimensions used in this project). Values are monitored between 2010 and 2021.

Table 5: Contribution of sub-industries to the tourism industrial ecosystem's total environmental impact as captured by emissions, material use, land use, water consumption and ecotoxic emissions - by NACErev2

F1	2010	2012	2014	2017	2019	2020	2021
I Accommodation and food service activities	9,38%	8,98%	8,02%	6,82%	6,88%	6,60%	9,68%
H51 Air transport	8,27%	8,08%	7,45%	7,58%	8,52%	8,22%	9,35%
H50 Water transport	8,65%	8,22%	7,13%	7,77%	8,42%	7,30%	9,05%
H 49.1 Passenger rail transport, interurban	8,90%	8,98%	8,12%	7,02%	7,30%	7,38%	8,92%
H 49 Land transport and transport via pipeline	8,43%	9,52%	7,95%	6,85%	8,02%	7,62%	8,57%
N79 Travel agency, tour operator reservation service and related activities; H52 Warehousing and su..	9,62%	9,42%	8,10%	7,17%	7,43%	7,48%	8,10%
R93 Sports activities and amusement and recreation activities	4,15%	4,22%	4,05%	3,93%	4,21%	4,49%	4,11%
R90-R92 Creative, arts and entertainment activities; libraries, archives, museums and other cultur..	4,15%	4,22%	4,05%	3,93%	4,21%	4,49%	4,11%

Source: Technopolis Group, 2022, based on Exiobase data

There are a list of further key impacts that cannot be easily quantified at the level of the industrial ecosystem but certainly need attention.

Solid waste is a further environmental issue at tourist destinations which need to be managed in order to avoid negative ecological and health disasters. Although data on waste generation linked to tourism is scarce, some studies help understand the magnitude of the problem. As it was pointed out in the study of the European Parliament, tourists generate more waste than residents in general¹⁵¹. In Portugal it was estimated that the tourism sector is responsible for approximately 45% of the solid waste generated per capita in Madeira Island taking into account seasonalities¹⁵². Some studies concluded that a tourist produces about 1.6 kg of waste per tourist per day¹⁵³. At the level of the industry, a study conducted in Slovenia¹⁵⁴ found that the average waste generated annually by a business

¹⁵¹ European Parliament (2017). [https://www.europarl.europa.eu/RegData/etudes/BRIE/2017/599327/EPRS_BRI\(2017\)599327_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2017/599327/EPRS_BRI(2017)599327_EN.pdf)

¹⁵² Martins, A. M., and Cró, S. (2021). The impact of tourism on solid waste generation and management cost in Madeira Island for the period 1996–2018. Sustainability 13:5238. doi: 10.3390/su13095238

¹⁵³ Obersteiner, G., & Gruber, I. (2017). Urban strategies for waste management in tourist cities D2.5 – Status quo (baseline) assessment report. Retrieved July 7, 2022 from <https://ec.europa.eu/research/participants/documents/downloadPublic?documentId=080166e5bc2d54d9&appId=PPGMS>.

¹⁵⁴ Juvan E., Grün B, Dolnicar S. (2023). Waste production patterns in hotels and restaurants: An intra-sectoral segmentation approach, Annals of Tourism Research Empirical Insights, Volume 4, Issue 1, 2023, 100090, ISSN 2666-9579, <https://doi.org/10.1016/j.annale.2023.100090>.

unit in hotels and restaurants was 41 807 kg and this volume was lower than in any other types of businesses. Further interesting finding of the study was that most waste generated by hotels and restaurants is kitchen and canteen waste with a substantially more mixed municipal waste compared to other sectors of the economy. The tourism industry is responsible for significantly contributing to the creation of a particular waste type notably marine littering and plastics thrown into the sea. This concerns especially coastal tourism such as in the North Sea, Mediterranean and Baltic seas¹⁵⁵. In the case of hotels and restaurants, the generation of food waste has become a key problem that needs to be addressed. (The survey conducted in the framework of this project and presented under Chapter 3 has presented some results related to handling of food waste.) Moreover, tourism industries produce waste water from activities such as bathing, swimming, laundry, and irrigation that result in further negative environmental impact.

The tourism industry has a significant impact on biodiversity, both directly and indirectly. Tourism infrastructure and activities contribute to habitat deterioration of wildlife and a broad range of animal communities. Tourism's most obvious impacts on European biodiversity can be seen on the coast threatening endemic fish species with extinction as found by the European Environmental agency¹⁵⁶. Tourism also often involves the development and intense use of tracks and paths in the natural areas. Another concern is linked to the ecological perturbations caused by foreign species such as insects, plants and diseases on the local environment brought in by tourism activities¹⁵⁷. Nonetheless, tourism can also help raise awareness to the importance of biodiversity¹⁵⁸. Visiting nature in particular from an ecotourism perspective can teach about the important value of local habitats and incentivise eco-conscious behaviour.

A major issue of the environmental impact of tourism is linked to overtourism as already mentioned at the beginning of this section. A recent analysis and case studies conducted in the subject¹⁵⁹ found that unbalanced tourism is a clear issue in the EU and it evolves uniquely at each destination. International tourism growth is a key driver of unbalanced tourism developments. Interestingly, the study also pointed out the link between overtourism and social media use that contributes to the creation of certain touristic hotspots.

¹⁵⁵ UNECE (2021). Draft thematic document for the Ninth Environment for Europe Ministerial Conference: Applying principles of circular economy to sustainable tourism https://unece.org/sites/default/files/2021-10/Sustainable_tourism.IP_.3.e.pdf

¹⁵⁶ <https://www.eea.europa.eu/soer/2015/europe/tourism>

¹⁵⁷ Anderson, et al (2015). The Role of Tourism and Recreation in the Spread of Non-Native Species: A Systematic Review and Meta-Analysis, Published online 2015 Oct 20. doi: 10.1371/journal.pone.0140833

¹⁵⁸ <https://www.unep.org/news-and-stories/story/tourism-can-help-sustain-biodiversity>

¹⁵⁹ European Commission (2022). Unbalanced tourism growth at destination level – root causes, impacts, existing solutions and good practices, Final Report, https://single-market-economy.ec.europa.eu/publications/study-unbalanced-tourism-growth-destination-level-root-causes-impacts-existing-solutions-and-good_en

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Appendix B: Methodological notes

Startup data and venture capital data analysis

Selected fields from Crunchbase and Net Zero Insights:

Table 6: Concordance between NACE and Crunchbase/NO

NACE		Crunchbase and Net Zero Insights
I	Accommodation and food service activities	Hotel, Travel Accommodations, Hospitality, Vacation Rental, Restaurants
N79	Travel agency, tour operator and other reservation service and related activities	Travel arrangement and reservation services Travel Agency, Adventure Travel, Business Travel, Hospitality, Tour Operator,
R93	Sports activities and amusement and recreation activities	Sports, Amusement Park
N82	Office administrative, office support and other business support activities	<i>Not applicable</i>
R90-R92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities	Museums and Historical Sites, Parks, Resorts, Casino
H49-H50-H51	Land-, water-, air transport	Public Transportation, Railroad, Marine Transportation, Air Transportation

Source: Technopolis Group and Kapa Research, 2023

Survey

The table below presents the overview of the sub-sectors included in the sampling frame, with corresponding sections according to NACE industrial classification. The survey has encompassed the entire tourism ecosystem more specifically the largest survey population comes from accommodation and food service activities. This is followed by creative, arts and entertainment activities and travel agencies, tour operators, reservation services and sport and recreational activities. The survey respondents come from a mix of micro-enterprises (less than 10 employees), small enterprises (10-50 employees) and medium-sized enterprises (50-250 employees). In terms of geographical coverage, the survey has a balanced coverage of all EU countries.

Table 7: Survey sampling strategy

NACE		Sample size of the survey
I	Accommodation and food service activities	330
N79	Travel agency, tour operator and other reservation service and related activities	50
R93	Sports activities and amusement and recreation activities	50
N82	Office administrative, office support and other business support activities	This category is broader as tourism hence only those organisations were included in the survey that are relevant for the industry such as trade fairs, tourism related support organisations

R90-R92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities	50 (taken into account but surveyed also as part of the cultural and creative industries)
H49-H50-H51	Land-, water-, air transport	175 (the results are presented separately)

Source: Technopolis Group and Kapa Research, 2023

Foreign direct investment data analysis

Table 8: Concordance between NACE and FDI Intelligence data

NACE		Code in FDI Intelligence
I	Accommodation and food service activities	Accommodation and food services
N79	Travel agency, tour operator and other reservation service and related activities	Travel arrangement and reservation services
R93	Sports activities and amusement and recreation activities	Performing arts, spectator sports, & related Amusement and theme parks
N82	Office administrative, office support and other business support activities	Other (Hotels & tourism)
R90-R92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities	Museums, historical sites, & similar Performing arts, spectator sports, & related
H49-H50-H51	Land-, water-, air transport	Transportation

Source: Technopolis Group and Kapa Research, 2023

CORDIS data analysis

Codes used:

NACE_rev2	Description
H49	Land transport and transport via pipelines
H50	Water transport
H51	Air transport
I	Accommodation and food service activities
N79	Travel agency, tour operator and other reservation service and related activities
N82	Office administrative, office support and other business support activities
R90-R92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities
R93	Sports activities and amusement and recreation activities

Keywords used: vacation, hospitality, air transport & tourism, restaurants, wheelchair access*, disabled guest*, culture, transport & tourism, tourism

TED data analysis

Table 9: Concordance between NACE and TED

NACE		CPV values
I	Accommodation and food service activities	55100000 Hotel services; 55200000 Camping sites and other non-hotel accommodation; 55300000 Restaurant and food-serving services; 55400000 Beverage-serving services; 55500000 Canteen and catering services; 98340000 Accommodation and office services;
N79	Travel agency, tour operator and other reservation service and related activities	63510000 Travel agency and similar services.
R93	Sports activities and amusement and recreation activities	92500000 Library, archives, museums and other cultural services; 92600000 Sporting services; 92300000 Entertainment Services;
N82	Office administrative, office support and other business support activities	98340000 Accommodation and office services;
R90-R92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities	92500000 Library, archives, museums and other cultural services; 92600000 Sporting services; 92300000 Entertainment Services;
H49-H50-H51	Land-, water-, air transport	Transportation

Source: Technopolis Group and TED

LinkedIn data analysis

Table 10: Concordance between NACE and LinkedIn

NACE		LinkedIn industry categories
I	Accommodation and food service activities	Hospitality, Restaurants,
N79	Travel agency, tour operator and other reservation service and related activities	Leisure, Travel & Tourism
R93	Sports activities and amusement and recreation activities	Recreational Facilities & Services, Sports
N82	Office administrative, office support and other business support activities	na
R90-R92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities	Museums & Institutions Gambling & Casinos
H49-H50-H51	Land-, water-, air transport	Airlines/Aviation

Source: Technopolis Group based on LinkedIn

Green skills – keywords used: Cleantech, Sustainability, Sustainable Development, Sustainable Business, Energy Efficiency, Clean Energy Technologies, Renewable Energy, Wind Energy, Biomass, Biomass Conversion, Solar Energy, Solar Power, Urban Forestry, Forest Ecology, Sustainable Communities, Organic Farming, Organic Gardening, Urban Agriculture, Organic Food, Waste Management, Waste Reduction, Recycling, Water Treatment, Water Resource Management, Water Purification, Green Marketing, Green Printing, Environmental Biotechnology, Environmental Science, Environmental Engineering, Environmental Management Systems, Environmental Protection, Wastewater Treatment, Ecology, Circular Economy, Zero Waste, Waste to Energy, Plastics Recycling,

E-Waste, Carbon Reduction Strategies, Carbon Footprinting, Carbon Neutral, Energy Retrofits, Biodiversity, Biodiversity Conservation, Nature Conservation, Advanced Materials, Nanomaterials, Biomaterials, Reuse, Separation Process, Sorting, Equipment Repair, Natural Resource Management, Sustainability Reporting, Green Development, Sustainable Cities, Energy Conservation, Energy Management, Environmental Awareness, Environmental Impact Assessment, Environmental Compliance, Leadership in Energy and Environmental Design (LEED), Environmental Policy, Green Technology, Sustainable Design, Sustainable Architecture, Environmental Consulting, Maintenance and Repair, Solar PV, Solar Cells, Wind Turbines, Wind Turbine Design, Carbon Capture, Low Carbon Technologies, Low Carbon, Renewable Fuels, Renewable Energy Systems, Renewable Resources, Integrated Water Resources Management, Natural Resources, Biodiesel, Bioplastics, Waste Treatment, Waste Water Treatment Plants, Electric Vehicles, Hybrid Electric Vehicles, Multi-modal Transportation, Energy Efficiency Consulting, Recycled Water, Adaptive Reuse, Ecodesign, Life Cycle Assessment, Energy Optimisation, Alternative Fuels, Green Building, Green Infrastructure, Green Purchasing, Biodegradable Products, ISO 14001, EMAS, Environmental Standards, Ecotourism, Nature tourism

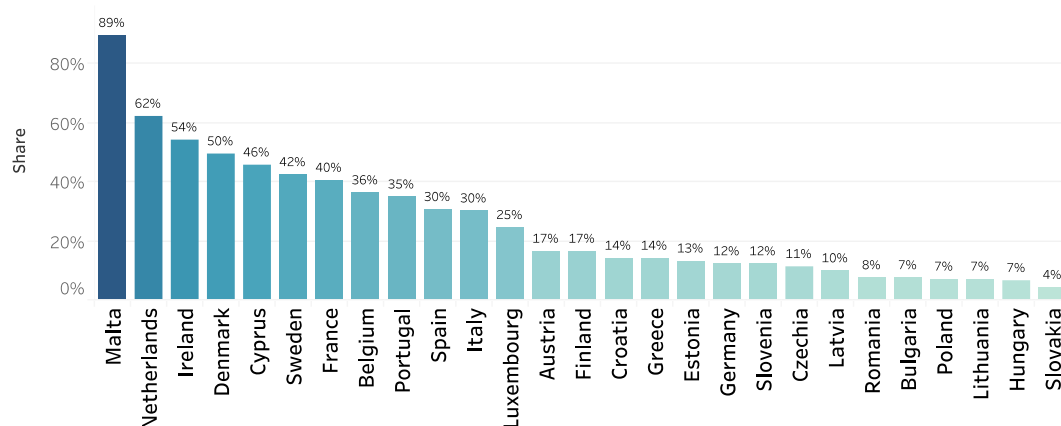
Digital skills – keywords used: data analytics, tourism flow management, online platforms, digital payment, online ticketing, Cybersecurity, Intrusion Detection, Malware Detection, Cloud Security, Cybercrime Investigation, Cyber Threat Intelligence (CTI), Cryptography, DLP, Malware Analysis, IDP; Vulnerability Assessment, Certified Information Security Manager (CISM), Computer Forensics, Cloud Infrastructure, Cloud Services, Google Cloud Platform (GCP), SAP Cloud Platform, SAP HANA, Everything as a Service (XaaS), Software as a Service (SaaS), Platform as a Service (PAAS), Infrastructure as a Service (IaaS), Private Clouds, Hybrid Cloud, Cloud Computing, Edge Computing, High Performance Computing (HPC), Serverless Computing, Robotics, Robot, Robotic Surgery, Human-robot Interaction, Drones, Connected Devices, Internet of Things (IoT), Robotic Process Automation (RPA), Wireless Sensor Networks, Embedded Systems, Cyber-Physical Systems, Smart Cities, Artificial Intelligence (AI), Biometrics, Cognitive Computing, Computer Vision, Deep Learning, Machine Learning, Natural Language Processing (NLP), Natural Language Understanding, Natural Language Generation, Reinforcement Learning, Speech Recognition, Supervised Learning, Unsupervised Learning, Big Data Analytics, Hadoop, Real-time Data, Yarn, Teradata Data Warehouse, Blockchain, Ethereum, Bitcoin, Cryptocurrency, Crypto, Distributed Ledger Technology (DLT), Hyperledger, Augmented Reality (AR), Virtual Reality (VR), Mixed Reality, Computer-Generated Imagery (CGI), Connectivity, M2M, 5G, SD-WAN, Home Automation, Flexible Manufacturing Systems (FMS), Smart Manufacturing, Smart Materials, Quantum Computing, Smart Devices, Intelligent Systems, Big Data, Computer-Aided Design (CAD), Computer Science, MATLAB, C (Programming Language), Python (Programming Language), Digital Strategy, Digital Printing, Digital Marketing, Online Journalism, Revit, Building Information Modeling (BIM), JavaCard, R (Programming Language), Digital Imaging, Digital Media, C++, Collaborative Robotics, Industrial Robotics, Medical Robotics, Mobile Robotics, AutoCAD, Automation, Autodesk 3ds Max, Lumion, Data Analysis, Data Mining, 5G Core, Integrated Security Systems, Cloud Applications, Cloud Computing IaaS, Cryptocurrency Mining, CryptoAPI, Automated Machine Learning (AutoML), Machine Learning Algorithms, Virtual Reality Development, Virtual Data Rooms, Intelligence Systems, Robot Programming, Predictive Analytics, Data Lakes, Blockchain Analysis, Digital Publishing, Enterprise Software, Software Development, SAS (Software), SAP Products, SAP ERP, Online Payment, Online Payment Solutions; Online Travel, Online Marketing, Online Business Management, Online Advertising, Online Gaming, Web Services, Mobile Applications, Mobile Marketing, Java Database Connectivity (JDBC), Data Warehousing, Statistical Data Analysis, Data Modeling, Databases; Electronic Data Capture (EDC), Data Centers, Oracle Database, SAP Solution Architecture Data Entry, Data Management, Data Mapping, Web Applications, GIS Applications, Oracle Applications, Visual Basic for Applications (VBA), Computer Hardware, Computer Maintenance, Computer Network Operations, Computer Networking, Computer Graphics, Online Communications, Social Media Marketing, Digital Direct Marketing, Digital Illustration, Digital Video, Digital Photography, Xero, GPS Applications, GPS Devices, GPS Tracking, GPS Navigation, Microsoft Power Apps, Social Networking Apps, Google Apps Script, Social Media, E-Commerce, Data Intelligence, Online Platforms, Mobile Payments

Representativeness

LinkedIn data have to be interpreted in the light of its representativeness for tourism and across the EU. To perform a representativeness analysis of LinkedIn, the available industry-specific dataset has been compared to Eurostat figures regarding the active population in the industrial ecosystem. Countries that have the highest share of professionals employed in the tourism industry with a profile on LinkedIn within the persons

employed in tourism according to Eurostat include Malta, Netherlands, Ireland and Denmark. Common tourism destinations such as Italy and Spain have an estimated 30% of tourism professionals on LinkedIn, while Greece has 14%. Nevertheless, there are several limitations in conducting a robust representativeness analysis due to the fact that the two datasets have different origins, classification systems and hence there are mismatches in the definition of some categories¹⁶⁰. Moreover, regarding the country profiles, there is an important heterogeneity in the national use of LinkedIn among EU Member States. Furthermore, tourism ecosystem is dominated by SMEs (99.8%) and in the EU the progress of digitalisation among tourism SMEs is still facing challenges. For example, in 2020 34.5% of SMEs only planned to adopt basic digital technologies and 18.9% didn't plan to adopt any digital technologies.¹⁶¹ This may imply that tourism professionals working in SMEs do not necessarily have even the basic digital skills or interest to register to LinkedIn and encode their skills in it.

Figure 40: Representativeness of tourism industry professionals on LinkedIn



Source: Technopolis Group calculations based on LinkedIn vs Eurostat - annual enterprise statistics

¹⁶⁰ See more in detail ATI Methodological report: <https://ati.ec.europa.eu/reports/eu-reports/advanced-technologies-industry-methodological-report>

¹⁶¹ SME annual report 2021 on SME's digitalisation

