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The impact of digitisation and big data analysis on the sustainable development of tourism and its environmental impact

Final report

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The impact of digitisation and big data analysis on the sustainable development of tourism and its environmental impact

Final report

by

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Abstract: Effects of digitalisation and Big Data analysis on sustainable tourism development and the environment

The impact of digitialisation on sustainable tourism development in its environmental and social dimensions will be investigated. In a first step, current developments in the digitisation are systematically identified and their current and future contribution to sustainable tourism development is examined. In doing so, both the digitialisation on the part of the customers (tourists) and the providers is taken into account, with an emphasis on Big Data-Analyses. The focus is on the use of digital applications during the trip, while the attention will not be on travel preparation or follow-up.

In a second step, the opportunities and risks arising from the analysis are identified and evaluated. Special consideration is given to the behaviour of different user groups with influences on resource use, environment and climate. The aim is to analyse possible environmental damage as well as opportunities for climate, resource and environmental protection and social sustainability aspects (e. g. avoidance of overtourism).

Kurzbeschreibung: Die Auswirkungen der Digitalisierung und Big Data-Analyse auf eine nachhaltige Entwicklung des Tourismus und dessen Umweltwirkung

Es wird untersucht, welchen Einfluss die Digitalisierung auf die nachhaltige Tourismusentwicklung in der ökologischen und sozialen Dimension haben kann. Dazu werden im ersten Schritt aktuelle Entwicklungen in der Digitalisierung systematisch identifiziert und auf ihren aktuellen und zukünftigen Beitrag zu einer nachhaltigen Tourismusentwicklung hin untersucht. Es wird sowohl die Digitalisierung auf Seiten der Nachfrager (Touristen) als auch der Anbieter berücksichtigt – mit dem Schwerpunkt auf Big Data-Analysen. Im Fokus steht die Nutzung digitaler Anwendungen während der Reise. Die Reisevor- und -nachbereitung steht nicht im Fokus.

Im zweiten Schritt werden die aus der Analyse erwachsenden Chancen und Risiken identifiziert und bewertet. Eine besondere Berücksichtigung finden dabei die Verhaltensweisen unterschiedlicher Nutzergruppen mit den Einflüssen auf Ressourcennutzung, Umwelt und Klima. Es sollen sowohl mögliche Umweltbelastungen durch die Digitalisierung als auch Chancen für Klima-, Ressourcen- und Umweltschutz sowie soziale Nachhaltigkeitsaspekte (z. B. Vermeidung von Overtourism) analysiert werden.

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Summary

The study "The impact of digitisation and big data analysis on the sustainable development of tourism and its environmental impact" examines the influence digitisation can have on sustainable tourism development in the ecological and social sphere as well as the resulting opportunities and risks.

The study has two primary objectives.

The first objective is the *structuring of the subject area*. Both "digitisation" and "sustainable development of tourism" are used in a variety of ways and, depending on the context, defined more or less strictly.

With regard to sustainability, we are particularly interested in the effects of travel on *nature and the environment* (i.e. air, water and ground; landscape and land use; biodiversity and ecosystems; climate impact and CO_2 emissions; water, energy and raw material consumption; waste water and waste and ecosystem services) and on *social issues* (i.e. participation and inclusion; encounters; cultural values as well as jobs and income distribution). These effect categories are taken from the literature.

With regard to digitisation, the first step was to systematically identify current developments in digitisation and to examine their possible current and future contribution to sustainable tourism development. Digitisation on the part of both consumers (tourists) and providers was taken into account. The focus was on the use of digital applications *while* travelling. We managed to identify eleven relevant categories and systematise them on the basis of four aspects. The four aspects are the categories themselves (main themes and areas of application), markets (phases of the customer journey and significantly affected segments), diffusion (status and perspective of technical development) and impact potentials (directions and paths of impact). To aid understanding, all categories were illustrated using examples in the form of concrete applications or plans. All examples are documented in the appendix. The eleven categories thus described can be found in three spheres. **Data connectivity** refers to the collection and linking of data as well as its processing. **Data infrastructure** enables data connectivity and the output of the processed data in the form of digital service applications. Finally, the **data ecosystem is** the business basis for such applications. The categories are classified in these spheres using the following structure:

- Data connectivity
  - Big data analytics: Refers to the analysis of complex data sets using (automated) methods to identify correlations, meanings and patterns.
  - Internet of Things and geo-intelligence: Describes the linking of and data exchange between objects, devices and systems that often use geodata to provide location-based services (LBS).
  - Artificial intelligence: Describes systems that continuously and independently develop data analysis. Artificial intelligence brings together mass data (big data), sufficient computing resources and machine learning.

- Data infrastructure
  - Smart mobile devices and digital payment: Describes the emergence of new and high-tech mobile phones that allow travellers to access the internet and use services. The key here is that visitors carry these devices and their various applications around with them and the fact that they are personalised, which means they can be used as ID and to make payments.
  - Extended reality (AR, VR, MR): Describes the superimposition of reality with computer-generated data using a display (for example, of a smartphone). A distinction is made between (fully) virtual, augmented (superimposed) and mixed (both virtual and superimposed) reality.
  - Security, data protection and blockchain: Describes the increasing relevance of data protection due to the fact that increasingly more data is generated and processed with and without reference to individuals. The focus here is on blockchain technology, whereby encrypted data (blocks) and their changes are documented (chained) and cannot be falsified.
  - Digital accessibility and open data: Describes the need for access to data. The category refers to the possibility of sending and receiving data. On another level it refers to the structure in which the data is available and how it may be used.
  - Cloud computing: Describes the possibility for data and software to no longer requiring installation and storage on local computers, but being available in a cloud system. This type of data management means that software can be continuously updated and data can be collaboratively processed and/or shared.
- Data ecosystem
  - Digital platforms: Business models that serve as intermediaries to link supply and demand. Digital platforms make use of data on the platform by processing it to create services (data economy).
  - Social networks and reputation management: Social networks (Facebook, Instagram, Twitter, etc.) enable communication between their users. Users can be individuals as well as companies or organisations. Which information appears in the flow of data with which priority depends on one's digital reputation.
  - Sharing economy: Platform business models based on sharing; it usually takes place between private individuals, but is increasingly also used commercially.

The second objective is the *identification and assessment of opportunities and risks*. Special consideration is given to the behaviours of different user groups and how they influence a change in travel volume and travel behaviour. The focus is thus on gaining an overview of any possible direct effects of digitisation. This study does not aim to quantify these effects, such as on air, water and ground, biodiversity, climate impact or CO_2 emissions.

On the one hand, digital applications can influence a *change in travel volume*. This refers to changes in the number of trips as well as distance covered and number of days away. An increase in travel volume generally constitutes more of a risk than an opportunity for sustainable tourism development.

On the other hand, digital applications can influence *changes to travel behaviour*. This refers to how travellers organise their trip, such as with regard to mobility (e. g. choice of transport to and from the destination and at the destination), accommodation (type and category) and organisation of stay (e. g. type and number of POIs visited). The choice of destination itself, however, is also part of the travel behaviour, for example with regard to particularly sustainable destinations.

It should be emphasised that the **sustainability opportunities and risks** identified in this study are not necessarily opportunities and risks. Many if not all applications cited here are about organisational possibilities. Here it depends on whether the possibilities of digitisation are taken advantage of to facilitate sustainability, especially on the provider side, or whether sustainability is not taken into account. **A priori, digitisation is neither positive nor negative**. In principle, technological progress opens up new possibilities for travel arrangement and the management of travel processes. This will always depend, however, on the extent to which aspects of sustainability are consciously taken into account in the individual processes. The basic requirement is that the issue of sustainability gains more relevance in society, because only then will policy-makers, administrations, researchers and companies take sufficient account of ecological and social aspects of sustainability in the development and use of digital technologies.

This study (change in travel volume and change in travel behaviour) identified, described and assessed *paths of impact* for each of the eleven digitisation categories. A path of impact, in analogy to the method already applied in the "Consumption 4.0" study(Keppner et al. 2018), is a verbal description of the possible future effect of a digital application. These paths of impact are differentiated according to:

- Content
  - Classification to one of the eleven categories or as a "cross-category"
  - Short description and, if necessary, illustration using examples
- Impact direction
  - Positive paths of impact describe a sustainability opportunity
  - Negative paths of impact describe a sustainability risk
- Impact category
  - Effect on travel volume
  - Effect on travel behaviour

- Assessment using a scoring model
  - Potential level of impact, on a scale from 0 (= no impact) to 10 (= very high impact)
  - Probability of realisation, on a scale from 0 (= impossible) via 1 (= extremely unlikely) to 10 (= already realised)
  - Time-scale of realisation, on a scale from 0 (= never) via 1 (= in the distant future) to 10 (= already realised)
  - Reliability of assessment, on a scale from 0 (= we are not at all sure about our assessment) to 10 (= we are very certain about our assessment)

The authors carried out the assessments using the scoring models on the basis of comprehensive literature and example research. In order to increase assessment reliability, feedback was collected during a meeting of experts with 18 participants in January 2019 and from the specialist departments of the UBA and the BMU. Nevertheless, the assessment was carried out by the authors. Two aspects complicated the assessment: Firstly, very little data is available to evaluate specific paths of impact. Even the paths of impact that have been known and discussed for a long time are difficult or impossible to back up with concrete data; this includes tourism-related resource consumption of data centres and IT infrastructure. And secondly, this is particularly true when the effects of very new applications are assessed, which means you have to look to the future and speculate.

Nevertheless, a total of 52 paths of impact were identified. Only two of them entirely eluded assessment using the scoring model: There is firstly the tourism-related consumption of energy and resources by the network and IT infrastructure, and secondly, the tourism-enhancing efficiency effect of digitisation, i.e., the ability of providers to generally apply digitised processes in such a way that efficiency increases, which in turn enables price and competitive advantages within the sector and in comparison with other sectors.

The following key results can be derived from the assessment of the remaining 50 paths of impact in terms of structure and content:

- Overall, significantly more positive (34) than negative (15) paths of impact were identified. This study thus identified **more opportunities than risks** from digitisation.
- If you include the assessment, the positive paths of impact are rated higher on average (6.4) as well as overall (219 scoring points) than the negative paths of impact (6.2 and 93 scoring points). The identified **opportunities** are thereby seen as having a greater impact than risk.
- In terms of travel behaviour, we identify significantly increased and more effective opportunities than risks. The opposite is the case for travel volume: Here, the number and the impact of the risks outweigh the opportunities. Or, if you reverse the perspective: If we look at the opportunities, they predominantly relate to travel behaviour and only very rarely to travel volume. If we look at the risks, they relate more to travel volume and less to travel behaviour.
- In many areas of application, we identified both a positive and a negative path of impact for the same application. Many impacts are thus ambivalent and can be deployed in a positive or negative way – this depends on which priorities are set on the part of the supplier or wheth-

er taking sustainability aspects on the part of the consumer into account leads to higher acceptance and thus marketability. One example is the use of virtual reality before travelling: This can lead to the trip not being taken in the first place because the virtual world serves as a substitute. This surrogate function already occurs quite frequently when it comes to business trips (video conferencing, etc., instead of the trip) and may be expanded to include private trips as technology advances. It is just as conceivable, however, that engaging with and exploring the destination virtually makes someone want to travel in order to not only experience the virtual substitute, but also the destination itself.

- The greatest opportunities for sustainability lie in the "artificial intelligence" category: It has the most positive paths of impact (8), which in addition have a high average relevance (7.0).
- The greatest sustainability risks lie in the "big data analytics" category with three paths of impact and an average relevance of 7.7. It must be emphasised, however, that assigning individual applications to categories is not an exact science. The categories are intertwined to such an extent that there are few applications that can only be assigned to a single category.
- Significant sustainability risks result from the fact that large companies in the tourism industry that are not particularly geared to sustainability use the potential of digitisation to increase volume (more and more trips) faster than the industry as a whole can realise the sustainability opportunities of digitisation with regard to travel behaviour. This potential primarily lies in the more efficient production and marketing of travel using networked, big data-driven digitisation techniques (paths of impact via market research and product design as well as more efficient target-group-oriented customer information). Companies that are able to use such techniques efficiently and effectively, especially due to their size, are better able to identify and monetise the needs of their customers and can do so faster. What is more, it is precisely these companies that are well placed to utilise the mechanisms of the platform economy. Furthermore, there is a risk for employees in the tourism industry, whose jobs are in jeopardy due to digitally automated customer support and service.
- Digitisation makes *travelling seamless*, because airport check-ins are straightforward with digital technologies, digital payment systems make foreign currency exchange obsolete and translation-on-demand services overcome language barriers. Furthermore, digital platforms can easily bring together supply and demand, niche offers become more visible and even private individuals can offer their services as part of the sharing economy. All these developments tend to lead to more rather than less travel and therefore, on balance, to more environmental impact, which we identified as the general efficiency effect.
- However, the risks are offset by numerous opportunities. The opportunities here can be found in the sphere of digital mobility, such as self-regulating, corrected traffic systems. In this context, possible savings through the optimised utilisation of mobility, accommodation and leisure resources (sharing) also deserve a mention. We see a further opportunity of digitisation in resource-saving smart facilities (hotels and other accommodation facilities, leisure facilities) such as self-regulating heating systems or "smart" showers, which help to reduce consumption by preheating the water.

- We believe that the most high-impact opportunities result from digitisation's potential to change the behaviour of consumers. More transparent real time information (such as about the capacity utilisation of attractions or the current weather and environmental situation) combined with intelligent recommendations (rec*ommender agents*) of the more sustainable alternative have the potential to encourage behavioural changes. Digitisation offers numerous opportunities to provide incentives for choosing the more sustainable alternative – through reward systems, real-time benefit promises, transparent information, awareness-raising or nudging. The Internet of Things is about the collection of data using sensors and their interconnections. We expect these opportunities to be successfully realised in the form of visitor guidance rather than "hard" visitor influence.
- Conversely, this also means that the measuring and analysing of a wide variety of variables has enormous potential for sustainable development in tourism. In the case of the identified examples that are assigned to this area, the analysis of the behaviour within the action space is particularly significant. Visitor flow and the consumption of resources associated with these movements and the activities of visitors can be measured more easily in the future, and resource-saving measures can be derived from this. These examples illustrate that awareness can be raised among visitors by making consumption transparent. This also means that tourists can be encouraged to choose an alternative behaviour. In our view, this is the biggest set of opportunities for sustainable tourism development through digitisation.

So far, we are only at the beginning of a development. While until now, considerations regarding digitisation mainly related to the periods before and after the trip, a clear change is emerging: Questions concerning digitisation are now increasingly about the trip itself. This is why many upheavals can currently be observed at the destinations and in the tourism companies. What matters now is how these questions are answered and how the destinations and businesses themselves are organised. This study provides a basis on which to build. The findings of this study are to provide the necessary understanding that aspects of sustainability should be taken into account before implementing digitisation.

Zusammenfassung

Deutsche Berichtsfassung vergübar

Der vollständige Bericht ist auch in deutscher Sprache (Originalfassung) unter dem Titel „Die Auswirkungen der Digitalisierung und Big Data-Analyse auf eine nachhaltige Entwicklung des Tourismus und dessen Umweltwirkung“ verfügbar.

Die Studie „Die Auswirkungen der Digitalisierung und Big Data-Analyse auf eine nachhaltige Entwicklung des Tourismus und dessen Umweltwirkung“ untersucht, welchen Einfluss die Digitalisierung auf die nachhaltige Tourismusentwicklung in der ökologischen und sozialen Dimension haben kann und welche Chancen und Risiken sich daraus ergeben.

Die Studie verfolgt zwei wesentlich Ziele.

Das erste Ziel ist die *Strukturierung des Themenfeldes*. Sowohl „Digitalisierung“ als auch „nachhaltige Entwicklung des Tourismus“ werden in vielfältiger Weise verwendet und je nach Zusammenhang unterschiedlich scharf abgegrenzt.

Auf der Nachhaltigkeitsseite interessieren wir uns besonders für die Effekte des Reisens auf *Natur und Umwelt* (also auf Luft, Wasser und Boden, auf Landschaft und Flächenverbrauch, auf Biodiversität und Ökosysteme, auf Klimawirkung und CO_2-Emissonen, den Wasser-, Energie- und Rohstoffverbrauch, auf Abwasser und Abfall und die Öko-Systemleistungen) und auf *Soziales* (also auf Partizipation und Inklusion, Begegnungen, kulturelle Werte sowie Jobs und Einkommensverteilung). Diese Effektkategorien sind der Literatur entnommen.

Auf der Seite der Digitalisierung wurden im ersten Schritt aktuelle Entwicklungen in der Digitalisierung systematisch identifiziert und auf ihren möglichen aktuellen und zukünftigen Beitrag zu einer nachhaltigen Tourismusentwicklung hin untersucht. Dabei wurde sowohl die Digitalisierung auf Seiten der Nachfragenden (Touristinnen und Touristen) als auch der Anbietenden berücksichtigt. Im Fokus stand dabei die Nutzung digitaler Anwendungen *während* der Reise. Im Ergebnis konnten wir elf relevante Kategorien der Digitalisierung identifizieren und anhand von vier Aspekten systematisieren. Die vier Systematisierungsaspekte sind die Kategorien selbst (Oberthemen und Anwendungsbereichen), Märkte (Phasen der Customer Journey und wesentlich betroffene Segmente), Diffusion (Stand und Perspektive der technischen Entwicklung) und Wirkpotenziale (Wirkrichtungen und Wirkpfade). Zum leichteren Verständnis wurden alle Kategorien durch Beispiele in Form konkreter Anwendungen oder Planungen illustriert. Alle Beispiele sind im Anhang dokumentiert. Die elf so beschriebenen Kategorien lassen sich in drei Sphären verorten. In der **Data Connectivity** geht es um die Erhebung und Verknüpfung von Daten sowie deren Verarbeitung. Die **Data Infrastructure** ermöglicht die Datenkonnektivität und die Ausgabe der weiterverarbeiteten Daten in Form von digitalen Service-Anwendungen. Das **Data Ecosystem** schließlich **ist** die Geschäftsgrundlage für derartige Anwendungen. In diese Sphären werden die Kategorien in der folgenden Struktur eingeordnet:

- Data Connectivity
  - Big Data Analytics: Beschreibt die Untersuchung von komplexen Datensätzen mithilfe von (automatisierten) Analyseverfahren, um Zusammenhänge, Bedeutungen und Muster in diesen zu erkennen.
  - Internet der Dinge und Geo-Intellligence: Beschreibt die Verknüpfung sowie den Datenaustausch zwischen Gegenständen, Geräten und Systemen, die oftmals Geodaten nutzen, um sogenannte Location Based Services (LBS) zu realisieren.

- Künstliche Intelligenz: Beschreibt Systeme, die die Datenauswertung kontinuierlich und eigenständig weiterentwickeln. Künstliche Intelligenz ist ein Zusammenspiel von Massendaten (Big Data), ausreichenden Rechenressourcen und maschinellem Lernen.

► Data Infrastructure

- Smart Mobile Devices und Digital Payment: Beschreibt das Aufkommen neuer und hochtechnologischer Mobiltelefone mit denen Reisende auf das Internet zugreifen und Dienste nutzen können. Die Besonderheit ist dabei, dass Gäste diese Geräte mit ihren vielfältigen Einsatzmöglichkeiten selbst mitführen und diese zudem personalisiert sind, sodass eine Identifikation sowie Bezahlvorgänge hierüber realisiert werden können.
- Erweiterte Realität (AR, VR, MR): Beschreibt die Überlagerung der Wirklichkeit mit computergenerierten Daten mittels eines Displays (bspw. dem eines Smartphones). Es kann zwischen (vollständig) virtueller, augmentierter (überlagerter) und gemischter (virtueller und gleichzeitig überlagerter) Realität unterscheiden werden.
- Sicherheit, Datenschutz und Blockchain: Beschreibt die zunehmende Relevanz des Datenschutzes aufgrund der Tatsache, dass zunehmend mehr Daten mit und ohne Personenbezug erzeugt und verarbeitet werden. Der Fokus liegt auf der Blockchain-Technologie, bei der verschlüsselte Daten (Blöcke) sowie deren Veränderungen dokumentiert (verkettet) werden und dabei nicht gefälscht werden können.
- Digital Accessibility und Open Data: Beschreibt die Notwendigkeit des Zugangs zu Daten. Die Kategorie bezieht sich dabei auf die Möglichkeit, Daten zu senden und zu empfangen. Auf einer weiteren Ebene bezieht sie sich darauf, in welcher Struktur die Daten vorliegen und wie diese (weiter-)verwendet werden dürfen.
- Cloud Computing: Beschreibt die Möglichkeit, dass Daten und Software nicht mehr auf lokalen Rechnern installiert und gelagert werden müssen, sondern in einem Cloud-System vorliegen. Diese Art der Datenhaltung führt dazu, dass Software kontinuierlich aktualisiert werden können und Daten kollaborativ bearbeitet und/oder geteilt werden können.

► Data Ecosystem

- Digitale Plattformen: Geschäftsmodelle, die als Intermediär Angebot und Nachfrage miteinander verbinden. Digitale Plattformen setzen Daten auf der Plattform in Wert, indem sie diese zu Services verarbeiten (Datenökonomie).
- Soziale Netzwerke und Self Reputation Management: Soziale Netzwerke (Facebook, Instagram, Twitter etc.) ermöglichen die Kommunikation zwischen ihren Nutzern. Nutzer können Personen, aber auch Unternehmen oder Organisationen sein. Welche Informationen mit welcher Priorität im Datenstromerscheinen, hängt auch von der digitalen Reputation ab.

- Sharing Economy: Plattformgeschäftsmodelle auf Basis von Austausch (Sharing), der meist zwischen Privatpersonen stattfindet, aber mittlerweile auch kommerzielle Strukturen angenommen hat.

Das zweite Ziel ist die *Identifizierung und Bewertung von Chancen und Risiken*. Besondere Berücksichtigung finden dabei die Verhaltensweisen unterschiedlicher Nutzergruppen mit den Einflüssen auf eine Veränderung des Reisevolumens und eine geänderte Reisegestaltung. Entsprechend liegt der Fokus darauf, einen Überblick über mögliche unmittelbare Auswirkungen der Digitalisierung im Vordergrund. Eine Quantifizierung dieser Auswirkungen auf beispielsweise Luft, Wasser und Boden, Biodiversität, Klimawirkung oder CO2-Emissonen usw. ist nicht Inhalt dieser Studie.

Zum einen können digitale Anwendungen auf eine *Veränderung des Reisevolumens* einwirken. Damit werden Veränderungen der Reiseanzahl, aber auch der zurückgelegten Distanz und der während der Reise verbrachten Aufenthaltstage beschrieben. Eine Vergrößerung des Reisevolumens stellt im Allgemeinen eher ein Risiko als eine Chance für die nachhaltige Tourismusentwicklung dar.

Zum anderen können digitale Anwendungen die *Veränderung der Reisegestaltung* beeinflussen. Damit wird beschrieben, wie Reisende ihre Reise im Hinblick auf Mobilität (z. B. Verkehrsmittelwahl zur An- und Abreise und im Zielgebiet), Unterkunft (Art und Kategorie der Unterkunft) und Aufenthaltsgestaltung (z. B. Art und Zahl der besuchten PoI) ausgestalten. Aber auch die Destinationswahl selbst ist Teil der Reisegestaltung, etwa im Hinblick auf besonders ausgezeichnet nachhaltige Destinationen.

In diesem Zusammenhang ist zu betonen, dass die in dieser Studie aufgezeigten **Nachhaltigkeitschancen und -risiken keine Automatismen** sind. Bei vielen, wenn nicht allen angeführten Anwendungen gibt es Gestaltungsmöglichkeiten. Hier kommt es darauf an, ob die Möglichkeiten der Digitalisierung vor allem auf der Anbieterseite positiv im Sinne der Nachhaltigkeit genutzt werden, oder ob Aspekte der Nachhaltigkeit dort keine Berücksichtigung finden. **Die Digitalisierung als solche ist a priori weder positiv oder negativ**. Grundsätzlich eröffnen sich durch den technologischen Fortschritt neue Möglichkeiten zur Gestaltung der Reisen und des Managements der Reiseprozesse. Im Grundsatz wird es jedoch immer darauf ankommen, inwieweit bei den einzelnen Prozessen Nachhaltigkeitsaspekte bewusst Berücksichtigung finden. Grundvoraussetzung ist entsprechend, dass das Thema Nachhaltigkeit eine gesellschaftlich relevantere Stellung erhält, denn nur dann werden sowohl Politik, Verwaltung, Forschung als auch Unternehmen bei der Entwicklung und Nutzung digitaler Techniken ökologische und soziale Aspekte der Nachhaltigkeit hinreichend berücksichtigen.

In dieser Studie (Veränderung des Reisevolumens und Veränderung der Reisegestaltung) wurden für jede der elf identifizierten Digitalisierungskategorien *Wirkpfade* identifiziert, beschrieben und bewertet. Ein Wirkpfad ist dabei, in Analogie zu der bereits in der Studie „Konsum 4.0“ (Keppner et al. 2018) angewendeten Methode, eine verbale Beschreibung der möglichen zukünftigen Wirkung einer digitalen Anwendung. Diese Wirkpfade wurden differenziert nach:

- Inhalt
  - Zuordnung zu einer der elf Kategorien oder als „kategorienübergreifend“
  - Kurze Beschreibung und ggf. Illustration durch Beispiele

- Wirkrichtung
  - Positive Wirkpfade beschreiben eine Nachhaltigkeitschance
  - Negative Wirkpfade beschreiben ein Nachhaltigkeitsrisiko
- Wirkkategorie
  - Wirkung auf das Reisevolumen
  - Wirkung auf die Reisegestaltung
- Bewertung im Scoring-Modell
  - Potenzielle Wirkstärke, auf einer Skala von 0 = keine Wirkung bis 10 = sehr große Wirkung
  - Realisierungswahrscheinlichkeit, auf einer Skala von 0 = ausgeschlossen über 1 = sehr unwahrscheinlich bis 10 = schon da
  - Realisierungszeit, auf einer Skala von 0 = nie über 1 = in ferner Zukunft bis 10 = schon da
  - Sicherheit der Bewertung, auf einer Skala von 0 = wir fühlen uns in unserer Bewertung sehr unsicher bis 10 = wir fühlen uns in unserer Bewertung sehr sicher

Die Bewertungen im Rahmen des Scoring-Modells erfolgten durch die Autoren auf Basis umfangreicher Literatur- und Beispielrecherchen. Zur Erhöhung der Bewertungssicherheit fand eine Rückkopplung mit 18 Teilnehmenden im Rahmen eines Fachgespräches im Januar 2019 und mit den Fachreferaten des UBA und des BMU statt. Gleichwohl bleibt die Bewertung eine Einschätzung der Autoren. Diese Bewertung wird durch zwei Aspekte erschwert: Erstens ist die Datenlage für die Bewertung konkreter Wirkpfade äußerst dünn. Selbst Wirkpfade, die seit langem bekannt sind und diskutiert werden, sind nur schwer oder gar nicht mit konkreten Daten zu hinterlegen, wie zum Beispiel der tourismusbezogene Ressourcenverbrauch von Rechenzentren und IT-Infrastruktur. Und zweitens gilt dies in besonderem Maße dann, wenn Wirkungen auf Anwendungen bewertet werden, deren Entwicklung noch sehr jung ist und der Blick damit zwingend auf die Zukunft gerichtet werden muss.

Gleichwohl konnten insgesamt 52 Wirkpfade identifiziert werden. Lediglich zwei davon entzogen sich einer Bewertung im Rahmen des Scoringmodells vollständig: Zum einen der tourismusbezogene Energie- und Ressourcenverbrauch durch die Netzwerk- und IT-Infrastruktur, zum anderen der tourismus-nachfragesteigernde Effizienzeffekt der Digitalisierung, also die Fähigkeit der Anbieter, digitalisierte Prozesse im Allgemeinen so anzuwenden, dass Effizienzsteigerungen und damit Preis- und Wettbewerbsvorteile innerhalb der Branche und im Vergleich zu anderen Branchen möglich sind.

Aus der Bewertung der verbliebenen 50 Wirkpfade lassen sich im Hinblick auf Struktur und Inhalt die folgenden zentralen Ergebnisse ableiten:

- Insgesamt konnten deutlich mehr positive (34) als negative (15) Wirkpfade identifiziert werden. Es konnten im Rahmen dieser Studie also **mehr Chancen als Risiken** durch die Digitalisierung identifiziert werden.

- Bezieht man die Bewertung mit ein, so sind die positiven Wirkpfade sowohl durchschnittlich (6,4) als auch insgesamt (219 Scoringpunkte) höher bewertet als die negativen Wirkpfade (6,2 bzw. 93 Scoringpunkte). Also werden die identifizierten **Chancen wirkmächtiger** eingeschätzt als die Risiken.

- Im Hinblick auf die Reisegestaltung finden wir deutlich mehr und wirkmächtigere Chancen als Risiken. Im Hinblick auf das Reisevolumen ist es umgekehrt: Hier überwiegen Zahl und Wirkmächtigkeit der Risiken gegenüber den Chancen. Oder in umgekehrter Perspektive: Betrachten wir die Chancen, so beziehen diese sich ganz überwiegend auf die Reisegestaltung und nur sehr selten auf das Reisevolumen. Betrachten wir die Risiken, so beziehen sie sich stärker auf das Reisevolumen und weniger stark auf die Reisegestaltung.

- In vielen Anwendungsbereichen konnten wir für die gleiche Anwendung sowohl einen positiven als auch einen negativen Wirkpfad identifizieren. Viele Wirkungen sind somit ambivalent und können sowohl positiv als auch negativ genutzt werden – je nachdem, welche Prioritäten auf Angebotsseite gesetzt werden oder ob die Berücksichtigung von Nachhaltigkeitsaspekten auf Nachfrageseite zu einer höheren Akzeptanz und damit Marktfähigkeit führt. Ein Beispiel ist die Anwendung von Virtueller Realität vor der Reise: Sie kann dazu führen, dass Reisen gar nicht erst angetreten werden, weil die virtuelle Welt als Ersatz dient. Diese Surrogatfunktion kommt bereits bei Geschäftsreisen recht häufig vor (Ersatz der Reise durch Videokonferenzen etc.) und könnte sich mit fortschreitender Technik auf die Privatreisen ausweiten. Ebenso gut ist es aber denkbar, dass die Auseinandersetzung mit der virtuellen Destination erst recht Lust aufs Reisen macht, um nicht nur das Surrogat, sondern auch das Original zu erleben.

- Die größten Nachhaltigkeitschancen liegen in der Kategorie „Künstliche Intelligenz“: Sie weist die meisten positiven Wirkpfade auf (8), die zudem mit einer hohen durchschnittlichen Relevanz versehen wurden (7,0).

- Die größten Nachhaltigkeitsrisiken liegen in der Kategorie „Big Data Analytics“ mit drei Wirkpfaden und einer durchschnittlichen Relevanz von 7,7. Es muss bei dieser Betrachtung aber betont werden, dass die Zuordnung einzelner Anwendungen zu den Kategorien nicht immer trennscharf ist. Die Kategorien sind so stark verschränkt, dass kaum eine Anwendung nur einer Kategorie zuzuordnen wäre.

- Wesentliche Nachhaltigkeitsrisiken resultieren daraus, dass nicht besonders auf Nachhaltigkeit ausgerichtete große Unternehmen der Tourismusbranche die Potenziale der Digitalisierung für eine Volumenzunahme (mehr und weitere Reisen) schneller nutzen als die Branche insgesamt die Nachhaltigkeitschancen der Digitalisierung bei der Reisegestaltung realisieren kann. Diese Potenziale liegen vor allem in der effizienteren Produktion und Vermarktung von Reisen durch die Anwendung vernetzter, Big Data-getriebener Digitalisierungstechniken (Wirkpfade über Marktforschung und Produktgestaltung sowie effizientere zielgruppenorientierte Kundeninformation). Unternehmen, die vor allem aufgrund ihrer Größe solche Techniken effizient und effektiv nutzen können, sind in der Lage, die Bedürfnisse ihrer Kunden besser und schneller zu erkennen und zu monetarisieren. Zudem sind gerade diese Un-

ternehmen besonders gut in der Lage, Mechanismen der Plattformökonomie einzusetzen. Hinzu tritt ein Risiko für die (heute noch) Beschäftigten der Tourismusbranche durch Arbeitsplatzverlust aufgrund von digital gesteuerter Automatisierung von Kundenberatung und -service.

- Durch die Digitalisierung wird das Reisen übergangslos (*Seamless Travel*), denn Abfertigungen am Flughafen sind durch digitale Eincheck-Technologien angenehm durchführbar, digitale Bezahlsysteme lassen umständliche Geldwechsel entfallen und mittels Translation on Demand-Services können Sprachbarrieren überwunden werden. Zum anderen können über digitale Plattformen Angebot und Nachfrage sehr leicht verbunden, Nischenangebote einfach wahrgenommen und durch Angebote der Sharing Economy Dienste von Privatpersonen in Anspruch genommen werden. All diese Entwicklungen führen in ihrer Tendenz eher zu mehr denn weniger Reisen und damit per Saldo zu einer höheren Belastung für die Umwelt, was wir auch mit dem übergreifenden Effizienzeffekt betont haben.

- Den Risiken stehen zahlreichere Chancen gegenüber. Zu den Chancen gehören unter anderem Möglichkeiten, die sich in der digitalisierten Mobilität finden lassen, etwa selbstregulierende, entzerrte Verkehrssysteme. In diesem Zusammenhang sind auch mögliche Einsparungen durch die optimierte Nutzung von Mobilitäts-, Unterkunfts- und Freizeitressourcen (Sharing) zu nennen. Eine weitere Chance der Digitalisierung sehen wir in der Verbreitung von ressourcenschonenden Smart Facilities (Hotels und andere Unterkunftsbetriebe, Freizeitbetriebe) wie etwa selbstregulierende Heizsysteme oder „smarte“ Duschen, die den Verbrauch durch Vorheizen des Wassers reduzieren helfen.

- Die nach unserer Einschätzung wirkkräftigsten Chancen resultieren aus den Möglichkeiten, welche die Digitalisierung für eine Verhaltensänderung der Nachfragenden enthält. Transparentere Echtzeit-Informationen (etwa über die Auslastung von Attraktionen oder die aktuelle Wetter- und Umweltsituation) in Verbindung mit intelligenten Empfehlungen (Rec*ommender*) für die nachhaltigere Alternative haben das Potenzial, Verhaltensänderungen zu stimulieren. Digitalisierung bietet zahlreiche Chancen, Anreize für die Wahl der nachhaltigeren Alternative zu setzen – durch Belohnungssysteme, Echtzeit-Nutzenversprechen, transparente Information, Bewusstseinsbildung oder Veränderung des Informationsumfeldes (Nudging). Mit dem Internet der Dinge wird zum einen die Erhebung von Daten mittels Sensoren sowie deren Vernetzung betont. Wir erwarten, dass sich diese Chancen weniger als „harte“ Besucherinnenlenkung, sondern eher Besucherbeeinflussung erfolgreich realisieren lassen.

- Im Umkehrschluss bedeutet dies zum anderen, dass in der Messung unterschiedlichster Variablen sowie deren Auswertung ein enormes Potenzial auch für die nachhaltige Entwicklung im Tourismus liegt. Bei den identifizierten Beispielen, die diesem Bereich zuzuordnen sind, wird insbesondere die Auswertung des aktionsräumlichen Verhaltens deutlich. Besuchendenströme sowie der mit diesen Bewegungen und den Aktivitäten der Gäste verbundene Ressourcenverbrauch können künftig einfacher gemessen werden und es lassen sich daraus Maßnahmen zur Einsparung von Ressourcen ableiten. Innerhalb der Beispiele wurde dabei deutlich, dass zum einen über die Transparenz des Verbrauchs eine Sensibilisierung

der Gäste stattfinden kann. Zum anderen können Touristinnen und Touristen dann aber auch zu einem alternativen Verhalten animiert werden. Dies ist aus unserer Sicht der größte Chancenkomplex für die nachhaltige Tourismusentwicklung durch Digitalisierung.

Insgesamt stehen wir erst am Anfang einer Entwicklung. Bezogen sich Überlegungen, welche die Digitalisierung betreffen bisher überwiegend auf den Bereich vor und nach der Reise, so ist hier eine klare Veränderung zu erkennen: Fragestellungen, welche die Digitalisierung betreffen, sind jetzt verstärkt auch während der Reise sichtbar. Dementsprechend kommt es aktuell zu vielen Umwälzungen in den Destinationen und Tourismusbetrieben selbst. Nun kommt es also darauf an, wie diese Fragestellungen beantwortet und damit die Destinationen und Betriebe selbst ausgestaltet werden. Diese Studie hält dafür Grundlage bereit, auf die es aufzubauen gilt. Aus den Erkenntnissen, die diese Studie aufzeigt, sollte die Einsicht entstehen, alle Digitalisierungsschritte auch im Sinne der Nachhaltigkeit zu überdenken, bevor es in die Umsetzung geht.

1 Introduction

This study examines the impact of digitisation on the sustainable development of tourism and its environmental impact.

We will first describe what tourism is, how we define sustainable tourism and what tourism means for us in the digital age. We will then discuss the objectives of the study and the details of the study. We will describe more specifically, which types of effects we can study in this report (opportunities and risks of digitisation in tourism), and which not (quantified impacts trough tourism). It is the objective of this study to assess the complex interrelationships between digitisation, sustainability and tourism, structure them and to make them accessible for prioritising consideration. Quantified impact analyses are outside the scope of this study and will be reserved for further research.

1.1 Tourism

Tourism is defined as the activity of tourists. This definition is accepted across Europe and throughout the world (Eurostat 2013; United Nations 2010; United Nations et al. 2010). It is a very comprehensive destination, because tourism includes all travel, accommodation and residential activities provided the traveller returns to their usual place of residence, the destination is further away than the traveller's usual environment, the trip does not involve employment in an organisation at the destination and does not last longer than one year.

Tourism is what tourists do

"A trip refers to the travel by a person from the time of departure from their usual residence until they return: it thus refers to a round trip. A trip is made up of visits to different places. (…)

A visitor is a traveller taking a trip to a main destination outside their usual environment, for less than a year, for any main purpose (business, leisure or other personal purpose) other than to be employed by a resident entity in the country or place visited. These trips taken by visitors qualify as tourism trips. Tourism refers to the activity of visitors." (United Nations 2010)

In addition, "frequent" or "regular" visits do not fall under the tourism definition (although this does not apply to holiday homes, which do fall under the definition). The problem of such a wide definition is perhaps best illustrated by reversing it: Migration (longer than one year), commuting (employment with an organisation at the destination) and activities in one's usual environment (e. g. recreational activities in the residential area) or trips undertaken often or regularly do not count as tourism.

This raises some obvious problems of definition. Strictly speaking, activities in typical tourism professions (e. g. travel guide) could be defined as tourism. The shopping trip to IKEA can be just as much a part of tourism as a rare visit to the cinema in a neighbouring town. And can a truck driver who spends a night at a rest stop hotel away from their usual route really be described as a tourist? It is included in the accommodation statistics, but is that what we mean when we look at the impact of digitisation on sustainable tourism in this study? Do we really mean a visit to the cinema in the neighbouring town or going to IKEA (which of course are not included in the accommodation statistics)? And if not: How do we distinguish between an IKEA visit and a day on the beach, which we generally describe as "day trip tourism"?

Irrespective of the definitional problems described above, it becomes clear that tourism not only includes "overnight trips for personal enjoyment", because the following also counts as tourism:

- **Private trips** and **non-private trips** and mixed forms. Private trips are holidays and visiting trips, for example. Non-private trips include business trips or trips for the purpose of professional training. Mixed forms include private extensions of a business trip or private leisure activities during a business trip.
- **Overnight travel** (at least one overnight stay) and **day trips** (no overnight stay).

Some data sources use distance-dependent definitions; the GfK Mobility Monitor, for example, records travel volumes from 50 km (Reif et al. 2017). Other studies make distinctions based on time away; the Reiseanalyse travel survey, for example, distinguishes between "long" holidays of five days or more and "short" holidays of two to four days (Schmücker, Grimm, and Wagner 2018), while the Tourismusanalyse survey only considers long holidays of five days or more (Reinhardt, Hilbinger, and Eilzer 2017). The World Travel Monitor, on the other hand, only covers trips abroad with at least one overnight stay and a maximum duration of three months (Freitag 2017).

With regard to the source-target market relation, three different groups are generally distinguished (United Nations 2010):

- **Inbound trip**: Travel from outside a country (or destination). Often also referred to as incoming tourism.
- **Outbound trip**: Travel to another country (or destination). Often also referred to as outgoing tourism.
- **Domestic trip**: Travel within a country (or destination). This can be referred to as domestic tourism.

Because the term tourism is defined so widely and differently, there are no measurements for tourism as a whole. Each data source only describes one part of tourism as a whole. Thus, when considering the status and development of tourism, we must differentiate in each case which part of tourism is represented by the available data.

1.2 Sustainable tourism

Sustainable tourism is understood to mean "an economically viable development that enables demand to remain stable or grow with little or no additional impact on the ecological and social environment" (Schmied et al. 2009; Günther et al. 2014).

This is a pragmatic definition that may be misleading. For it goes without saying that "no additional impact on the ecological and social environment", irrespective of the development of demand, can objectively be "too much" because certain limits have already been exceeded.

An even softer definition of *sustainable tourism* is provided by the World Tourism Organization (UNWTO): "Tourism that takes full account of its current and future economic, social and environmental impacts, addressing the needs of visitors, the industry, the environment and host communities"[1]. While this is a popular definition (Postma, Cavagnaro, and Spruyt 2017), it is

[1] http://sdt.unwto.org/content/about-us-5, accessed on 8 April 2019

ultimately unhelpful, because it places too much focus on awareness (or taking account of) and too little on actual impact.

The practical guide of the DTV (*Nachhaltigkeit im Deutschlandtourismus (Sustainability in tourism in Germany)* also uses the UNWTO definitions from the early 1990s: "Sustainable tourism not only meets the needs of tourists and the local population in the destinations, it also contributes to safeguarding and improving future development opportunities. Resources are used to meet economic, social and aesthetic needs, while preserving cultural integrity, essential ecological processes, biological diversity and essential systems that satisfy our basis needs" (Balas and Rein 2016).

Balaš and Strasdas proffer a similar argument when they reject the sustainable vs. unsustainable tourism dichotomy and instead demand: "In the context of the modern understanding of sustainability as an ethically founded concept of an intra- and intergenerationally equitable global development such a delimitation is much more complex, since sustainability leaves it to the social deliberation process to decide how the content pans out. This would have to be based on a binding understanding of sustainability that outlines which specifications, guidelines or rules are associated with sustainable tourism. This in turn requires binding criteria and goals to be determined in public debate. The problem here is that there is no morally legitimised specialist authority that could prescribe standard social guidelines. Rather, value judgements have to be made to choose between heterogeneous and often conflicting interests. In addition, the target values necessary for delimitation are characterised by a high degree of factual and social complexity, which is further increased by the very complex structure of tourism." (Balaš and Strasdas 2018, 25f.) They believe that "…the term 'sustainability in tourism' is used correctly when the applicable principles of sustainability are to be transposed into all tourist activities and levels of action and the developmental nature is to be presented." (Balaš and Strasdas 2018)

While these definitions and explanations have many advantages given their comprehensiveness, they are a little too abstract for our study. To evaluate developments, we need at least a general guiding idea of what sustainability is in practice. When we consider the paths of impact, we are essentially concerned with the question of whether a particular development (digitisation, big data analysis) *has a positive or negative effect on the ecological and social aspects of sustainability*. Tourism, i.e., tourist mobility and staying at the destination including the associated upstream and downstream services, undoubtedly has an effect on the natural environment, but also on the social and economic aspects of society. We are ignoring the economic aspects because it can be taken as a given that a tourism provider has an economic incentive to generate income. However, we consider the question of income distribution to be part of the social dimension and therefore examine it in the context of the paths of impact.

Sustainable tourism development is the attempt to reduce the negative effects of tourism (risks) and to strengthen the positive effects (opportunities). The criteria for sustainable tourism of the *Global Sustainable Tourism Council* (GSTC) are also laid out with this in mind:

"In order to meet the definition of 'sustainable tourism', destinations must adopt an interdisciplinary, holistic and integrative approach that includes the following four main objectives:

(i) Effective sustainability management;

(ii) Maximising the social and economic benefits for the local population;

(iii) Preservation of the cultural heritage and maximisation of benefits for the local population and visitors;

(iv) Maximising environmental benefits and generally reducing negative impacts in all the areas mentioned above." (Global Sustainable Tourism Council 2013; Eurostat 2018)

The following always applies, however: Due to the additional consumption of resources during transport and stay, almost every form of tourism usually involves a risk to sustainable development. From this, we can infer: The more tourism there is, the greater the ecological risk tourism poses to sustainable development. On the other hand, well-designed tourism can bring social and economic benefits for the local population.

Our operationalisation of these sustainability aspects can be found in Section 2.4.2 from page 46 of this report.

1.3 State and development of tourism in Germany

In order to have a tangible numerical basis for the following discussions, we will briefly describe the tourism volume and, as much as possible, the temporal development of the key figures. In each case, we will indicate which tourism segment is covered by the figures provided.

We also develop an empirical representation of the current situation regarding demand for "sustainable" tourism in Germany.

1.3.1 Volume and volume development

Globally, tourism is regarded as a growth market. Each year, the World Tourism Organization (UNWTO) provides the number of international arrivals. In 2017, ironically the *International Year of Sustainable Tourism for Development*, this figure was at a record high of 1.3 billion arrivals, with a growth of 7% – far above the growth rates of recent years[2]. The billion mark for international arrivals was not exceeded until 2012, and for 2030 the UNWTO is expecting 1.8 billion international arrivals.

Compared with this, how is the volume of tourism developing in Germany? There are various sources with different explanatory powers for the tourism-relevant indicators in Germany.

Overnight stays in accommodation establishments with ten beds or more are recorded in the accommodation statistics. Table 1 only lists the overnight stays of German residents (domestic tourism). This number rose to 22% between 2010 and 2018, reaching 390.3 million overnight stays in 2018.

The balance of payments in tourism outlines how much more German residents have spent abroad than foreign nationals in Germany. This figure is traditionally negative, not least because many more German residents travel abroad than foreign nationals travel to Germany. The balance of payments deficit in tourism rose by 31% between 2010 and 2018 to EUR 43.1 billion.

[2] http://media.unwto.org/press-release/2018-01-15/2017-international-tourism-results-highest-seven-years, accessed on 8 April 2019

The number of passengers flying to and from Germany rose by 29% between 2010 and 2018 to 244.3 million. Even though the Berlin Brandenburg Airport, planned for 2011, has still not been completed, the number of passengers at Berlin airports rose by 56% to 34.7 million over the same period.

The turnover of German tour operators is traditionally strongly driven by the outgoing business. The market growth of 69% to EUR 36 billion shown in the table is based on data from the GfK Mobility study (holiday and private travel services with at least one overnight stay booked prior to travelling).

The strongest growth in the segments considered here was recorded by ocean cruises, with the number of passengers buying cruise holidays in Germany having grown by 87% to 2.3 million (CLIA estimate based on the first three quarters of 2018). Similar growth rates are recorded in the German cruise ports of Hamburg, Bremerhaven, Kiel and Rostock-Warnemünde(Holst and Wolf 2017), causing some cities to fear over-use (Grimm et al. 2018).

Table 1: Selected indicators of tourism development

Indicator	Description	Value in 2018	Change 2010-2018
Overnight stays of German residents	Accommodation establishments in Germany with 10 beds or more, source: Federal Statistical Office	390.3 million	+ 22%
Balance of payments tourism	Spending of foreign nationals in Germany – spending of German residents abroad, source: German Federal Bank	EUR –43.1 billion	+ 31%
Passengers to/from German airports	Local volume To+From, without transit, source: German Airport Association (ADV)	244.3 million	+ 29%
Turnover of German tour operators	Industry figures, source: German Travel Association (DRV)	EUR 36.0 billion	+ 69%
Cruise passengers to/from German ports	CLIA method: Turnaround: To+From, stopover: Only To, only sea cruises sold in Germany, worldwide cruising area, source: CLIA estimate (ITB 2019)	2.3 million	+ 87%

Development of balance of payments: The *balance sheet deficit* increased by 31%. Figure in 2010: EUR –32.8 billion

If we look at the development of long and short holidays in the source market Germany based on the Reiseanalyse survey data, which we have newly compiled, we can see in Table 2 that the number of long holidays has only increased by 0.82% in the last ten years. The share of domestic German holidays included in this figure has in fact decreased. This market segment fell by more than 12% between 2010 and 2018. The number of holidays in faraway countries, on the other hand, has increased.

Table 2: Holiday travel volume Germany

Long and short holidays in the source market Germany

Key figure	2018	Change 2010-2018
Holidays (five days and more)	70.1 million	+1%
Of which within Germany	18.9 million	−12%
Of which abroad	51.1 million	+7%
Of which long-distance travel (holidays outside Europe and the Mediterranean)	4.5 million	+27%
Short holidays (two to four days)	83.7 million	±0%
Of which within Germany	62.1%	−2%

Data source: Reiseanalyse survey 2019, Reiseanalyse survey 2011, our own analysis, holidays of the German-speaking resident population from 14 years in Germany, short strips of the German-speaking resident population 14-75 years in Germany

For business travel, measuring demand volume is extremely difficult and leads to very different results depending on which source you use. According to the German Business Travel Association (VDR), the German business travel market volume in number of trips is 187.5 million with 72.5 million overnight stays. Other realistic seeming surveys suggest figures of approx. 60 million overnight business trips and about the same number of day trips, with a clear downward trend (Eisenstein et al. 2019).

In summary it can be said that the volume of tourism in Germany continues to grow, although only very moderately in the case of holidays. This is not obvious; in the Netherlands, for example, the holiday market has in fact shrunk in recent years (Eijgelaar et al. 2016).

However, it should be emphasised that tourism segments which are considered to have particularly harmful effects on the environment (air travel, cruises) are growing at an above-average rate in Germany (Gössling et al. 2017; Frick et al. 2014).

1.3.2 Demand for sustainable tourism

While people's attitude towards and expressed preference for sustainable holidays in the wider sense is rising according to data gathered most recently in 2014 by the Reiseanalyse survey, the demand is not growing at the same rate despite the availability of offers. The high level of interest expressed in sustainable travel is expressed in approval rates of 50-60% of the population for the statement "I would like my holiday to be sustainable" (Kreilkamp, Krampitz, and Maas-Deipenbrock 2017; Günther et al. 2014). Current research, such as that conducted by the research projects Green Travel Transformation or FINDUS, shows a high level of interest in sustainability-oriented product features, while at the same time sustainability-oriented product features were not recognised much during the booking process itself (Schmücker et al. 2018; Kuhn 2017; Kreilkamp, Krampitz, and Maas-Deipenbrock 2017). Many consumers believe that it is their responsibility, but they do not act accordingly (Günther et al. 2014).

Table 3: Positive attitude towards sustainability among holidaymakers

TOP 2 on a scale of 1 (= applies completely) to 5 (= does not apply at all)

	Jan 2013	Jan 2019	Change
My holiday should be as ecologically sound, resource-saving and eco-friendly as possible.	42%	43%	+ 3 PP
My holiday should be as socially responsible as possible (i.e. fair working conditions for the staff and respect for the local population).	48%	52%	+ 4 PP
At least one of the two statements	52%	57%	+ 5 PP

Data source: Reiseanalyse survey 2013, 2019, our own analysis, basis: Holidaymakers in the German-speaking resident population aged 14 and over in Germany (2018: 55.0 million, n=6.041)

While the attitude ratings are positive, the actual usage rates of sustainable holidays are significantly lower. The share of holidays and short breaks when people deliberately choose to lower their CO_2 impact is four percent. Around seven percent of all holidays and short breaks are deliberately booked with a sustainability label, and around six percent of holidaymakers state that sustainability was a decisive factor in their decision, given otherwise equivalent alternatives. At the same time, the number of flights and the distances covered in the German market as a whole and for holidays has risen significantly[3]. As part of the research project Green Travel Transformation, 7% of respondents stated that they paid a lot of attention to sustainability during their last holiday, and another 26% stated that sustainability was one aspect among many (Kreilkamp, Krampitz, and Maas-Deipenbrock 2017).

Table 4: Usage of sustainable holiday travel

	Holidays of 5 days or more	Short breaks of 2-4 days
Number	70.1 million	83.7 million
Percentage of trips with CO_2 compensation	2%	5%
Percentage of trips with sustainability label, eco-label, etc.	6%	7%
Percentage of trips where sustainability was the deciding factor, given otherwise equivalent alternatives	4%	7%

Data source: Reiseanalyse survey 2019, our own analysis, basis: Holidays in the German-speaking resident population aged 14 and over in Germany (2018: 55.0 million, n=6.041)

It is thus evident that people's attitude towards sustainability is much more positive than actual demand. There is a *gap* between the two aspects. In economic terminology, there is a gap between professed (stated) and actual preference as revealed through action (*stated vs. revealed preference*) (Freeman, Herriges, and King 2014; Bockstael and Freeman 2005). The assumption that a certain attitude leads to a certain behaviour has its basis in the *Theory of Planned Behaviour* (Ajzen and Driver 1992; Ajzen 1991; Ajzen and Fishbein 1977). It has not been possible to

[3] First results from the ongoing project "Nachhaltige Urlaubsreisen: Bewusstseins- und Nachfrageentwicklung" (Sustainable holidays: development of awareness and demand), FKZ UM18165020

confirm this theory a number of times, both in general (Auger and Devinney 2007; Caruana, Carrington, and Chatzidakis 2016; Davies, Lee, and Ahonkhai 2012; Hibbert et al. 2013; Shaw, McMaster, and Newholm 2016) and regarding demand for tourist services (Juvan and Dolnicar 2017, 2014; Weaver 2008; Wehrli et al. 2014).

A number of explanatory models have been identified for the postulated gap between a (positive) attitude and (reticent) booking behaviour:

- As a rule, holidays are a hedonistic leisure product that are exceptional in character, which can lead to people granting themselves an exemption, as it were, from their usual disciplined sustainability behaviour.
- Holidays are typically high-involvement products that focus on risk, fun and symbolic value, and not on arguments that appeal to reason. Generally speaking, people do not go on holiday in order to act in a sustainable and eco-friendly way, but rather despite wanting to act in a sustainable and eco-friendly way. This is diametrically opposed to the low or at best medium-level involvement with sustainability aspects (Schmücker et al. 2018).
- The immediate benefit that choosing the more sustainable alternative could bring (above and beyond a more favourable price) is reduced to the social benefit (prestige), enjoyment benefit (better quality of sustainable products) or self-affirmation through the feeling of having done the right thing, the consumer equivalent, you could say, of the *warm glow of giving* (Andreoni 1990). This is up against a large number of possibly competing motives (Günther et al. 2014). There also seems to be a well-established stereotype that in the case of holidays sustainability means higher quality and thus higher prices (Kreilkamp, Krampitz, and Maas-Deipenbrock 2017; Schmücker et al. 2018).

Overall, given people's actual behaviour, the positive attitude values should probably be interpreted as an indicator of *acceptance* rather than *preference*.

1.4 Tourism in the digital age

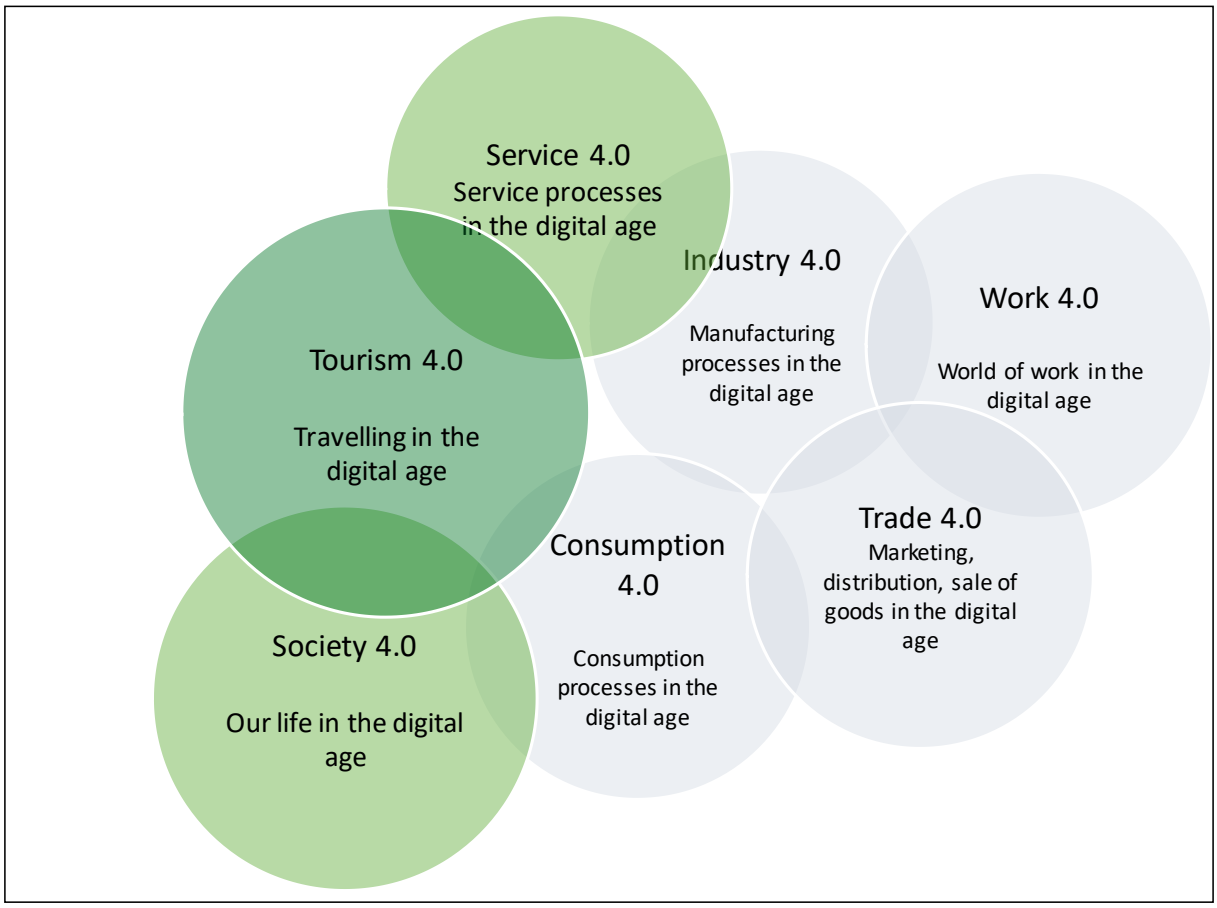
This study examines the impact of digitisation on sustainable tourism development. This question slots in with studies on other life and economic processes in the age of digitisation. With reference to the Consumption 4.0 study, we can call this Tourism 4.0, i.e., travelling in the digital age; digitisation in this sense refers to the digital interconnectedness of humans and things via the internet" (Keppner et al. 2018).

Tourism 4.0 comprises consumption processes as well as service processes and societal life in general in the digital age (Figure 1). With reference to Industry 4.0, we can speak of Tourism 4.0 when tourists, tourism providers and the things required for travel and accommodation are connected via the internet.

A more precise definition of the digitisation developments relevant to this project is given in Section 3 of this study.

Figure 1: Tourism in the digital age

Putting Tourism 4.0 into context



Source: Extended presentation based on Keppner et al. 2018

1.5 Impact of digitisation and big data analysis on sustainable tourism

In general, digitisation is only marginally associated with sustainability in general and specific environmental impact. According to a study published in 2018 by the German Federal Foundation for the Environment (DBU), among the German public unprompted associations with digitisation are at best about "less paper". When prompted, environmental impact and environmental protection rank last, far behind changes in the world of work, globalisation or acceleration (Forsa Politik- und Sozialforschung 2018, 5–6; Bonde 2018). When it comes to social impact in particular, digitisation tends to be seen as a risk rather than an opportunity (Lange 2018).

With regard to *sustainable tourism*, we found that tourist mobility and staying at the destination, including the associated upstream and downstream services, has an effect on the natural environment as well as on the social and economic aspects of society. Sustainable tourism development is the attempt to reduce these negative effects (risks) and to strengthen the positive effects (opportunities) (cf. Section 1.2).

- The impact on the natural environment primarily relates to resource consumption and the associated effects on air, water and ground, landscape, biodiversity and climate. Ecosystem services can also be considered, because the utilisation of nature and landscape (at least for the recreational part of tourism) are a cultural ecosystem service (Lienhoop 2016; Hermes et al. 2018).

- The impact on the social aspects primarily relates to the possible strains on the social fabric from (too much) tourism on the one hand, and the opportunities for enriching encounters, or at least a job, on the other. While the debate surrounding the social dimension was very lively in the 1980s (Krippendorf 1984) and then quietened down, the overtourism discussion has been quite dynamic in recent years (F. Weber et al. 2017; Postma and Schmücker 2017; Seraphin, Sheeran, and Pilato 2018). It seems rather doubtful, however, whether the problem can be solved with *crowd management* alone (McKinsey & Company and WTTC World Travel & Tourism Council 2017).

Digitisation in society can influence these effects by increasing or reducing them. This results in the opportunities and risks of digitisation in sustainable tourism development. The identification and assessment of such opportunities and risks is the subject of this project.

The description of the impact potentials with regard to individual criteria is the topic of Section 2.4, the assessment itself follows in Section 4.

At this point we want to derive at least the two main impact aspects from the preceding sections:

- **Travel volume**: If digitisation affects the (further) increase in travel volume, then this usually represents a risk factor. More transport, more overnight stays and more services usually lead to higher resource consumption, with regular negative impacts on the environment and nature (air, water, ground, landscape, biodiversity, noise, light pollution, resources and system services), and the social fabric at the destination. If digitisation decreases travel volume (for example, by replacing travel with digital communication), this represents an opportunity.

- **Travel behaviour**: Digitisation can involve both opportunities and risks for the environment, nature and social aspects when it comes to the organisation of transport, accommodation and stay. These paths of impact therefore have to be viewed in a differentiated way.

As part of a paths of impact analysis, the tourism-relevant areas of application are identified for each category and their possible effects on travel volume and more sustainable travel behaviour are described. This is divided into sustainability opportunities (reduction in travel volume or the associated indicators number of trips, distance and days of stay and/or more sustainable travel behaviour) and sustainability risks (increase in travel volumes or the associated indicators number of trips, distance and days of stay and/or less sustainable travel behaviour).

1.6 The aim of the study: Opportunity/Risk assessment, not prediction

The terms sustainability opportunities and risks make it clear that this study is not about predicting future developments.

Rather, we are carrying out an opportunity/risk assessment. Which areas of application represent more opportunities or more risks for the two central sustainability effects, namely travel volume and (more sustainable) travel behaviour, according to today's assessment?

What the concrete effects of digitisation are on the individual aspects is not at all certain. The documents accompanying the BMBF agenda conference on "sustainability research" which took place in September 2018 cites the head of the sustainability office of Robert Bosch GmbH, the sustainability expert in a company that makes a living from mobility, as saying: "In my view, an important question for sustainability research is what effects digitisation will have on the mobility behaviour of road users as electrification and autonomous driving increase."

(Bundesministerium für Bildung und Forschung (BMBF) 2018, 65). This uncertainty not only affects the mobility sector, but also all other tourist services, and it affects many, if not all, of the categories and applications we have examined.

The objective of this study is therefore not to predict what will happen, but rather to identify those paths of impact that are worth investigating in more detail.

1.7 Details of the study

In **Section 2** we lay the systematic foundations for research into the relevant digitisation categories and areas of application.

In **Section 3** these categories and areas of application are presented in detail. The three spheres data connectivity, data infrastructure and data ecosystem form the basis here. Here we also assign the above to the previously developed systematisation elements, i.e., to the categories, phases of the customer journey, particularly affected segments and diffusion level. Furthermore, the areas of application are illustrated using many examples.

The relevance assessment itself follows in **Section 4**. To this end, the areas of application identified in Section 3 were fleshed out again in an internal workshop and, if possible, made more concise, to create a manageable number of paths of impact to be evaluated. The team of experts then evaluated these paths of impact and reached a consensus.

In January 2019, an expert dialogue session was held with 18 participants, including UBA and BMU staff and external experts, during which the preliminary results were presented, discussed and tightened up. The contents of the discussions were incorporated into the development and assessment of the paths of impact. The list of participants can be found in Appendix A.

2 Systematisation structure

The research into the current state of digitisation with regard to a sustainable development of tourism is structured based on a variety of aspects. This chapter provides a description of these aspects.

The systematisation grid includes the following points:

Categories: Identification of

- categories (general topics)
- areas of application

Markets: Classification of

- phases of the customer journey
- significantly affected segments

Diffusion: Estimate of

- the state of development
- development perspective

Impact potentials: Identification of

- directions of impact
- paths of impact

This systematisation is necessary in order to provide a uniform processing scheme for the subsequent relevance assessment of the identified applications. This is the only way to adequately assess the different applications and their heterogeneity.

Role of systematisation

The systematisation grid provides a standard structure for the research findings for the digitisation trends (Section 3) and prepares them for assessment (Section 4).

We have adapted the *Horizon Scanning* (Behrendt et al. 2015) method to suit our questions. *Horizon Scanning* consists of the three phases *scoping*, *scanning* and *assessment*. Of these, the first two phases are relevant in the "systematisation" step, while the assessment is dealt with in the "Assessment" step.

The scanning field in our case is (sustainable) tourism, the environment to be considered is digitisation.

The surrounding topics are the categories and applications. *Weak signals* and *emerging issues* are also considered in this study, and their classification takes place as part of the assessment of the market significance.

When comparing Table 5 and the list of systematisation elements, it becomes clear that the impact potentials considered here represent an additional information level compared to horizon scanning. However, the impact potentials are of the utmost importance for us in preparing the assessment in the next work step.

Table 5: Using the *horizon scanning* technique

Terms and implementation

Conceptual element	Characterisation	Application in this study
Scanning field	Area of investigation	(Sustainable) tourism
Surroundings	Potential areas of impact on the object of investigation	Digitisation
Surrounding topics	Pooling individual topics	Categories and applications
Topics	Subject of the sources	Markets
Weak signals, emerging issues	Newly emerging signals/topics	Market significance

Adaptation by Behrendt et al., 2015

2.1 Categories

The identified categories are initially based on our own considerations, supported by the "major lines of digitisation" discussed in the literature (deductive part, top-down, a-priori).

The categories identified this way were then reviewed on the basis of concrete examples from tourism: Can relevant developments be integrated into the existing grid or are modifications such as extensions or reassignments necessary (inductive part, bottom-up, process-related)?

Individual applications are then assigned within the categories. Finally, the applications are the level of perspective for all other systematisation elements.

The actual identified categories and areas of application are discussed in detail in Section 3.

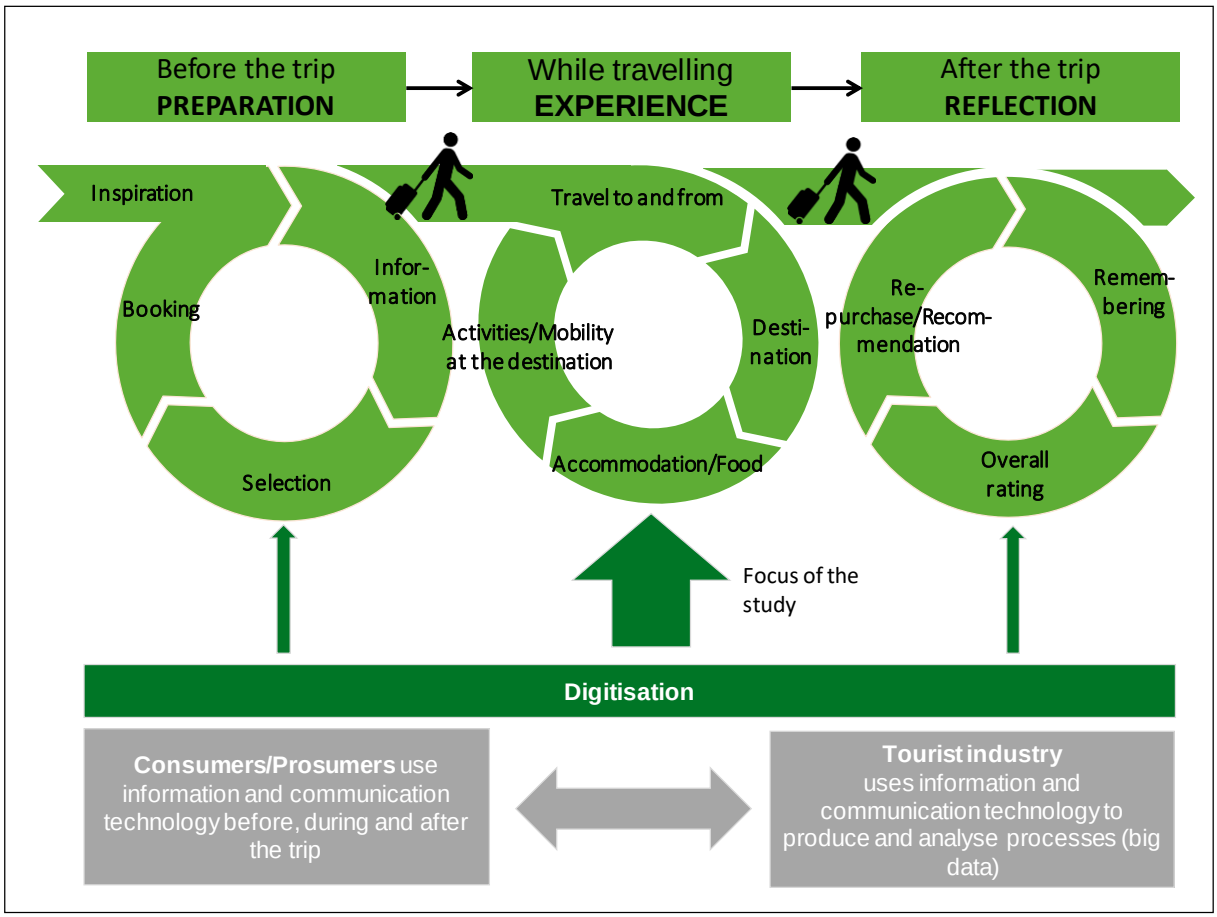
2.2 Markets

2.2.1 Customer journey

On the "markets" systematisation level, the application is first classified in the phases of the customer journey. The reduced form of the customer journey, which is regularly found in publications on online marketing, is not used here. These often only describe the path of potential customers through various digital touchpoints (e. g. travel preparation and booking, from inspiration to purchase), sometimes also the complete pre-consumption chain and sometimes the digital post-consumption contacts (Liebrich 2018a; Spelman et al. 2017; Keppner et al. 2018).

We use a broader version of the customer journey which is not limited to digital contact points before and after consumption (here: the journey), but also explicitly focuses on analogue contact points and the journey itself. The version in Figure 2 was developed based on a module report of the Reiseanalyse survey, which considered the customer journey integratively (Schmücker 2014).

Figure 2: Influences of digitisation on the customer journey



Source: following Schmücker 2014

2.2.2 Affected segments

The second market dimension that we use for systematisation is the segments that are particularly affected. As was already pointed out in Figure 2, two main groups must be initially distinguished.

Firstly, this is the increased use of digital information and communication technologies (ICT) in the form of devices and networks before and after, but above all during the journey. Consumers are prosumers also and precisely because of the integration of interactive, digital elements during a trip, and the influences of digitisation on these "prosumer" processes are to be the focus of consideration.

Secondly, we look at the use of ICT on the part of the producer when it comes to the organisation and analysis of service processes. The consideration of big data mechanisms and their processing through self-learning systems (*machine learning*) will play a special role here. Of course, the two aspects are interdependent; in particular, the use of ICT by the consumer is only possible if the relevant content and processes are made available by the producer.

These two main groups can be further differentiated as required, for example, into specific demand segments (e. g. air travellers, online bookers) or provider categories (e. g. tour operators, destination management organisations).

2.3 Diffusion

When considering the level of systematisation diffusion, we assume an ideal-typical course in line with the literature (Rogers 1995; Dibra 2015; Welz 2014; Ganglmair-Wooliscroft and Wooliscroft 2016; Nobis 2013). This is based on technical developments outside tourism and assumes a later adoption of the technical development by tourist providers and then later by the end consumers (tourists). In this sense, tourism is usually a user and not a developer of technical innovations (e. g. B. digital terminals or networks) and related business models (e. g. payment methods, platforms, etc.).

Tourism applications are sometimes among the earlier and heavily used adaptations of technical innovations if they are related to the mobility component. Examples are the development of computer reservation systems for airlines or the usage rate of the DB-Navigator app. Typical tourist applications for accommodation and the destination experience, on the other hand, are generally less widespread and are often adopted later.

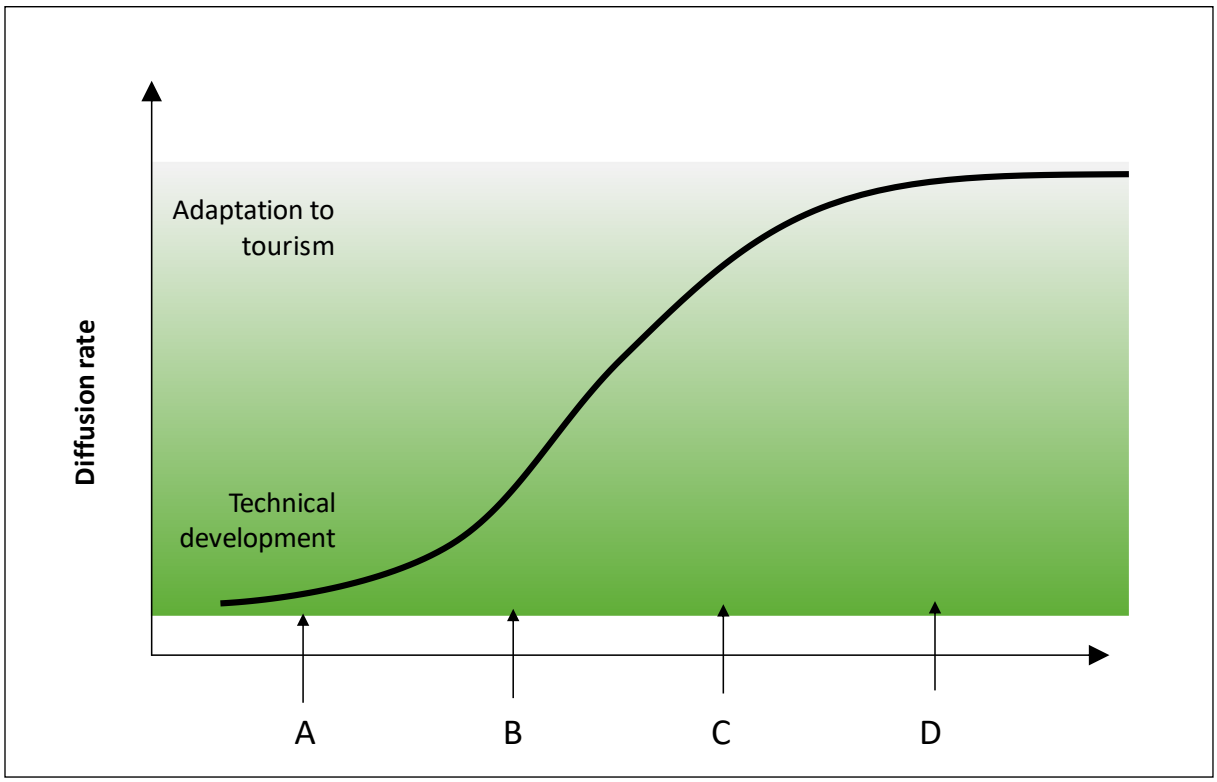
We used this ideal-typical representation (Figure 3) in order to classify the applications into one of the four phases at least roughly: Is it still at the beginning of technical development (prototypes, phase A), are productive applications beginning to be used (*early adopting*, phase B), is it already used as tourist applications (phase C), or is it already established in the tourism market (phase D).

This rough classification enables a quick overview. It is possible that individual application areas or categories can refer to several of the phases mentioned due to the different possible application, so that this is documented in each case. If the process does not follow this path, then this is also commented on. This representation follows each category as a summary and also in the individual examples. However, the focus of the study as a whole is clearly on the paths of impact.

The position in the diffusion curve provides a basic estimate for the likely further development. Of course, this relationship is not mechanical, since there are applications at the beginning of the diffusion curve that have little potential for further diffusion.

Figure 3: From technical development to adoption in tourism

Idealised sketch



Source: Own design

2.4 Impact potentials

The systematic tracking of the impact potential is the most extensive and difficult task in this work step. Another reason why this is the focus is that the result of this work step are the effect chains through which the connecting lines between digitisation and sustainable tourism development become apparent.

To this end, we first examined current approaches for their transferability and then created an impact potential model on this basis. This model serves as a framework for the recording and later assessment of the applications.

Even if a "sustainability deficit of digitisation" has been identified in principle, generic paths of impact result in particular from dematerialisation (replacement and optimisation strategies) and decoupling through digitisation, in particular applications in the *sharing economy* (sharing, not owning) and the *circular economy* (Sühlmann-Faul and Rammler 2018).

2.4.1 Current approaches

We first looked at three current approaches from the work for the Federal Environment Agency and examined their applicability for our research objective:

- VERUM 2.0,
- Consumption 4.0,
- "Making use of digitisation in an ecologically sustainable way".

2.4.1.1 VERUM 2.0

The *simplified environmental assessment of the Federal Environment Agency,* VERUM 2.0, (Berger and Finkbeiner 2017) is a current approach aimed at assessing or comparing the environmental impacts of a product, process or a service. VERUM 2.0 focuses on environmental protection and human health. It is thus similar to the ecobalance or *life-cycle assessment (*LCA) technique, but with the requirements of "as good as possible" and "applicability before accuracy".

There are several reasons why VERUM 2.0 should not be adopted uncritically. First, VERUM 2.0 is a strain analysis tool (given sufficiently precise input parameters), not an opportunity/risk analysis tool. However, the latter is the focus of our project. Second, the process definitions necessary for the application of VERUM 2.0 would overcomplicate the project, even qualitative regarding strain determination: For many of the potential strains, the necessary input data is simply not available and—in any case—not necessary for a general analysis. One limitation of VERUM 2.0 is probably its restriction to environmental impacts, while economic and social impacts do not play any role.

Nevertheless, we are making use of the central idea behind VERUM 2.0. This is the utilisation of impact as an essential assessment criterion in the next step. The scenarios used in VERUM are reflected to an extent in the relevance parameters realisation period and probability which we use.

2.4.1.2 Consumption 4.0

The UBA study *Consumption 4.0: How digitisation changes consumption* (Keppner et al. 2018) differentiates between direct and indirect effects when analysing the environmental impacts of digitisation. The direct effects are assessed in increments using a four-stage traffic light system (assessment grid):
Potentially relevant (negative)/Inconclusive/Potentially relevant (positive)/Not relevant.

The "greenhouse gases", "consumption of mineral resources", "consumption of biotic resources" and "water consumption" indicators are evaluated. And the same applies here: We will not be able to generate sufficient input data for this type of assessment. In addition, such a focused consideration would not be useful for a general survey such as this one, because it would exclude aspects that go beyond those mentioned by definition. However, we are adopting the concept of potentials, because we are not able to predict the future of course; we can only estimate the potentials for certain future effects.

Then there is the assessment of indirect environmental impacts. Sub-topics are defined for a given situation and evaluated with regard to the environmentally relevant impacts in terms of

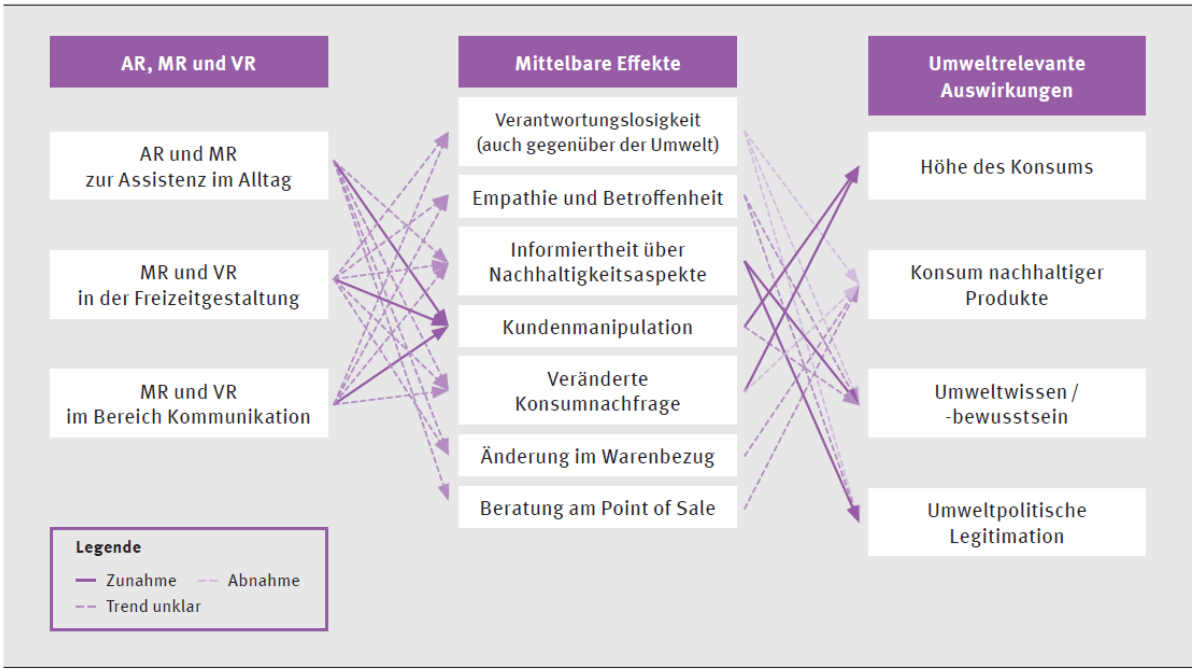
direction (increase/decrease/trend unclear). For this purpose, an additional level ("indirect effects") is defined to help make the effect chains easier to understand (Figure 4).

The Consumption 4.0 study examines the following consumption processes:

- Instant shopping;
- Consumer influence;
- Digitally active consumers;
- Green mobile apps;
- Augmented (AR), mixed (MR) and virtual reality (VR);
- Digital payment.

Figure 4: Example of Consumption 4.0 effect chains (indirect effects)

Example of the effect chain augmented, mixed and virtual reality



Source: Keppner et al. 2018, 65

We believe that the indirect approach in particular seems promising for this project: The argumentative definition of effect chains is therefore also used in this project.

2.4.1.3 Making use of digitisation in an ecologically sustainable way

According to the project description, the current UBA project (FKZ 3717 14 102 0) is designed to do the following: "to identify environmentally relevant developments that fall under the heading of digitisation and to systematically relate them to each other in order to do justice to the systemic nature of digitisation; to look into the many different opportunities of digitisation for climate and environmental protection and to at the same time analyse the opportunities of digitisation for environmental management as part of a more in-depth work package; to identify

possible environmental impacts of digitisation and to help BMUB establish the 'digital change for climate and environmental protection' platform."

Initial results of a short study by the Fraunhofer ISI on a similar topic are now available, which we have based our work on (Fraunhofer ISI 2018; Friedrichsen 2017).

That study defines eight "digital trend technologies" with the corresponding subtopics (Fraunhofer ISI 2018):

- Big data;
- Cloud computing;
- P2P computing;
- Internet of Things;
- Artificial intelligence;
- Virtual reality;
- Augmented reality;
- Robotics.

The assessment in this project is based on three "relevance axes": Potential in terms of ecological factors, maturity/state of research, research needs and reach in terms of market size.

The above-mentioned Fraunhofer study also distinguishes between (Horner, Shehabi, and Azevedo 2016; Hilty et al. 2006; Börjesson Rivera et al. 2014) direct and indirect effects: Direct effects relate to production, operation and disposal (of products), indirect effects to efficiency and replacement (dematerialisation). Then there are third order effects under the keyword of "structural change". These include direct and indirect *rebounds* as well as change processes throughout the economy and society.

We make use of the principle of indirect effects in this project; we cannot evaluate the direct effects due to a lack of data and structural change processes would go too far in the context of a general survey. We use the maturity and range of a technical development along the same lines when considering diffusion (cf. Section 2.3).

2.4.2 Impacts and effects

As already stated in Section 1.5, the analysis of impact potentials raises two fundamental questions:

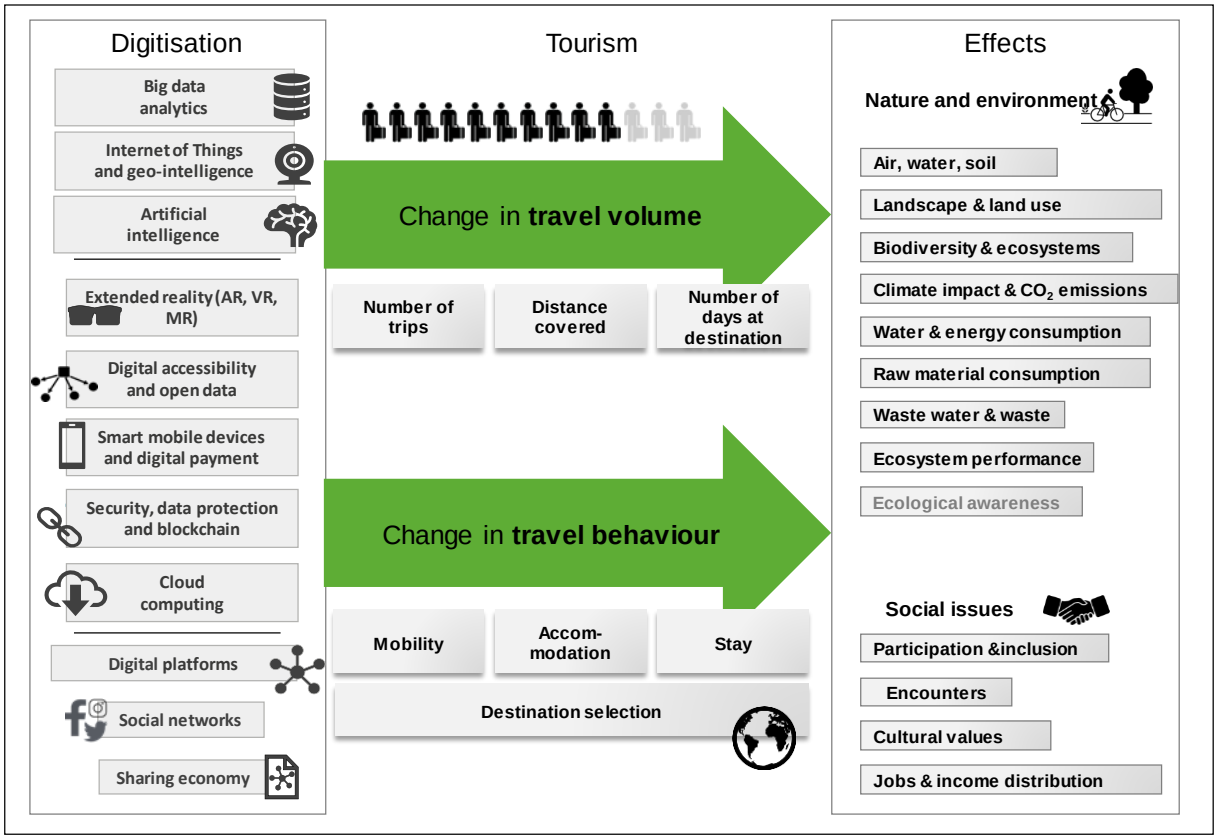
- Does the digitisation aspect investigated have an effect on **travel volume**? In that case, in the event of a potential volume increase, it regularly represents a risk rather than an opportunity for sustainable tourism development. Volume can refer to the number of trips, but also to the distances travelled and the number of days away.
- Does the digitisation aspect investigated have an effect on **travel behaviour**? In that case, determining a path of impact requires a differentiated analysis. Travel behaviour can refer to numerous aspects and facets of mobility (travel there and back), accommodation and organ-

isation of the stay and, above all, the choice of destination category. What is more, a change in travel behaviour can originate from the consumer or the supplier (which is why we do not use the generally consumer-oriented term "travel behaviour").

The concrete paths of impact for each digitisation application can of course only be created and evaluated on the basis of the concrete digitisation categories. Nevertheless, the schematic process can be outlined here (Figure 5).

Figure 5: Impact potentials of digitisation

With regard to parameters of nature, environment and social issues



Source: Own design

The categories listed under "effects" comprise the main tourism impacts on nature and the environment and social conditions (based upon Neligan et al. 2015, 26). They are based on essential aspects of the general sustainability discussion, as can be found in the UN SDG[4] or current cross-departmental statements and recommendations for action on sustainability in society (WBGU 2019, 19 ff.).

Unlike the Consumption 4.0 (Keppner et al. 2018) study, for example, we only use "environmental awareness" as an independent target category to a limited extent. The reason for this is that a change towards greater environmental awareness in the travelling public is only a preliminary phase to a change in travel volume or travel behaviour. Environmental awareness is an attitude that can guide action (in which case it must be taken into account as a path of impact at least indirectly), but it does not necessarily lead to an action.

[4] https://www.un.org/sustainabledevelopment/sustainable-development-goals/, accessed on 8 April 2019

Data on the divergence between a (positive) attitude towards sustainable holiday travel and actual behaviour (*attitude-behaviour gap*) can be found in earlier studies (Higham, Reis, and Cohen 2016; Günther et al. 2014; Caruana, Carrington, and Chatzidakis 2016; Hibbert et al. 2013; Shaw, McMaster, and Newholm 2016), cf. Section 1.3.2.

2.4.3 Paths of impact

The paths of impact used later in Section 4 have a slightly different graphic form, but their basic structure is in line with the impact potential model developed here. An example presentation of the impact path models can be found in Figure 6**Fehler! Verweisquelle konnte nicht gefunden werden.**.

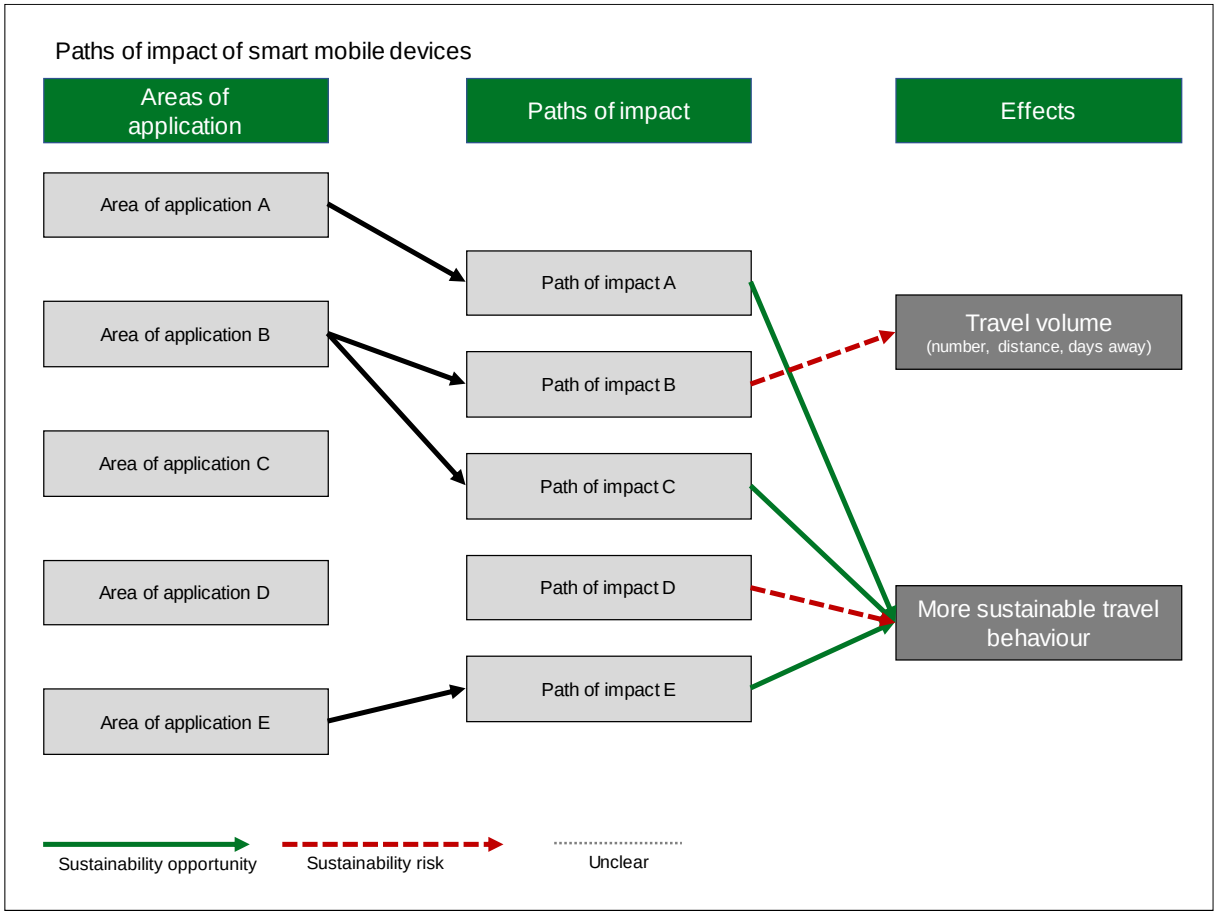
The two central aspects are analogous to the "level of consumption" and "volume of transport" (≅ travel volume) and "consumption of sustainable products"[5] (≅ travel behaviour) impact categories used in Consumption 4.0 (Keppner et al. 2018).

The Consumption 4.0 study also uses the "environmental knowledge/awareness", "environmental legitimacy" and "regional development" impact categories (cf. Figure 4on p. 45). We do not consider these aspects here. As shown in the introduction, environmental knowledge or awareness has very little to do with actual demand and the gap between awareness (attitudes) and behaviour seems to widen rather than narrow over time (see Section 1.3.2 starting on page 33). Regional development can be seen as an aspect of the social dimension, but is not in itself an environmental objective. This also applies to the "environmental legitimacy" category described in the study.

In contrast to the model used in the Consumption 4.0 study, we do not name the paths of impact (arrows) "increase" and "decrease", because this would result in opposing interpretations of the same type of effect: An *increase* in travel volume is, from a sustainability perspective, generally the opposite of an *increase* in sustainable travel behaviour. In order to avoid double negatives and other semantic confusions, we name the green arrows "sustainability opportunity" and the red dotted arrows "sustainability risk" (Figure 6).

Figure 6: Digitisation paths of impact (schematic)

Effects: Change in travel volume and more sustainable travel behaviour



Source: Own design

3 Digitisation categories and areas of application

This section focuses on the **identification of current digitisation trends** in tourism. Special focus will be placed on big data analysis. The process of identifying trends is carried out in four steps according to the systematisation grid defined in Section 2 (see Horizon scanning):

1. Collecting relevant sources (both general and specific to tourism).
2. Screening and assessment of identified sources.
3. Arranging and linking topics that were identified in the sources.
4. Structuring of the topics, which then form the basis of the category system (structured research).

The first step is to compile the digitisation solutions that can be used in tourism. In addition, individual digital trends are identified and looked into, which are summarised in an overview of the systematisation structure developed in Section 2 with regard to markets, diffusion and impact potentials.

On the basis of the systematisation (for the methodological approach see Section 2), the digitisation trends are classified, which will form the basis for the subsequent analysis of the potential environmental impacts of digitisation in tourism. This will be the topic of Section 4.

3.1 Sources and categories

A variety of sources were used to identify the categories and areas of application as relevant topics in the "digitisation" environment of the scanning field of (sustainable) tourism (cf. Table 5):

- Reference books and articles to clarify a general perspective;
- White papers, blog posts, trend reports to provide an overview of current developments;
- Interviews, conference proceedings and presentations to take into account individual points of view.

We thus also honour the premise of triangulation (Kuckartz 2014, 46) in order to ensure an inter-subjective picture with regard to the diversity of sources.

3.1.1 Review of sources

For an initial overview and to identify the categories or "trends" of digitisation, we used general sources as well as sources that explicitly refer to tourism.

Among the general sources, we first reviewed trend reports and studies by international market research and consulting firms, including the etventure/GfK study on *digital transformation* (etventure 2018), the trends from 2017 and 2018 taken from Gartner Inc.'s *hype cycle*(Panetta 2017, 2018), the *Tech Trends 2018* by Deloitte Consulting (Deloitte 2017), the *Accenture Technology Vision 2018*, (Accenture 2018) and others (Bundesanstalt für Finanzidenstleistungsaufsicht BaFin 2018; Adigital Compass 2015; Leimbach and Bachlechner 2014; Shirer and Torchia 2017; Prashant, Somesh, and Sree 2016; Ladak 2018; Maini 2017; Fraunhofer ISI 2018). As well as the UBA study *Consumption 4.0: How digitisation changes consumption* (Keppner et al. 2018) was used as a basis here (cf. Section 1.4, "Tourism in the digital age").

This was followed by a search for tourism specific reports and studies on the subject of digitisation and tourism, including publications by tourism providers such as *Leitfaden für die Digitalisierung von Tourismus-Destinationen (Guide for the digitisation of tourism destinations)* by Outdooractive GmbH (OutdoorActive 2017), the *2018 Digital Transformation Report* by Skift/Adobe (SKIFT 2018), as well as a discussion paper by Amadeus on *Defining the future of travel through intelligence* (Amadeus IT Group SA 2016). We also reviewed a number of publications from universities and universities of applied sciences, including on *Digitalisierung im Tourismus (Digitisation in tourism)* by Chur University of Applied Sciences (Deuber and Möller 2017) and Lucerne University of Applied Sciences and Arts(Liebrich 2018b) as well as an input paper from the University of Bern entitled *Tourismusrelevanten Trends und Entwicklungen (Tourism-relevant trends and developments)*, and others (Demunter 2017b; Fuchs, Hoepken, and Lexhagen 2014; Orange 2016; GlobalData Technology 2018; S Imhanwa, Greenhill, and Owrak 2015; IST-Studieninstitut 2016a; Land 2018; Quadlabs Technologies 2017; Travel Technology & Solution (TTS) 2015; 'Outcome Document' 2017; CRED-T 2018; Weltbank 2018; Weston and Peeters 2015; Wirtschaftskammer Österreich (WKO), Österreich Werbung, and Bundeministerium für Wissenschaft 2017; World Tourism Cities Federation (WTCF) 2017; Liebrich 2018a).

3.1.2 Screening and assessment of identified sources

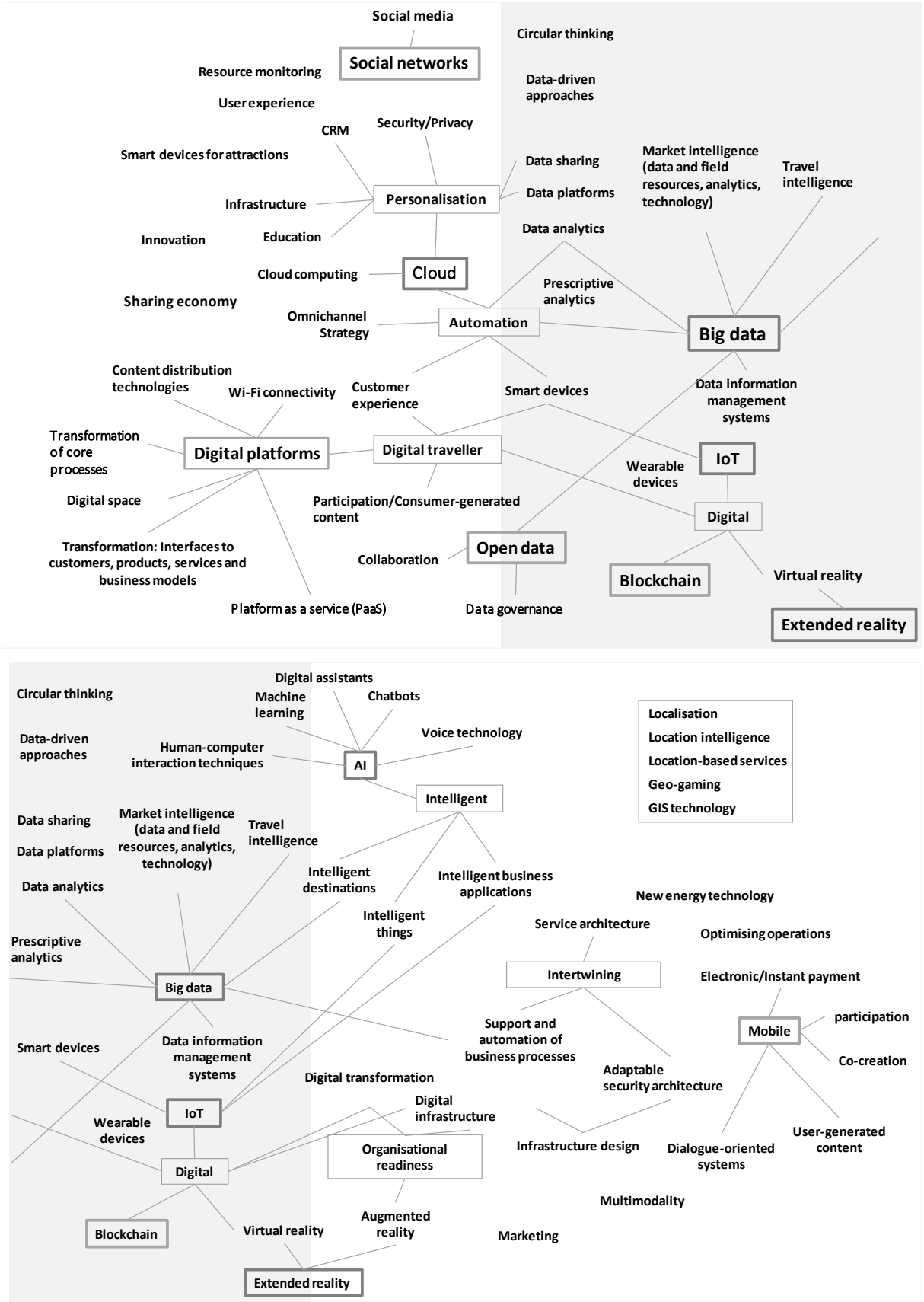
Based on this initial review (of both the general and the tourism-specific sources), the topics identified in the sources were compared with the categories (deductively) adopted in advance. The starting point of the category formation was a study by Kreilkamp and Conrady (2014): *Digitisation as a success factor in the tourism industry* on behalf of the Federal Ministry for Economic Affairs and Energy (BMWi).

The identified sources (see the previous Section 3.1.1) were scanned for their main topic. Since this process led to a large number of topics, these were then organised and merged into main topics.

Topics that were mentioned in connection with existing terms were then merged. An example overview of all extracted terms and topics and the topic clusters from tourism literature can be found in Figure 7.

Figure 7: Visualisation of identified topics

Extract from tourism sources



Source: Own design

3.1.3 Organising and merging topics

The aim of this next step was to compare the categories previously identified with the subject areas from the sources (see Section 3.1.2 above).

Almost all categories arrived at deductively appeared in the general trends. Nevertheless, some trends were mentioned more frequently than others. The **big data analytics**, **extended reality**, **Internet of Things** and **artificial intelligence** topics were mentioned frequently.

There were also terms that needed to be explained: The term "P2P computing", for example, was subsumed under the category "cloud computing". We proceeded in a similar way with other terms when they related to the same topics in order to achieve a clear structure.

The term **biohacking** is noteworthy, which is named one of five *emerging technology trends* in 2018 by Gartner Inc. (Panetta 2018)in particular. Since this is primarily about implants and the development is still very young, it is even harder to assess than other categories. Any applications and examples are therefore listed under smart mobile devices.

Biohacking

The term biohacking refers to the intervention of laypeople (so-called biohackers) in biological processes. This movement does not necessarily have to be related to digitisation. Biohacking is fundamentally about experimenting with biological processes – often with the aim of optimising one's own body according to the efficiency principle (e. g. as much muscle gain in as short a time as possible).

In the context of digitisation, it refers to transhuman modifications using computer chip implants in the human body. This is often done with the aim of being able to monitor one's own body and its functions. Such implants also serve the purpose of identification – which is why the catchword **digital twin** (a digital replica of one's real identity) plays an important role in this context.

Digital infrastructure seems to be another important topic (because it is mentioned often). We do this justice by assigning a number of categories to this higher-level complex of topics (with a focus on data management). (Data) infrastructure as a whole is not a separate category, because it would be too broad.

Similar things apply to the complex of topics surrounding the **transformation of business processes**. The trigger here (agile working methods, innovation management, etc.) is without a doubt digitisation, but they are not originally digital topics. There are quite a few examples that trigger changes in business processes, but this does not justify calling it a separate category.

In addition, the topic of **sharing economy** was mentioned in many general studies, which means it has relevance. Nevertheless, the idea of the sharing economy is based on that of the platform economy and can therefore be subsumed under this category (digital platforms). The same applies to the set of topics related to social networks, which are also based on the platform concept.

If we look at the **tourism specific topic clusters**, similar results can be identified. The areas mentioned earlier, social networks and sharing economy, were even more prominent here. Both topics are covered by the **digital platforms** category and their relevance is emphasised by the higher-level **data ecosystem** set of topics. This gives them a prominent position, because the underlying business model (platform economy) creates a framework around the predefined categories. The basis of many platforms is the trade with and the processing of data, which can

be done in particular through the networking of data (connectivity) using big data analytics, the Internet of Things and artificial intelligence.

The keyword **organisational readiness** was found in the field of tourism-specific clusters, which focuses on the transformation of business processes. Here, as explained above, the need to change organisations is triggered by digitisation, but it is not originally a digitisation issue if you focus on the area of big data analytics, as we do.

Then there are the terms intertwining, geo-intelligence (localisation) and digital traveller. While the first of these terms is about the connection between people and machines in a specific context (geo-intelligence) and is covered by the category **Internet of Things (IoT)**, the latter is assigned to the topic of **smart mobile devices**. The term "digital traveller" is closely linked to the fact that visitors increasingly carry and use their own digital device on their trip (the "bring your own device (BYOD)" approach).

3.1.4 Structuring of topics and creation of categories

First, the existing and additionally identified categories were assigned to the individual sources – based on the findings from the third step (ordering and connecting, Section 0). Categories and sources were then linked in order to better understand the degree of interconnectedness and their relationships. The same was done with the tourism specific sources. This overview then led to the final category system. The result of the research and systematisation work is thus the category system, which is represented Figure 8. As can be seen, the categories were sorted into different higher-level sets of topics, which are all intertwined or influence each other. The requirement or reason for the higher-level sets of topics was already addressed in Section 0.

The eleven categories presented in the shell model in Figure 8 are used as the basis for further work. The focus of this shell model of digitisation (where the categories are located) is on the **big data analytics** category and the adjacent **artificial intelligence** and **Internet of Things** categories. All three categories in combination lead to the interconnectedness and assessment of large amounts of data (connectivity). Assigning the examples to the respective category was not always clear, since in practice the examples can of course also be used in combination with other categories defined here. We therefore classified the examples into the respective category based on the most obvious mechanism.

Apart from the first three, other categories are of course also relevant. Firstly, the extended reality, smart mobile devices, digital accessibility, cloud computing as well as security and data protection categories provide the infrastructure (**data infrastructure**), on the basis of which the data can be connected and evaluated (**data connectivity**). Secondly, the ecosystem (**data ecosystem**) in which these developments are located is characterised by economic and social processes. These include the economy (digital platforms) as well as social networks and the so-called sharing economy platforms.

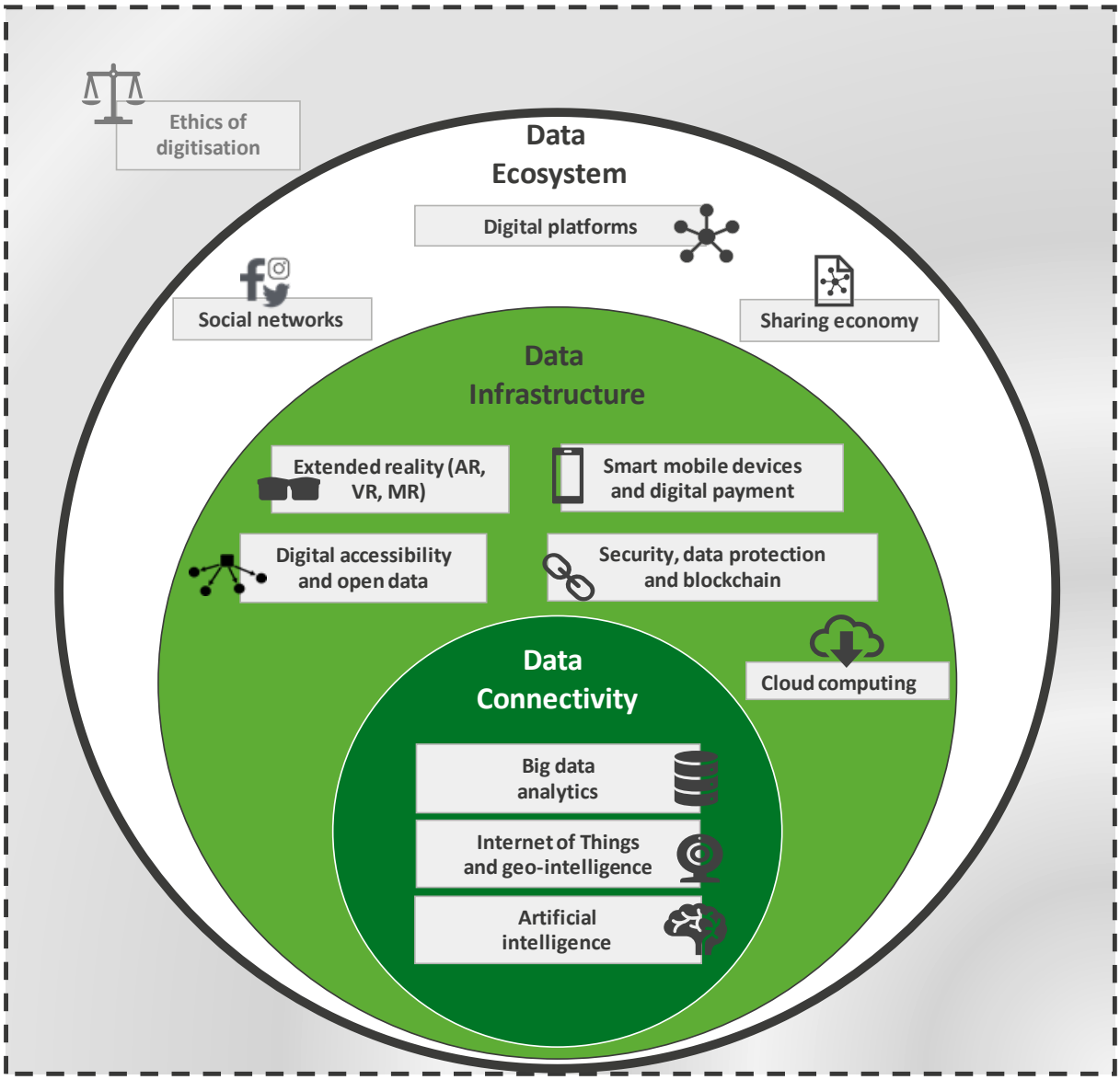
Ethics of digitisation

Ethics in the context of digitisation is about what is good and right when it comes to digital change. The ethical discourse provides an orientation with the help of which the digitisation process can be shaped in a way that promotes freedom. The starting point for ethical reflection are the aspects of digitisation that trigger (new) ethical questions because they offer unprecedented options for action, such as data acquisition (sensor technology), assessment (big data) and interpretation (artificial intelligence), automation and algorithmic decision-making processes, and human-machine interactions (Horn and Müller 2017).

In the context of a "digital universe" viewed holistically, the question of an **ethics of digitisation** becomes increasingly important. However, this is not supposed to be a separate category. Rather, this aspect is expressed in fundamental social questions: As a society, what technical developments do we want to allow, and which to we want to ban, even if we could allow them? The relevance of ethical questions in the context of digitisation is also illustrated by the fact that large corporations such as Google itself have set ethical rules for the development of artificial intelligence, in which they stipulate, for example, that AI developments should always have a social benefit, such as for health care, security, energy, transport, production or entertainment (für weitere Informationen hierzu siehe Pichai 2018).

Figure 8: Eleven central digitisation categories

Classification within a "digital universe"



Source: Own design

3.1.5 Development of areas of application for the categories

Based on the nine categories presented here, desk research was carried out to find practical examples for these categories. The starting point was the examples given in the sources

searched for the purpose of category formation. We then carried out a combined search using search engines and the Trendexplorer tool (www.trendexplorer.com). On this basis, approximately 10 to 20 examples could be identified per category, which were then clustered into areas of application. Via this inductive approach we identified areas of application that appeared in several categories, and some that explicitly only related to one category.

Examples in appendix

The descriptions in the following sections sometimes refer to the appendix for the relevant example. For a better overview, these examples and their classifications can be found in appendix. Examples are only listed in the text in exceptional cases, if we believe it is necessary to gain a full understanding.

The areas of application were classified in the customer journey (cf. Section 2.2.1 from page 40), such that for each area of application it is clear which travel phase the area of application relates to. What is more, the temporal diffusion was also potentially assessed here.

Below we will describe the individual categories and their areas of application (with reference to the individual examples in appendix, where these are also assigned with regard to their relevance for the individual industry segments) are explained in order to create a basis for understanding the categories and their identified areas of application in tourism. The following section is thus to be seen as the basis for the subsequent classifications of the influence of digitisation on sustainable development in tourism, i.e., the relevance and the opportunities and risks for sustainable tourism development will then be assessed in Section 4.

3.2 Data connectivity

Big data analyses as a singular system have not met the, sometimes exaggerated, expectations. Huge amounts of data can often not be read efficiently, even with modern computer centres at your disposal. In order to process the data, big data today is usually linked with machine learning, which means it comes closer to **artificial intelligence (AI)**. On the basis of the "artificial" generation of knowledge through experience, controlled by algorithms that develop dynamically and independently (or under supervision), large amounts of data can be analysed in a short time.

Big data and "machine learning" will drive many of the innovations that will emerge in the coming years. Thanks to today's combination of big data and machine learning, completely new products and services can also be created in tourism (Amadeus IT Group SA 2016, 10). In tourism in particular, the **Internet of Things (IoT)** plays a decisive role here. The rise of digital and mobile communication, the interaction between objects and visitors with the aim of creating networks generates a volume of data that can be stored, analysed and managed for further use and value creation (SEGITTUR 2015, 38). The Internet of Things is characterised by the fact that physical objects are digitally interconnected with each other. This automatic connection is created by transponders (e. g. RFID) and allows almost all physical objects as well as people to be linked.

The effect of combining these three concepts is the rapid processing of large amounts of data by means of machine learning, in which the IoT is used to create strong digital links in real time, which leads to a contextualisation of the environment – so-called smart data.

This connection, assessment and utilisation of data is our focus under the "data connectivity" category defined by us; we will discuss the areas of big data analytics, artificial intelligence and the Internet of Things as separate categories below.

3.2.1 Big data analytics

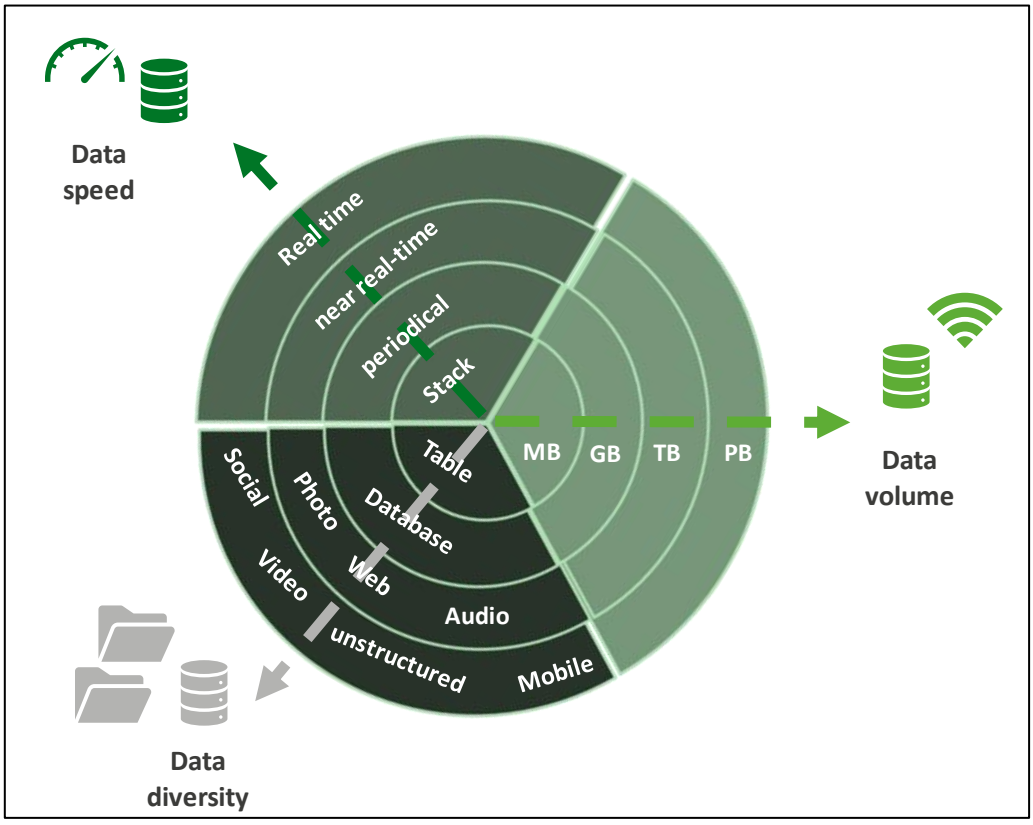
Due to the explosion of digital data in recent years and the resulting rapid growth in information volume, large amounts of data can now be collected from the physical environment and transferred to the digital world where it can be stored, processed and understood thanks to big data (United Nations World Tourism Organization (UNWTO) 2018).

Big data refers to the study and application of data sets that are so large and complex that data can no longer be processed efficiently using standard technologies. Big data analytics thus helps structure information from a variety of sources and recognise connections, meanings and patterns (Bundesverband Informationswirtschaft Telekommunikation und neue Medien e.V. (BITKOM) 2012, 41).

As shown in Figure 9, big data is characterised by the amount of data (volume), the speed with which it is generated and analysed (velocity) and the heterogeneity of data (variety) (Leimbach und Bachlechner 2014, 39).

Figure 9: Big data characteristics

Similar to the 3V model of Gartner Inc.



Source: Own design based on Gartner (2011).

In addition to these three "core elements" of big data that reflect a more IT-oriented perspective, there are others which have gained in importance in recent years and which vary depending on your perspective. Here, the veracity of the data and its economic value should be stressed. This means that data should not only be assessed on the basis of the speed of its availability, volume and uniformity, but also based on its accuracy and utility (vgl. auch Demunter 2017a, 6).

The basic aim of big data analyses is the collection of information from different sources. Analysing this information serves to generate knowledge that can be used in various areas, such as to

optimise existing processes or forecast future scenarios, e. g., with regard to visitor behaviour or possible environmental impacts of tourism.

The **areas of application** in this category were extracted from the examples and are:

- Visitor guidance / Product design:

Big data enables the analysis of the movement patterns and behaviour of visitors, which in turn allows us to gain a better understanding of them. This can be used to make forecasts about demand and visitor flow so that travellers can be guided and highly frequented places at a destination can be freed up. This can be done, for example, by showing visitors (via an app) how busy certain areas or attractions are or give them insider tips on as yet undiscovered areas (see example B.1.1). Easing the burden in specific places can not only lead to greater satisfaction among tourists, it can also have a positive effect for the local population and protect heavily frequented places from overtourism. At the same time, this can lead to an increase in the volume of tourists, which in turn would result in an increased overall burden within the destination.

- Market research / Product design:

In market research, big data is used to gather information using customer profiles and then analysed in order to gain a better understanding of the needs and satisfaction of visitors. Big data offers methods of analysis that eliminate the need for costly surveys. The results can be used to produce improved predictions about demand development in order to expand or improve existing offers. They can also be used to customise offers and/or services. Market research can therefore also help gauge visitors' environmental awareness, among other things, so that offers can be adapted accordingly. Offers adapted to the needs of the visitors in this way can also lead to increased utilisation as a result of a greater number of tourists.

- Quality management / Product design:

In quality management, big data forms the basis of customer satisfaction and competitive analyses. These should generate a better understanding of visitors' needs and a certain amount of knowledge of the product offers of competitors. Digital services are used in tourism, for example, to analyse customer ratings and compare them with those of the competition. They also allow us to identify visitors' environmental awareness and attitude towards sustainable tourism development. With the help of such services, offers can be improved or expanded where necessary to increase customer satisfaction and thus demand.

- Communication / Sales and travel planning:

Big data helps with the collection, monitoring and analysis of data so that suitable advertising campaigns can be developed. Targeted, tailored marketing activities are above all intended to improve the positioning of brands and products. Big data can also help create digital services that compare travel offers and display the best offers for the customer taking specific environmental conditions into account. These applications can also be used without reference to sustainability, which can, for example, strengthen non-sustainable modes of transport such as air traffic (see example B.1.20).

- Crisis management:

With big data, environmental conditions can be observed and the impact of natural disasters on destinations and tourism analysed. These analyses help identify the need for action and with the planning of resources and capacities. In tourism, for example, sensors that can monitor environmental conditions such as water quality, store the information in databases and thus indicate when and to what extent action is required are used. These applications are especially relevant for the environment as they limit the environmental burden to the greatest extent.

Example: Monitoring the flow of visitors with the Amsterdam City Card

In order to better understand and manage Amsterdam's growing visitor flow, the city uses the Amsterdam City Card to collect visitor data on tourist behaviour, which in combination with the "Discover the City" app is used to manage queues to attractions, expand product offers based on customer preference and offer suggestions for alternative attractions. The city uses other developments such as a future AI solution for the city to counter the challenges of overtourism without restricting tourists (cf. example B.1.3).

In summary it can be stated that when it comes to big data, the visitor guidance, market research and product design areas of application are in close proximity to each other and central. Such applications, if established, can lead to a levelling of visitor numbers, however, the same mechanism can also lead to the touristification of hitherto undiscovered places.

Positioning within the customer journey and estimation of adoption in tourism

Big data analytics is primarily used before and during the journey, such as for visitor guidance or market research. Before the journey, the application is mainly used to create a better user experience within the information process.

For the phase during the journey itself, cities (the Amsterdam City Card is an example of this) experiment with analysing visitor data. In addition, major players (such as Google) are establishing market-ready solutions that visualise visitor traffic in shops (example B.1.2) or help commuters avoid high traffic volumes (example B.1.4).

There is thus an order of adoption in tourism within the diffusion curve in the areas B to D (*early adopting*, adoption in tourism and market penetration, cf. Section 2.3).

3.2.2 Internet of Things and geo-intelligence

It is no longer just computers that are connected with each other over the internet or other wireless connections (such as Bluetooth), everyday objects are as well. The latter is called the Internet of Things (IoT). This refers to the linking and data exchange (uni-, bi- and multilateral) between all kinds of objects, devices and systems, whether they are vending machines, industrial plants, medical equipment, vehicles or entire buildings (Wirtschaftskammer Österreich (WKO), Österreich Werbung, and Bundeministerium für Wissenschaft 2017). The Internet of Things is thus a network of objects, devices (such as smartphones), vehicles, buildings and other things fitted with sensors that are embedded in electronics, software and network connections to enable these objects to collect and exchange data. Typically, large volumes of data is generated this way, which is often processed and analysed using artificial intelligence (Liebrich 2018b). There are four different IoT types (Airey 2018):

- **Portable technology:** Any object or garment such as a watch or glasses that contains sensors that help improve the object's functionality.
- **Measuring devices for human activities:** Any device for people wishing to store and monitor information about their habits or lifestyle.
- **Smart home:** Any device that can be used to control or remotely modify an object such as motion sensors, identification systems or other security systems.
- **Industrial equipment:** Any device that can be used to convert physical quantities (temperature, pressure, humidity, etc.) into electrical signals.

On the basis of these four types and the examples, the following **areas of application** can be differentiated with regard to sustainable development in tourism:

- Visitor guidance:

The IoT can be used to identify movement patterns and analyse the behaviour of tourists, which in turn leads to a better understanding of visitor flow. This means that highly frequented places can be detected in real time. The applications may incorporate wristbands in leisure parks that serve as entrance tickets, room keys and credit card information storage. Various services (payment, virtual queuing, photography, etc.) can be used via transponders installed in the park. At the same time, connecting the wristbands with devices allows movement patterns to be analysed in real time (see example B.2.1). This principle can be transferred to other areas of tourism and is already in use in some (such as on cruise ships).

- Smart facilities:

In tourism, smart facilities are used to increase building efficiency and reduce costs at the same time. These applications are particularly suitable for the hotel industry. Already today, hotel guests can book rooms that can be controlled using voice assistants. For example, guests can adjust the colour and intensity of lighting and room or shower temperatures to suit their needs (see examples B.2.2 and B.2.3). While these applications focus on the needs of guests, intelligent buildings are mainly about saving resources. This includes sensor technologies, for example, which observe the activities within a building. This prevents energy being wasted by heating or lighting vacant rooms (B.2.17).

- Market research:

In tourism market research, the IoT can help analyse the environmental conditions at a destination. Actions can be derived from these analyses that promote sustainability and improve the quality of the environment. On the island of Mallorca, the environmental impact of the port of Palma, primarily caused by (tourist) ship traffic, will be analysed (see example B.2.13). The results will help make decisions that improve living conditions and make the environment more sustainable.

- Market research / Product design:

In tourism, IoT applications that combine market research and product design are increasingly used. The aim is to utilise user data to gain important insights about the environment. These can then be used to make services, accommodation and transport more sustainable. Hotels use it to introduce their future developments to hotel guests, experts and employees. Visitors can give real time feedback and help shape their future hotel experience this way (see example B.2.15). At destinations, the new knowledge is used to show users the currently most relevant offers and information, which can change how people perceive the tourism product.

- Logistics / Sensor technology:

In logistics, IoT applications are used to automate processes. In air traffic, electronic labels are used for luggage, which can connect to smartphones via Bluetooth. This allows passengers to check their luggage in online, saving long waiting times at the check-in desk. This saves resources and increases efficiency. However, the high energy consumption resulting from making the technical infrastructure available also needs to be taken into account.

- Crisis management:

IoT is used in crisis management to inform visitors and locals about possible dangers by installing sensors at critical points. It is also used to analyse the environmental conditions so that

disasters can be prevented through timely intervention (early warning system). This is implemented with the help of sensors, which can signal the presence of hazardous gases in the environment (see example B.2.6). In general at-risk areas (forests, etc.) sensors are used to detect forest fires and to inform all relevant stakeholders. These applications help with visitor guidance and information, ensuring increased security in at-risk areas at all times. However, sensors that are installed in the countryside can disturb the ecosystem.

Positioning within the customer journey and estimation of adoption in tourism

Almost all areas of application in the Internet of Things category are about "during the trip". Since this is also the focus of the present study, the applications are also of relevance in the later assessment (Section 4).

The various examples also indicate that some Internet of Things (IoT) applications are still being developed or launched. However, applications have already been adopted in tourism for the investigation of environmental conditions and for improved visitor guidance.

Therefore, the classification of this topic with regard to adoption in tourism in the diffusion curve was in the range from A to C. It can therefore be assumed that the possibilities of the Internet of Things (IoT) will increasingly find their way into tourism and will soon be used across the board.

3.2.3 Artificial intelligence

Thanks to artificial intelligence (AI), data processing operations that normally require human skills and a lot of time to learn can be automated, which accelerates processes, improves analysis quality and capacity and reduces costs. Artificial intelligence is executed through machine learning. The aim is for computers to learn independently. The learning algorithm of a machine makes it possible to recognise patterns in observed data and/or to create models. And the system itself continues to learn. Artificial intelligence can thus be understood as an interplay of mass data, sufficient computing resources and machine learning (GlobalData Technology 2018). This combination has caused the spectrum of systems to evolved rapidly and today includes the following (vgl. hierzu auch Herweijer et al. 2018, 5):

- **Automated intelligent systems** that perform repetitive and work-intensive tasks. Tasks can be processed automatically by the machine.
- **Supported intelligent systems** that analyse data, such as from unstructured social media content, identify patterns and help people process tasks faster.
- **Advanced intelligent systems** that are used in the analogue world (such as via AR applications) to help people understand and predict complex relationships in real time and thus make better decisions there and then.
- **Autonomous intelligent systems** that automate decision making without human intervention.

Various **areas of application** can be derived from these systems, which are also fed by the examples collected as part of this study. Overall, whether the application is software or hardware-based, this is always about machines doing the work of humans. Often the hardware (such as a physical robot) acts as an intermediary of the software (which in turn is based on artificial intelligence).

► Customer service and robotics:

An AI-based software in the form of a chatbot or virtual assistant is often made available. They are programmed to imitate human conversation. Some companies use natural language processing and an instant messaging interface to create virtual travel assistants. This is also increasingly being used in tourism to automate and personalise consulting and booking processes. A reversal of this feature has also already been presented by Google (Duplex); here, an assistant can reserve a seat in a restaurant, for example.

In the hotel industry, robots can not only advise guests on attractions, make food recommendations or recommend facilities (see example B.3.12), they can also be used in service. They can deliver ordered food or laundry to the hotel room, for example (see example B.3.14). Robots are increasingly becoming an important part of automation for companies and can also form a substitute for human labour.

► Autonomous vehicles and robotics

AI and robotics are often used in combination. This applies in particular to autonomous vehicles. There is an enormous potential here when it comes to local public transport and thus also regarding the mobility of tourists at the holiday resort. AI can predict traffic jams and general traffic load (caused by cars) at destinations, which can be reduced with the help of navigation systems used by the majority of tourists. In tourism, there are many examples of autonomously operating vehicles. Autonomous ferries are used to take people across rivers or canals, which is designed to reduce the need to build bridges (see example B.3.8). At the destinations, electric and autonomous buses are used to pool traffic (see example B.3.3). There is also a noticeable trend towards autonomous traffic in airspace, such as air taxis (see example B.2.5) or drones, which may be particularly relevant for tourism providers. How feasible such systems are in practice is not yet foreseeable.

The transport infrastructure is also being expanded underground, for example, through the construction of so-called Hyperloops; although this technology is not primarily based on artificial intelligence (see excursus). While traffic based on artificial intelligence thus increases efficiency, its likely expansion into airspace and underground also means additional interventions in nature.

Excursus: Public transport with Hyperloop

The American company *The Boring Company* has developed a network of tunnels – so-called "Loops" and "Hyperloops". This is a high-speed public transport solution. The Loops support speeds of 125-150 km/h, and the Hyperloops as much as 600 km/h and more. Although the two systems are very similar, there is one fundamental difference – the Hyperloop networks are equipped with vacuum technology designed to eliminate air friction. They are operated autonomously and electrically and are not only intended for transporting people, but can also carry small cars. The tunnel networks are currently planned for Hawthorne, Los Angeles, Chicago and the east coast of the USA.

Source: www.boringcompany.com/faq, accessed 16 September 2019

► Visitor guidance

Autonomous vehicles are often also an example application for visitor guidance. They can serve as the basis for movement and behaviour pattern analyses to improve eco-friendliness at the destinations. For example, bins can be installed at the destinations that are integrated into a recycling system that helps visitors dispose of their waste correctly. Via an app they can then be rewarded with points for each correctly disposed item, and the points can be redeemed in shops

(see example B.3.7). This reward system, which in a broader sense can be described as *nudging* people towards a certain behaviour, can be transferred to other applications; it thus offers the potential to influence visitors' actions in a way that leads them to act more sustainably.

- Company-internal process optimisation

Artificial intelligence helps to automate certain business processes in order to save costs and increase efficiency. This means that potential errors such as bottlenecks in the supply chain can be identified early (see example B.3.21). This can be calculated by the IBM Watson system, for example. This supercomputer offers interfaces to develop a wide variety of applications. All types of data should be analysed here to draw conclusions that enable predictive analytics.

- Crisis management

This form of calculation (predictive analytics) is also of interest in crisis management. Anomalies can point to early indicators of hurricanes and other important weather events. This way, scenarios related to climate policy and greenhouse gas emissions can be examined. For this purpose, systems are used, for example, which can analyse data on sea-level rise and erosion with the aid of machine learning. They can, among other things, work out the health impact of hazardous industrial waste during a flood (see example B.3.18). This can minimise the impact of environmental disasters, because general security in coastal regions can be improved as a result.

In summary, there are two particular areas of application that are central when it comes to artificial intelligence and sustainable tourism development: First, artificial systems can do work that would otherwise be done by humans. Combining calculations using machine learning and data generation from various sources (Internet of Things) can improve processes and make them more efficient. Secondly, these systems can make predictions about future situations, which can lead to a multitude of applications.

Positioning within the customer journey and estimation of adoption in tourism

A number of different subtopics could be identified within the field of artificial intelligence (including machine learning and robotics), which impact the customer journey to a different extent. Artificial intelligence is primarily utilised in tourism before and during the trip (e. g. chatbots and robots). Autonomous vehicles as well as visitor management options, where many relevant examples could be identified, deserve special mention.

The various examples point to the adoption of applications in tourism, particularly in the area of customer service, through the use of intelligent chatbots and robots. However, the areas of mobility (e. g. autonomous vehicles) are still largely under development today or are being tested for tourism. The AI map of the German Academy of Science and Engineering shows 430 applications, of which only one of them is for tourism[6].

The classification of topics with regard to their adoption in tourism in the areas A to C is thus made on the diffusion curve. It can therefore be assumed that the possibilities of artificial intelligence have only partially been accepted in tourism and will be used even more in the near future.

[6] https://www.plattform-lernende-systeme.de/ki-landkarte.html, accessed on 8 April 2019

3.3 Data infrastructure

3.3.1 Smart mobile devices and digital payment

The emergence and application of mobile technologies have had a major impact on tourism and the travel industry. Today, customers can choose different options before and during their trip by surfing the internet on their mobile phones and spontaneously selecting offers. QR codes and services such as Apple Wallet offer a wide range of possibilities, because booking confirmations, for example, can simply be shown to the airline or hotel on the digital device. The emergence of new and high-tech mobile phones is particularly helpful when they enable a user to access the internet and use services online. Tour packages and other travel-related services can also be booked on the smartphone (Quadlabs Technologies 2017).

Bring your own device (BYOD)

Bring your own device (BYOD) is the trend for employees to increasingly use their own mobile devices at work for company activities. When applied to tourism, this means that visitors almost always bring their own digital device (often in the form of a smartphone) with them to their holiday destination. This allows tourism companies to offer digital services at low cost. This ranges from digital guest cards at the destinations and key functions in hotels to entertainment offers in the transport sector (information and entertainment systems that can be played on personal devices). The basis for being able to offer this form of digital service is a good digital infrastructure that allows secure access to data and systems.

Visitors are today increasingly using more mobile devices and are often dependent on smartphones and tablets at every phase of their journey. This trend has become an important driver of development that tourism companies must adapt to. As a result, tourism companies are continually investing in modern mobile technologies to make it easier for customers to make enquiries and reservations, to exploit the potential of e-commerce, and to generally improve services for tech-savvy travellers. Given that the information has to be presented so that it can be properly displayed on a mobile device, it is presented using so-called responsive design (Fundación Orange 2016, 25).

With mobile first and mobile only strategies, customers can virtually do anything on their smartphone: from checking in and ordering room service to opening the room door. It is therefore theoretically possible to make an entire trip, from booking to the overnight stay itself to returning home, without ever having spoken to a real person. In addition, mobile applications can help to provide customers with personalised offers and (digital) services, which are increasingly in demand. This results in a great number of **areas of application** for tourism:

- Logistics

Mobile technologies can be used in logistics to automate and simplify processes. Virtual stops are installed at the destinations, for example, which means that users can order a shuttle using a smartphone app. These shuttle services use (electric) vehicles that adjust their routes depending on demand (so-called pooling). This can improve public transport and make it more sustainable (see example B.4.15).

When electronic labels are used in air travel, the smartphone is used for check-in and locating baggage. This not only prevents long waiting times at the check-in desk, it also makes the logistics easier (see example B.4.6). These examples in particular show clear parallels with IoT-based solutions. However, it should be noted that in the case of mobile technologies the device itself is the focus of the solution.

- Digital payment

Digital payment is becoming increasingly important in tourism. This is reflected in established systems such as PayPal, but also in the developments of the major platform operators. Only recently, Apple announced its own virtual credit card during a keynote speech in March 2019[7], thereby once again emphasising the relevance of digital payment and increasing its popular appeal. But other smartphone apps can also be used to conveniently pay for products or services. The user normally uses an app to scan a QR code to make the payment (see example B.4.12). Such services have also greatly simplified overall travel planning, because digital payment means cashless travel. In addition, visitors no longer have to worry about currency exchange. Such smartphone apps make payments easy, fast and secure, and no paper is needed for receipts or other documents.

- Translation on demand

The development of mobile applications that enable immediate translation from one language into another is of great importance in tourism. They can ensure that people can communicate without language barriers. As a result, misunderstandings can be avoided right from the beginning, and barrier-free exchanges between different nationalities can take place. While until a few years ago this was only possible by text, today various voice assistants can translate conversations in real time (see example B.4.8).

Positioning within the customer journey and estimation of adoption in tourism

The examples suggest that smart mobile devices are particularly relevant before and during the trip. This particularly applies to applications in the area of translation on demand and digital payment.

The various examples in the field of digital payment, for example, show that smart mobile device applications are still in a final development phase, but are already established in tourism, because guests have been using these devices on site for years (e. g. for navigation).

Therefore, the classification of this topic with regard to adoption in tourism takes place on the diffusion curve in the areas B to D, and they can be expected to be fully established in the near future, especially digital payment applications.

[7] www.apple.com/apple-card, accessed on 8 April 2019

3.3.2 Extended reality (AR, VR, MR)

Extended reality can be differentiated into virtual, augmented and mixed reality (Kečkeš and Tomičić 2017, 158):

- **Virtual reality** (VR) simulates an imaginary environment. This can involve interaction. VR is fully immersive, which gives you the sensation of being in an environment different to the real world. People use a head-mounted display (HMD) or headset to experience a computer-generated world of images and sounds in which they can manipulate objects and move around with haptic controllers.

- **Augmented reality** (AR) describes the superimposition of reality with computer-generated data using a display (e. g. of a smartphone). This can be navigation information or useful additional information about the depicted place. Augmented reality thus refers to a contextualised, audiovisual information system that can create interactive experiences for people. In an augmented reality environment, the user is thus presented with a real view in real time, but artificially enhanced with information generated and superimposed by a computer system, including but not limited to digital images, videos, texts, sounds, GPS location, tactile vibrations, etc. (Horster and Kreilkamp 2016).

- **Mixed reality** (MR) can be understood as a sub-form of VR; it is sometimes referred to as hybrid reality. With mixed reality, data glasses (e. g. the Microsoft HoloLens) merge the real world with the virtual world to generate new environments and visualisations in the current place where the person is using them. Physical and digital objects coexist in real time. In mixed reality, people interact both with physical and virtual objects.

This superimposition of digital elements onto the real world also gives rise to numerous **areas of application** for tourism.

► Visitor guidance

Augmented reality games, which users download to their smartphone, can help control visitor flow. These applications could be used to attract visitors to specific places, which can become more attractive (again) with the help of AR (see example B.5.1). Mixed reality applications can also be used to digitally reconstruct ruins and offer interactive tours. This is designed to attract tourists to historic sites (see example B.5.4). Applications of this kind enhance destinations for tourists and at the same time influence user awareness of environmental issues and of their consumption.

► Sales and travel planning

In sales, virtual reality applications for tourism are used to present travel offers in advance. This is designed to enable potential customers to obtain detailed visual information about the destination, accommodation and attractions before their trip. Some tourism companies have already created features on their platforms that enable customers to use virtual reality to look at holiday apartments (see example B.5.7) or their seat on the plane (see example B.5.9) before travelling. These applications can steer customer awareness towards sustainability or sustainable travel. However, they can also enhance the attractiveness of tourist destinations, which can lead to a greater number of visitors and more environmental impact.

- Virtual travel

In tourism, virtual reality is also used to digitally reproduce entire trips. This is particularly useful if places or attractions are not (or no longer) accessible due to certain restrictions. Users of these applications will thus be able to experience what they might not be able to during their real journey for various reasons, such as climbing Mount Everest (see example B.5.12). Today, museums can even use the technology to offer visitors a special experience. They can use VR glasses to visit the past or get to know the surroundings. Such applications can change the total volume of tourists in two ways. The virtual destinations can become more attractive, which increases the overall volume of tourists. The destination could also lose attractiveness because people have already visited it virtually, which would lead to a decline in the number of visitors.

- Customer service

In customer service, extended reality is used to offer customers a special experience, for example, while they are waiting. These applications are for entertainment, but they can also influence the consumption of sustainable offers and steer user awareness in a certain direction. This could be achieved by communicating sustainability issues, which thus far is not being done.

Positioning within the customer journey and estimation of adoption in tourism

While virtual reality is often used for inspiration and therefore before the journey, augmented reality applications can be used to enhance attractions at the destination. Virtual trips can be taken before and during the actual trip, and perhaps even afterwards.

Enabling virtual travel and improved visitor guidance are already very important at the destination.

Therefore, the classification of this topic with regard to adoption in tourism was in the C range of the diffusion curve. It can therefore be assumed that the augmented reality options are already accepted in tourism and will be used more extensively.

3.3.3 Security, data protection and blockchain

Because increasingly more (personal) data is collected and analysed, the security and protection of data is also becoming ever more relevant. The blockchain technology could be a key here to comply with the necessary data security. The technology is used to superimpose (chain) encrypted data (blocks) according to the time sequence in order to generate permanent data sets that cannot be modified in reverse and, therefore, not be falsified (World Tourism Cities Federation (WTCF) 2017, 32).

In the blockchain system each data record, including a bank transfer or a contract, is mathematically confirmed by thousands of computers and is inextricably linked to previous transactions between involved business partners. The chained blocks are not stored in a large central data centre that can easily be attacked by hackers. Instead, the database is replicated on thousands of servers involved in the blockchain, which practically prevents manipulation by third parties (Müller 2018).

Smart contracts

Smart contracts have developed enormous potential as a result of the blockchain technology. The term refers to an automated contract based on software. The underlying concept has existed for some time; the triggering of a vending machine by putting in a coin and selecting a drink, for example, could be described as a smart contract. With regard to blockchain technology, such contracts are the basis for application scenarios that can now be executed in a forgery-proof environment. This provides many opportunities within the sharing economy. The rental of private cars or an apartment can be contractually fixed without an agent.

This means that the blockchain technology can result in a variety of **application options** that can be relevant for sustainable tourism:

- Sales, travel planning and digital payment

In sales and travel planning processes, intelligent contracts (smart contracts) as well as digital payment processes are used to increase data control through transparency. They potentially eliminate the need for agents, such as is promised by the Windingtree[8]platform; its system can be integrated via interfaces based on blockchain technology and offers a number of smart contracts. Blockchain technology is thus used to automate various processes and to save agent transaction fees (see also example B.6.15).

- Visitor management / Product design

In visitor management, blockchain technology is used to develop digital wallets that can be converted into a digital currency, for example, with air miles (see example B.6.17).

Example: Reward system for bicycle rental

In London, the e-bike supplier 50Cycles, in cooperation with LoyalCoin, introduced electric bikes called Toba, which generate LoyalCoins cryptocurrency during a ride. Users can track how many LoyalCoins they have collected using an app. For 1,000 miles they receive LoyalCoins worth GBP 20. Users can trade the collected cryptocurrency and use it to pay for various 50Cycles products (cf. example B.6.2).

So they represent a reward system for customer loyalty that supports air traffic and can thus counteract sustainable development. At the same time, blockchain-based applications can be used to advertise (integrated) sustainable offers, thereby influencing consumer behaviour towards sustainability (see example B.6.2).

- Digital payment:

In tourism, blockchain-based cryptocurrencies are used to guarantee secure payment transactions. They can be used, for example, to compensate passengers for long delays or cancellations. Passengers can then use this cryptocurrency to buy tickets from another airline or hotel accommodation (see example B.6.6). These applications are similar to the mobile payment processes mentioned under smart mobile devices. They also allow customers to pay conveniently by app (see example B.4.12). This type of compensation could increase customer satisfaction. However, it can also improve air traffic and thus counteract sustainable development in tourism.

[8] www.windingtree.com, accessed on 8 April 2019

► Digital identification and data security:

Blockchain technology is also used to automate security and control processes, reducing long waiting times and improving travel experience and customer satisfaction. The "Presence" ticketing method, for example, uses Smart Tones to transfer data between compatible devices and to authenticate ticket holders (see example B.6.5). New security functions can identify customers based on biometric data in particular. Customers can simply be identified by their voice, fingerprint or through face recognition (see examples B.6.12 and B.6.14). With this function passwords or security questions become obsolete. In addition, it enables the creation of a digital identity whereby people's personal data is securely stored using blockchain technology and linked to a crypto address (see example B.6.9). These new methods allow the creation of so-called digital twins, which means real people store their identifying features in the digital world.

Example: Crypto heating

The French start-up company Qarnot has developed the QC-1 crypto heater, which utilises the heat generated by the mining of cryptocurrencies. In crypto mining, transactions are processed and secured in a decentralised network. This is a process that consumes a lot of energy and releases lots of heat, which is currently not used. The crypto heater wants to change this and in the future use it to heat entire buildings and flats. While this does not reduce the energy used during mining, it does utilise the thermal energy which would otherwise be wasted.

It can be used to digitise many business processes, which on the one hand can lead to a conservation of resources, but at the same time uses them for the energy consumption of the blockchain technology (see the info box on crypto heaters).

► Logistics / Crisis management

Today, logistics in tourism is supported by new blockchain technologies in order to realise the automation of various processes through increasing transparency. In air traffic, for example, passengers can track their luggage in real time to make sure that it is on the right plane (see example B.6.13). Furthermore, serious aircraft accidents are to be prevented by storing the logbook data digitally and transparently. These applications can significantly improve logistics in tourism and not only contribute to environmental protection but also to the protection of human lives.

► Company-internal process optimisation

Blockchain technology can support tourism companies in optimising internal processes in order to increase efficiency. The tour operator TUI, for example, uses transparent databases in the Bed Swap project to distribute available beds and other services across different source markets. This means that intermediaries (e. g. brokers or travel agencies) that cause additional transaction costs can be dispensed with and, at least in theory, a bed occupancy rate of almost one hundred percent can be achieved.

Positioning within the customer journey and estimation of adoption in tourism

Most applications of the security, data protection and blockchain category are to be assigned to the periods before and during the journey. During the trip, this is particularly true for digital payment transactions, whereas platform solutions based on blockchain technology are more likely to be used before the trip.

Since the various examples are currently still primarily in the research and development phase, or there are only a few applications in tourism thus far, this topic, with regard to adoption in tourism, was assigned to areas A and B on the diffusion curve. It can be assumed that security

and data protection will gain in importance and will also be applied in tourism in the near future, although it is not as yet exactly clear how this will be done.

3.3.4 Digital accessibility and open data

Access to data is an important pillar of data infrastructure. The terms refer to the possibility of sending and receiving data. Real infrastructure conditions are decisive here: It is all about fast and easy access to the internet. This refers both to the speed of data transmission and to availability in remote locations (that may be relevant for tourism) without dead zones as well as to free access – in tourism roaming charges are a strongly limiting factor.

The linking of data in particular can be given a further boost by the upcoming 5G mobile communications standard. 5G enables complex traffic systems in which vehicles interact autonomously or with virtual reality applications that are currently not possible. In the future it may not only be possible to connect more than 200 billion devices worldwide, but also to control them in real time. The 5G mobile communications standard will supplement LTE in the future, and later replace it altogether. With regard to digital data infrastructure, the technology thus plays a key role and is considered to have no alternative. The quality and nationwide coverage of the standard and therefore digital accessibility play a central role in ensuring that the above-mentioned solutions can be deployed correctly.

On another level digital access refers to the structure in which the data is available and how it may be used. It is about the term open data, which can be considered on two levels:

- **Open licensing**: The legal framework for the use of data must be clearly regulated. Here, the Creative Commons license offers a set of six license models which regulate, for example, whether the data may be changed, whether the author must be named or whether it can be used for commercial purposes. A truly open data approach is offered by the CC-BY and CC-0 licensing models, because they allow the data to be used without restrictions and the data can be changed.

- **Open format**: To ensure interoperability and comparability of data, data must be available in a specific and structured form. If, for example, weather data is available unstructured in an image format (e. g. .png), it is very difficult to connect it with others. On the other hand, if this weather data is stored in a well-established structure or in a certain scheme (e. g. Schema.org) and in a format such as JSON-LD, then it can easily be connected with others (so-called Linked Open Data (LOD)). The five-star open data model created by Tim Berners-Lee provides a model for data openness[9].

Because there is a paradigm shift from closed to open data, the **Open by Default** principle is widely used. This means that all non-personal data should initially be opened. If this is not the case, reasons should be given as to why it makes sense to protect the data. This demand is in particular made when it comes to open government data policies on the grounds that the collection and processing of data is financed from tax revenues. This contrasts with the **Open on Demand** approach. According to this approach, data is only released if requested by third parties.

It is to be expected that the structure of the web as we know it will change fundamentally. Tourism related data is currently often processed for just one output channel (e. g. the website).

[9] 5stardata.info/de, accessed 16 September 2019

Developments, especially those of major players like Google (Knowledge Graph), and mark-up standards like Schema.org indicate that data will soon be provided independently of the respective output channel. This is what's called headless web development: In the future, web content will be displayed in a modular way, e. g., via so-called progressive web apps[10], which can be individually compiled and presented on various user interfaces. The "head" through which the content is displayed is therefore no longer necessarily your own website, which as a result loses relevance. However, the way in which the content itself is provided is becoming increasingly important in order to make it machine-readable so that it can be automatically displayed on the various output channels. This means that in addition to an open license, a uniform structure of the data is also of fundamental importance. In the future, data flow will be more important than the data channel (Sommer 2018). Projects such as the Linked Open Data Cloud or Wikidata provide examples of what this data structure can look like. With regard to digitisation in tourism, digital access can be understood as the basis of a data infrastructure. There are also **areas of application** here.

- Smart destination management

The disclosure of data can be integrated into destination management in order to improve knowledge of relevant developments and identify a possible need for action. Tools are being developed that use data from Google Maps, among others, to measure how much energy individual buildings consume and the level of released emissions. This provides the destinations with a carbon footprint calculator (see example B.7.2). This not only raises awareness of sustainability among locals, but also among local tourism providers.

- Customer service

Data accessibility not only refers to the disclosure of data, but also to the availability of signals for data exchange. For example, a satellite system was set up to offer high-speed internet access on planes (see example B.7.1). This is expected to increase the attractiveness of air travel, which can have a negative impact on sustainable development in tourism.

- Company-internal process optimisation

The disclosure of data and its linkage (Linked Open Data) can be particularly useful for customer acquisition and for defending your market position. To give companies this opportunity and to allow customers to find out about the manufacturers of the products or their suppliers, supply chains can be made transparent. A specific example is a map that shows the ecological footprint of Chinese manufacturers working for global companies. This allows suppliers to certify their compliance with environmental regulations. The pressure exerted by the public being able to inspect the value chain through the disclosure of data can lead to a sustainable change in production patterns and thus to a reduction of resource consumption. In the hotel industry, this is offered by integrated gastronomy software such as Gastronovi[11], which connects merchandise management, purchasing and ordering systems with each other, providing important data and its connections. Here, the transparency of supplier processes can also potentially be represented to demonstrate to visitors that the products are regional.

[10] Progressive web apps (PWA) are mobile web applications that can provide many features that could previously only be offered by native apps. The advantage lies in the possibility of being able to access them directly, which means visitors no longer have to download them.
[11] www.gastronovi.com, accessed on 8 April 2019

Positioning within the customer journey and estimation of adoption in tourism

A digital infrastructure, both with regard to the possibility of accessing the internet and with regard to an open data infrastructure, is to be assigned to where it unfolds the greatest relevance, "during the journey". However, it is important to bear in mind that the disclosure and use of data should be ensured throughout the travel process.

The different examples illustrate the first applications in tourism. Both the topic of open data and the discussions surrounding the 5G mobile communications standard are highly topical and are receiving a great deal of attention. The classification of this category with regard to its adoption in tourism is in the "B" area of the diffusion curve; however, due to its increasing importance, it can be assumed that the relevance of digital accessibility in tourism will increase rapidly and will soon be used or required across the board.

3.3.5 Cloud computing

Cloud computing refers to a combination of software-based technologies on the internet that are used for personal or business data processing. The fact that the programs no longer have to be installed and stored on a local computer changes the way in which data can be managed. Because all data and applications are hosted over a network, this is in contrast to a traditional data processing model where data and software resources are hosted on a local computer, the client server, or the company's server, and thus all skilled staff are required to perform and maintain the relevant IT services (Samuel Imhanwa, Greenhill, and Owrak 2015, 7).

Everything as a Service (XaaS)

Cloud computing is particularly relevant with regard to software solutions that can also be used by smaller companies via external providers. The Everything as a Service (XaaS) approach has become the buzzword, which comprises Software as a Service (SaaS), Platform as a Service (Paas), and Infrastructure as a Service (IaaS). The term describes a digital infrastructure consisting of software solutions (SaaS) that can be used by end users via a finished user interface (such as Dropbox), platforms (PaaS) on which solutions can be programmed (such as the Google App Engine), and/or infrastructure systems (IaaS) that provide servers, storage and networking (such as Amazon Web Services (AWS)). A distinction between private and therefore closed applications, public and therefore accessible applications and hybrid systems that are a combination of private and public can be made here.

Source: www.weclapp.com/de/cloud-computing, accessed 16 September 2019

Cloud technologies are not new. Solutions with web-based services have been around for decades. However, it is only recently that the cloud has become greatly more established and accepted among both providers and customers. The advantage lies in their high level of flexibility (updates can be implemented immediately) and cross-device data access – such as cloud-based data storage systems like Dropbox (Travel Technology & Solution (TTS) 2015).

Even though cloud computing is more of a hygiene factor in a data infrastructure, its many possibilities means that there are also business models that are based on cloud applications and also have **areas of application** in tourism:

- Travel planning

Cloud-based services are also increasingly being used by tourism companies to make sales processes simpler and more efficient. Tour operators and hotels, for example, use cloud computing to gain flexible and easier access to data. They can access reservations, change bookings or

issue tickets from anywhere in the world (see example B.8.3). This gives them a big advantage because the cloud is online any time and anywhere. By improving sales processes resource consumption can be reduced, because frequent communication processes, for example, are no longer necessary because it is so easy to access the cloud.

- Data management

The cloud is increasingly being used by businesses to store data. It offers the advantage of being able to retrieve data at any time and from anywhere. This means companies have flexibility in accessing their data. Providers of tourism services use the cloud, among other things, to make their platforms more complex and agile (see example B.8.2). By automating processes it helps companies increase their efficiency.

Positioning within the customer journey and estimation of adoption in tourism

The cloud is relevant for data management and the simplification of booking processes in every phase of the customer journey.

The different examples point to a broad adoption in tourism, but there are also cloud applications that are still being developed. The topic is thus assigned to area B and C on the diffusion curve. By simplifying data management, it can be assumed that the possibilities of cloud computing will increasingly be taken advantage of. The cloud therefore represents a fundamental infrastructure factor that is necessary in order to be successful on the market. Given this high level of relevance, it is to be expected that various cloud services will be adopted quickly and completely in tourism.

3.4 Data ecosystem

Digital platforms play a central role within a data ecosystem. The dominant digitisation business model is the platform. It is no coincidence that the use of the term platform economy is ubiquitous. Phenomena like social networks as well as the so-called sharing economy, which especially plays an important role in tourism, are closely linked with digital platforms.

3.4.1 Digital platforms

Digital platforms are changing the way the tourism sector is structured from the beginning to the end of the value chain, and they influence how products are developed, data is collected (the so-called data economy) and markets opens up (Weltbank 2018).

Advances in networking have led to increased use of mobile devices (and many apps) and social networks. These events have had a major impact on tourism, one of the sectors that has changed the most as a result (SEGITTUR 2015, 19). Every tourist today provides an enormous amount of data about everything that is relevant for the different phases of a trip – before, during and after a trip. Customers share their perceptions, experiences and desires on social media at all times. Digital platforms thus represent a business model which is not based on the creation of a product, but rather on the use of the large amount of data that the platform provider receives in its capacity as a broker of information. Data processing and the services on this basis are thus the foundation of digital platforms, which means a wide range of **areas of application** can be identified here for tourism.

- Visitor guidance

In visitor management, digital platforms are sometimes used to advertise unknown places or attractions. This means that heavily frequented places can be freed up. This in turn means that visitor flow can be controlled. Digital platforms thus offer the potential to improve visitor guid-

ance and influence consumption patterns towards sustainability. At the same time, this results in the touristification of small, unknown places.

Example: Digital guest card in the Upper Black Forest

A digital guest card is a way for destinations to offer a platform for guests and thus to adapt the dominant business model to the digital economy. In the Upper Black Forest, this has already been introduced. One of the special features of this card is the way it is issued; the card does not have to be actively purchased by guests, but it is otherwise included with around 450 accommodation companies and is issued to guests free of charge on arrival. The card is financed via a levy. Guests can use the card to visit more than 100 attractions free of charge. The system is expandable and destinations can integrate other services if they wish. For example, the option of using a car sharing service for three hours per day of holiday was subsequently added.

Source: www.hochschwarzwald.de/Card, accessed 16 September 2019

This tool can also be used at the destination in the form of a digital guest card, whereby the destination itself can act as a platform and thus has the opportunity to influence both service providers and guests (see also the example of the Upper Black Forest Card).

The **classification within the customer journey and estimation of adoption in tourism** will be done at the end of this section, because the social networks and sharing models are also digital platforms.

3.4.2 Social networks and reputation management

Advances in connectivity have led to increased use of mobile devices (and many apps) and social networks (Facebook, Instagram, Twitter, etc.). These developments have a major impact on tourism, as visitors have the opportunity to share their perceptions, experiences and wishes at almost every moment of their journey on social media. Social media platforms are used to exchange information between users inside and outside the tourism industry, as well as to market companies, initiatives and destinations. These networks allow each individual to participate. It is not just private individuals who use these networks to maintain friendships or find new ones. Companies from all industries also use these networks as a marketing and communication tool (IST-Studieninstitut 2016b). The relevant tourist applications examined in this context are mainly found in reputation management.

- Reputation management

Tourism companies use digital platforms to market their services. But they are also an opportunity to interact with customers. With the help of social networks such as Instagram or Facebook, companies can trigger certain emotions in potential customers by sharing countless pictures and impressions, but also information (see examples B.9.6, B.9.7 and B.9.8). This affords them special possibilities for easily influencing user consumption in a certain direction, sometimes even unconsciously. Platforms such as TripAdvisor or Airbnb also have a reputation management system, which works based on reviews (see example B.9.4). It is important for companies and/or private individuals to receive good ratings on such platforms, as they can generate higher capacity utilisation through a greater number of bookings. Companies can also use the ratings to identify customer attitudes towards specific topics and adapt their offers accordingly.

Newer platforms such as Uber and Airbnb are primarily aimed at private individuals – both on the user and provider side. Here, bidirectional reputation systems are already widespread and accepted. This means that the reputation system itself leads to better behaviour on the part of

both parties, which means it serves as a tool for controlling behaviour – this could also be relevant with regard to sustainable behaviour, if such (sustainable) behaviour is considered important by the platform itself, as it defines the rules of the system.

The **classification within the customer journey and estimation of adoption in tourism** will be done at the end of this section, because the social networks and sharing models are also digital platforms.

3.4.3 Sharing economy

The sharing economy has emerged from these networks to a certain extent and describes platform business models based on sharing, which usually takes place between private individuals, but has now also been adopted commercially. The platform itself brings providers and consumers together – creating the platform economy. Popular examples in tourism are the sharing of accommodation (Airbnb), of services (GetYourGuide; Eatwith), and mobility (e. g. BlaBlaCar or DriveNow).

Botsman and Rogers (2010) have provided a pioneering definition of the sharing economy. There are different forms of sharing economy. The resale of used goods is easier on the internet, which has led to platforms like eBay, who took advantage of this potential. On the one hand, this is about the circulation of goods. On another level, this is about a more efficient use of assets as a result of sharing (sometimes for a limited period of time). A last (third) area is about the exchange of services.

There are three primary sharing economy models (vgl. hierzu auch Scholl et al. 2015b, 8):

1. The change of ownership of used goods (e. g. eBay).
2. The granting of a temporary right of use both between private providers (e. g. Airbnb) and between commercial providers (e. g. DriveNow).
3. The exchange of services such as in the case of Uber.

The last (third) areas cannot be clearly distinguished from the classical economic system (MyHammer, for example, mainly offers commercial services).

For the economic cycle this means that the products or services are either used more intensely or for longer. If a drilling machine, for example, is sold on or hired out, its period of use intensifies or becomes longer. The business model that underlies these platforms is, as usual, based on charging a fee for each transaction. Depending on the degree of commercialisation between supplier and customer, a distinction can be made between selling vs. giving away and between lending vs. renting. When it comes to service, a distinction is made between a voluntary activity and a paid-for service.

With regard to application in tourism and sustainable development, there are many diverse and interesting examples here:

- Sharing models

In tourism, sharing models that can decisively change consumption and production patterns and sometimes also lead to a reduction in resource consumption have become established. Examples of their use are in mobility and transport at a destination. Here, platforms have been set up where private local individuals can offer tourists their own vehicles (see example B.9.10). While hiring out vehicles can save resources because no rental vehicles have to be produced for the tourism, this also enhances private transport, which results in greater environmental impact within the destination.

Sharing models are also used in the areas of accommodation and activities. The Airbnb platform allows private individuals to rent out their homes to tourists while they themselves are away on travel (see example B.9.15). Companies like GetYourGuide and Eatwith, for example, use the sharing models to bring people together (see example B.9.9). This leads to a commercialisation of the social sphere, which makes these platforms economically viable and allows them to become established on the market (Scholl et al. 2015a). These models can change the consumption patterns of both tourists and the local population in the direction of sustainability, and at the same time they can touristify small, unknown places and neighbourhoods.

Positioning within the customer journey and estimation of adoption in tourism

Digital platforms are used in all phases of the customer journey. They serve as inspiration, are used to make bookings and, in the sharing economy, to find information about and book private accommodation or other services. At the destinations, platforms are increasingly used by providers of attractions (e. g. OutdoorActive). Digital guest cards also make platform models more relevant during the journey.

The various examples illustrate that digital platforms are already widely used in tourism. Many of the various sharing models, however, are still in the introductory phase. This topic in relation to its adoption in tourism is therefore assigned to areas C and D in the diffusion curve. It can therefore be assumed that the possibilities of digital platforms have already been or will be accepted, but that their potential has not yet been fully exploited and will therefore be used even more in the future.

It must also be borne in mind and emphasised here that this category is positioned outside of our model (cf. Section 3.14). The potential of platform models is thus directly dependent on the developments that take place in the other categories. It is therefore to be expected that this type of business model will increase significantly once the possibilities of big data analytics are also fully established in tourism.

4 Assessment: the impact of digitisation

The aim of this section is to assess the opportunities and risks of digitisation for sustainable development in tourism on the basis of the digitisation trends (Section 3) and their systematisation (Section 2); in particular the paths of impact, i.e., the identified tourism-relevant areas of application are assessed on the basis of the paths of impact with regard to their possible effects on travel volume and sustainable travel behaviour.

4.1 Paths of impact and relevance assessment

For each of the categories identified in Section 3 and their development trends, the paths of impact and the relevance assessment are presented in a separate chapter.

4.1.1 Paths of impact

The paths of impact indicate the ways in which an application can affect the two central target values "travel volume" and "sustainable travel behaviour". They serve to provide a quick, graphical and schematic overview, as discussed in Section 2.4 . They are therefore presented in an overview chart for each of the nine categories.

4.1.2 Relevance assessment

In the relevance assessment we try to estimate the influence of the digitisation trends in the identified categories on sustainable tourism development. The relevance assessment rates the significance of the paths of impact.

The central criterion of the relevance assessment is the *potential level of impact* of an application or digitisation category on the target values "travel volume" and "sustainable travel behaviour". We use the terms "level of impact" and, as in the simplified environmental assessment VERUM for environmental burden, simply "impact" (Berger and Finkbeiner 2017) synonymously here.

In addition to level of impact, we also consider two other relevance indicators, namely probability of realisation and time-scale of realisation.

Estimating the *probability of realisation* is designed to help estimate the probability of a development occurring. We also adopted this assessment dimension from the VERUM report (Berger and Finkbeiner 2017).

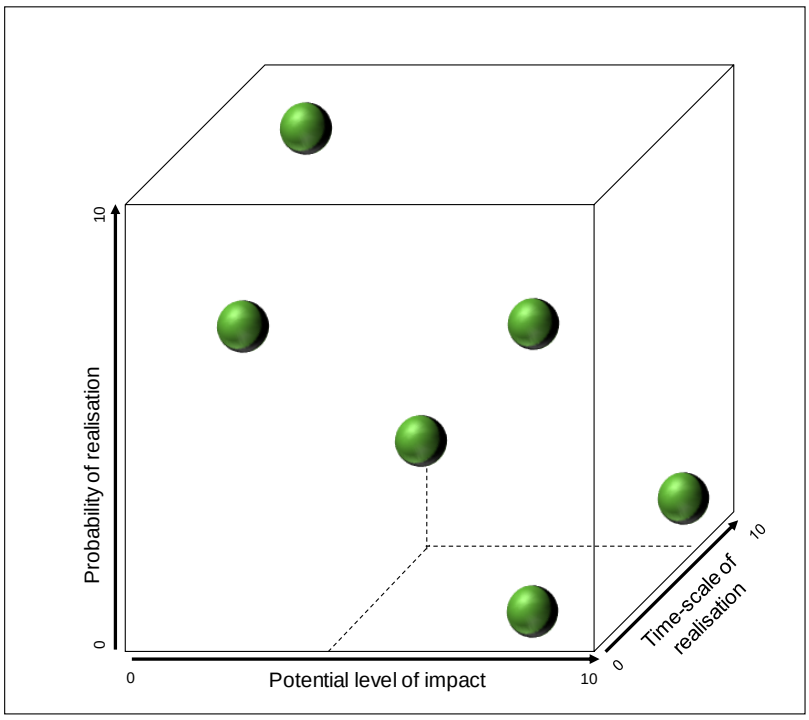
It is relatively easy to derive the *time-scale of realisation* from the systematic research results in Section 3: There the position on a diffusion curve is indicated for each application on the basis of four categories (A to D). However, we adjusted the classification there again in line with the paths of impact, as these were not taken into account in Section 3. There may thus be slight differences between the assessment of the diffusion on the one hand (Section 3) and the assessment of the impact on sustainable tourism development on the other (this Section 4). The reason for the inclusion of this temporal level in the relevance assessment is that it makes a difference whether a development will become relevant for tourism sustainability in the near future or in several years' time.

This results in three relevance assessment dimensions, namely *potential level of impact*, *probability of realisation and time-scale of realisation* (

Figure 10).

Figure 10: Dimensions for relevance assessment

Potential level of impact, probability of realisation, time-scale of realisation



Source: Own design

The assessment method is based on *sound reasoning*, it is *scoring-based* and *involves several steps.*

The *sound reasoning basis* is the definition of the paths of impact: The paths of impact serve to describe the content of the impact and therefore also provide the reasoning: How can an impact come about? Which aspects play a role?

The *scoring model* records an expert assessment for each of the three dimensions on an eleven-point scale (0 to 10). The scale is verbalised differently for each dimension (Table 6).

At least three independent assessments per dimension were carried out for each object to be evaluated and the results were then consensualised for each dimension (Printz et al. 2017; Gheondea-Eladi 2016). In addition, during the expert meeting on 16 January (cf. Section 1.7) the preliminary list of paths of impact was discussed, assessed and added to by the participants. The results of the technical meeting were adopted in the following sections.

The results are presented separately for the three dimensions. A merging (e. g. weighted addition) of the three dimensions into a single index value would not be expedient, because the three dimensions are not mutually compensatory. A low score for "potential level of impact" should not be compensated by high scores in the other two dimensions.

In addition, for each path of impact we have indicated how certain we are about the assessment. This is necessary because of the lack of sufficient data in some cases and, above all, the very dynamic developments in the field of digitisation.

Table 6: Scales for the scoring model

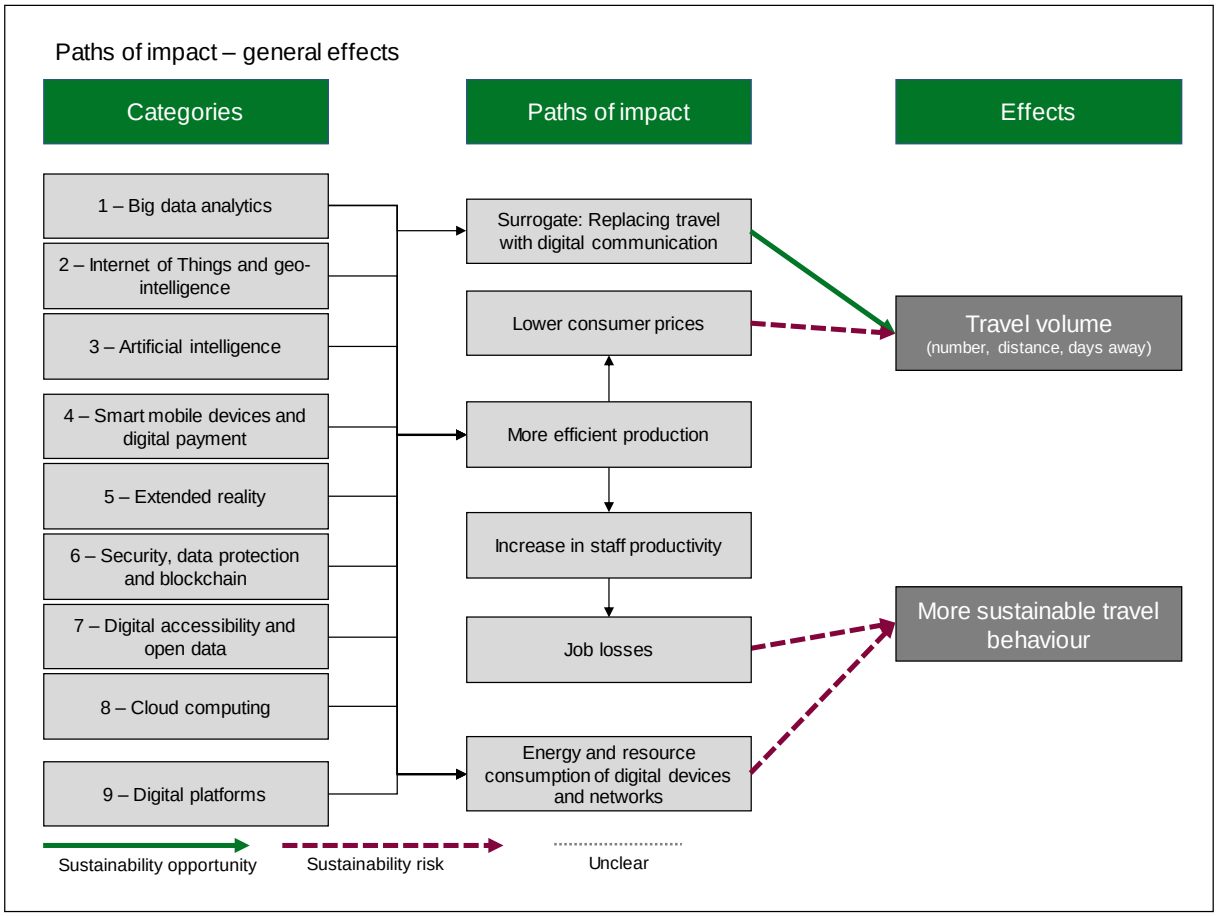
Scale points	Potential level of impact	Probability of realisation	Time-scale of realisation	Reliability of assessment
0	No impact	Excluded	Never	We do not feel at all certain about our assessment
1	Very low impact	Very unlikely/uncertain	In the distant future	…
…	…	…	…	…
10	Very large impact	Already exists	Already exists	We feel very certain about our assessment

4.2 Cross-category impacts

The consensual assessments made it clear that there are three impact patterns that apply to all digitisation categories: Surrogate effects (travel is substituted with digital experiences), efficiency effects (enhanced productivity when it comes to travel behaviour) as well as energy and resource consumption of digital devices and infrastructure.

In order to avoid having to continue to repeat these paths of impact and emphasise their primary relevance, we will list them here and summarise them in Figure 11.

Figure 11: Paths of impact of the cross-category effects



Source: Own design

4.2.1 Surrogate: Replacing travel with communication

The development of information and communication technologies to date may well have led to a "dematerialisation" of travel: "A number of scientific studies advocate that ICT can be a means of enabling the transition of society to a less material-intensive economy, and therewith sustainability." (Arushanyan 2016, 6). We have addressed these developments in the relevant areas of application.

However, there are also current studies in which a significant proportion of business travellers state that **they go on fewer business trips due to the digital communication possibilities** than they would without these digital options (Eisenstein et al. 2019). The idea that communication technology replaces travel is not new. It can be traced back to the 1990s in connection with the start of video conferencing.

Whether this connection does in fact exist and how effective it is, is not well documented. Although we find little evidence in our detailed assessments that digitisation has such an effect, this may be due to the very long-term and difficult-to-measure structure of this path of impact. We have assessed the volume reducing path of impact as medium strong because we assume that the desire for actual mobility will particularly continue to predominate among private travellers.

Table 7: Opportunity: Surrogate/Replacing travel with communication – travel volume

Category: General effects

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact					●						
Probability of realisation										●	
Time-scale of realisation										●	
Reliability of assessment					●						

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.2.2 Efficiency effects

4.2.2.1 Increase in demand

Without describing precise effect chains, the authors of the German TSA study assume that digitisation will increase demand in tourism: "In the sub-segments particularly affected by digitisation, i.e., mediation, accommodation and passenger transport, the TSA system tends to show a positive development in tourism consumption and domestic gross value added" (Bundesverband der Deutschen Tourismuswirtschaft (BTW) 2017, 39). The path of impact via increased efficiency in production seems particularly plausible here. This also includes more efficient customer information through digital media. However, the TSA authors are generally uncertain as to the direction and extent of the digitisation effect.

We have therefore described the volume effect separately in the particularly affected categories and have decided not to carry out an overall assessment at this point.

4.2.2.2 Staff productivity and jobs

On the one hand, almost all digitisation applications tend to increase productivity due to their innovative nature, which is almost always characterised by the economic paradigm of increased efficiency (in particular the reduction of marginal costs) (Balsmeier and Wörter 2017; Rifkin 2011). This is especially true for digital innovations due to their disruptive potential (Brynjolfsson and McAfee 2014). In a staff-intensive industry like tourism, this primarily concerns staff productivity. However, enhanced staff productivity goes hand in hand with a decline in jobs with demand remaining constant. This is particularly evident when it comes to the direct substitution of humans by robots, but it is not limited to this (Ford 2015; Frey and Osborne 2013). The faster data becomes available and can be processed autonomously, the greater the impact on all possible areas of tourism, from automatic beach cleaning and user-generated processing of open data for travel recommendations to autonomous buses or flying drone.

It is highly likely that jobs in tourism that are lost will be compensated elsewhere because new jobs in digitisation are created in other sectors (E. Weber et al. 2017; E. Weber 2016; Wolter et al. 2016, 83). However, since we are looking at the tourism industry here, it is reasonable to

assume a net job loss due to digitalisation rather than a net job gain in tourism; although this may only have a small impact, since the job profiles within the industry itself can also change and thus create a compensation effect.

Table 8: Risk: efficiency effects – staff productivity and jobs – sustainable travel behaviour

Category: General effects

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact									●		
Probability of realisation									●		
Time-scale of realisation									●		
Reliability of assessment				●							

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

The possibility of job losses is not a sustainability risk per se, of course. Particularly in regions and sub-sectors in which providers complain about a shortage of skilled workers, autonomous machines or customers who require less support from service staff due to digitalisation can bring relief for all parties involved (e. g. in the hotel industry in large parts of Germany).

On the other hand, tourism continues to be one of the few remaining employment opportunities, especially in peripheral areas. With regard to the social indicator "jobs" (cf. Figure 5), a sustainability risk can therefore be assumed across the board for these cases.

When this is looked at in more detail in Section 4.3.3.1, the path of impact "reduction of routine jobs" is discussed as a sustainability opportunity. This was heavily discussed at the expert meeting in January 2019, which is why we referred back to the job loss risk in the relevant section.

4.2.3 Energy and resource consumption

In order to be able to work, digitisation requires software as well as hardware. Stationary and mobile computers as well as wired and wireless networks consume electricity and raw materials. Since data is increasingly the basis of business models in the platform economy (or data economy), the volume of data stored and processed has increased – with a corresponding increase in energy consumption. Resource consumption is thus assumed to shift from the end device user to networks and data centres (Ferreboeuf, Efoui-Hess, and Kahraman 2019). “The most significant trend, regardless of scenario, is that the proportion of use-stage electricity by consumer devices will decrease and will be transferred to the networks and data centres” (Andrae and Edler 2015).

In 2008, information technology was held responsible for around 2% of man-made emissions worldwide, and this is set to increase further (Hilty et al. 2009; Prakash et al. 2014; Hilty and Aebischer 2015). At 4%, Germany's share in 2008 was around twice as high as the global average (Stobbe et al. 2009).

According to the Federal Environment Agency, the main problem lies in the increasing energy consumption of computer centres and the consumption of energy and raw materials for the production of electronic components. "In addition to the significant quantity of metals such as iron, copper, aluminium, nickel and zinc, special and precious metals are used in servers, which have not as yet been recycled much" (Umweltbundesamt 2015). The same applies to the produc-

tion and disposal of terminal devices (Deutsche Umwelthilfe 2018). (Performance) indicators for assessing the resource efficiency of data centres are now available (Schödwell and Zarnekow 2018).

At the same time, the CO_2 emission resulting from running the internet (mobile data transmission in particular) is now significantly greater than the emission generated by computer centres; although providers such as the *Green Web Foundation* would be able to offer emission-free operation (Jordan 2018). The increasing data volume is due in particular to the rising number of videos, but blockchains are also considered to be particularly energy-intensive (Bonde 2018).

There is currently uncertainty regarding the net energy effect of information and communication technology. On the one hand, advancing digitisation is said to have the potential for energy savings: "Uncertainty persists in understanding the net energy effects of ICT. [...] However, there is general agreement that ICT has large energy saving potential, but that the realisation of this potential is highly dependent on deployment details and user behaviour." (Horner, Shehabi, and Azevedo 2016). The first attempts to remedy the situation (e. g. the Sustainability Impact Canvas) are already in place (Gerlach 2018).

At the same time, however, it can be assumed that the ever greater use of computer centres for the management of mobile services (currently, for example, the introduction of 5G) and for cryptocurrency mining and operating blockchains (despite examples such as crypto heating, see description on page 69) will have the opposite effect (Gröger 2018).

As far as we know, there is no data available on tourism-specific energy and resource consumption caused by digitisation. We have therefore refrained from assessing its level of impact.

4.3 Data connectivity

The "big data analytics", "Internet of Things and geo-intelligence" and "artificial intelligence" categories are being discussed in the context of data connectivity.

4.3.1 Big data analytics

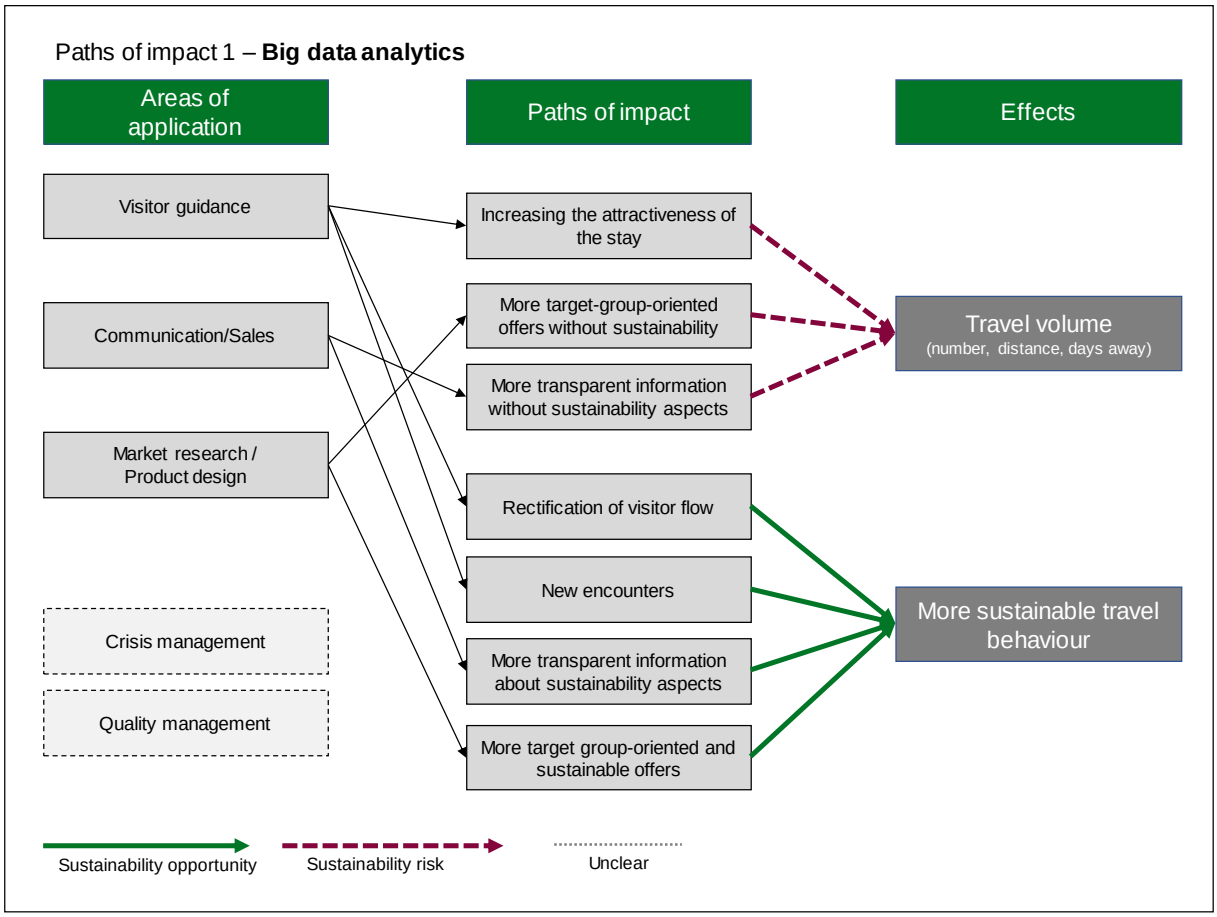
Basic information on the "big data analytics" category
The description of this category with examples is given above starting on page 57 in Section 3.2.1

For the area of big data analytics, we have derived three primary areas of application from the research results, for which we can describe paths of impact and evaluate their relevance:

1. Visitor guidance;
2. Communication and sales;
3. Market research and product design.

An overview of the identified paths of impact is shown in Figure 12. In addition, there are two areas of application which are described in connection with big data analytics, but for which we could not identify any relevant paths of impact with regard to sustainability (crisis management, quality management).

Figure 12: Paths of impact of the big data analytics category



Source: Own design

4.3.1.1 Visitor guidance

In our context, visitor guidance comprises all measures that serve to correct visitor flow and thus contribute to increasing the attractiveness of the destination. This is as such about correcting the social effects of crowding and overtourism, as well as directing visitor flow to avoid overuse from an ecological point of view. According to this view, visitor guidance can be seen as part of visitor management.

Visitor guidance is assigned to the "big data analytics" category because the processing and structuring of large and heterogeneous data volumes is at the heart of the visitor guidance process. Visitor guidance is almost equally relevant in the "Internet of Things and geo-intelligence" categories (because this is where automated sensor technology could come in) and the "smart mobile devices and digital payment" category (because these allow guidance suggestions to be communicated to visitors in real time).

In practice, visitor guidance is generally carried out by a sequence of (subsequent or real-time) measurement of visitor flow and (real-time) information of potential visitors via mobile devices. The measurement can be made with passive mobile radio signals, stationary measuring equipment or by Internet-based methods (Reif 2018; Beeco and Hallo 2014; Hallo et al. 2012; Volcheka et al. 2018; Cerdan Schwitzguébel and Romero Bartomeus 2018).

In conservation areas, visitor monitoring and management processes have a special significance (Eagles et al. 2002). These procedures are increasingly being digitised (Fairfax, Dowling, and

Neldner 2014; Jurado Rota, Pérez Albert, and Serrano Giné 2019). However, visitor guidance in urban environments has probably become just as relevant as in (protected) natural spaces.

The information given to tourists via their mobile devices thus fulfils the function of an "electronic tour guide". This distortion correction has a positive sustainability potential when it comes to sustainable travel behaviour. It is also conceivable that such systems are used to improve encounters between people.

Table 9: Opportunity: visitor guidance – correction of visitor flow – more sustainable travel behaviour

Category: Big data analytics

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact									●		
Probability of realisation										●	
Time-scale of realisation										●	
Reliability of assessment										●	

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

Table 10: Opportunity: visitor guidance – new encounters – more sustainable travel behaviour

Category: Big data analytics

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact						●					
Probability of realisation									●		
Time-scale of realisation								●			
Reliability of assessment									●		

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

However, the same mechanism can also be seen as harbouring a sustainability risk, because either more skilful crowd management can simply lead to even higher capacity and therefore environmental impact, or the increase in the quality of stays through correction has the same effect, namely an increase in demand volume.

However, we consider the overall opportunities of visitor guidance to be greater than its risks.

Table 11: Risk: visitor guidance – increased attractiveness – travel volume

Category: Big data analytics

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact							●				
Probability of realisation									●		
Time-scale of realisation								●			
Reliability of assessment						●					

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.3.1.2 Communication/Sales

The use of big data in communication and sales has the potential to influence tourist travel decisions.

This harbours sustainability opportunities as well as risks. If we succeed in communicating sustainability-relevant aspects to potential tourists this way, it will of course result in an opportunity for more sustainable travel behaviour.

Table 12: Opportunity: communication/sales – more transparent customer information that includes sustainability aspects – more sustainable travel behaviour

Category: Big data analytics

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact						●					
Probability of realisation									●		
Time-scale of realisation								●			
Reliability of assessment									●		

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

If this does not happen and if the mass market providers only influence customers in the direction of ever more expensive travel without taking sustainability aspects into account (as has largely been the case up to now) then there is a likelihood of volume growth (or a reduction in a drop in demand, which on balance amounts to the same thing), which can be regarded as a risk from a sustainability point of view. In this respect, we consider the risk to be more relevant than the opportunities. The volume effects will probably occur somewhat earlier than the opportunities, because larger (platform) companies tend to be able to leverage the potential of big data analysis faster than specialists and these large platforms then serve as the interface to customers.

Table 13: Risk: communication/sales – more transparent customer information that does not include sustainability aspects – more sustainable travel behaviour

Category: Big data analytics

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact									●		
Probability of realisation									●		
Time-scale of realisation									●		
Reliability of assessment										●	

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.3.1.3 Market research and product design

In our opinion, market research and the tourism product design have a somewhat higher level of impact than big data-based customer communication. The reason is that large, heterogeneous amounts of data tend to be processed more effectively in market research than in communication – even though these areas cannot be completely viewed separately in the digital environment (for example in *real-time marketing*, which is based on the immediate processing of data). As a result, product changes tend to have a greater impact than communication about these product changes.

Here, too, we see greater potential when it comes to risks. This is because mass market providers concentrate on increasing numbers and turnover. Since the larger providers (especially platforms) can use big data more effectively than specialists, we also expect the risks to unfold a little earlier here than the sustainability opportunities.

Table 14: Opportunity: market research / product design – more target group-oriented and sustainable offers – more sustainable travel behaviour

Category: Big data analytics

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact								●			
Probability of realisation										●	
Time-scale of realisation									●		
Reliability of assessment								●			

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

Table 15: Risk: market research / product design – more target group-oriented offers without sustainability – travel volume

Category: Big data analytics

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact										●	
Probability of realisation										●	
Time-scale of realisation										●	
Reliability of assessment										●	

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

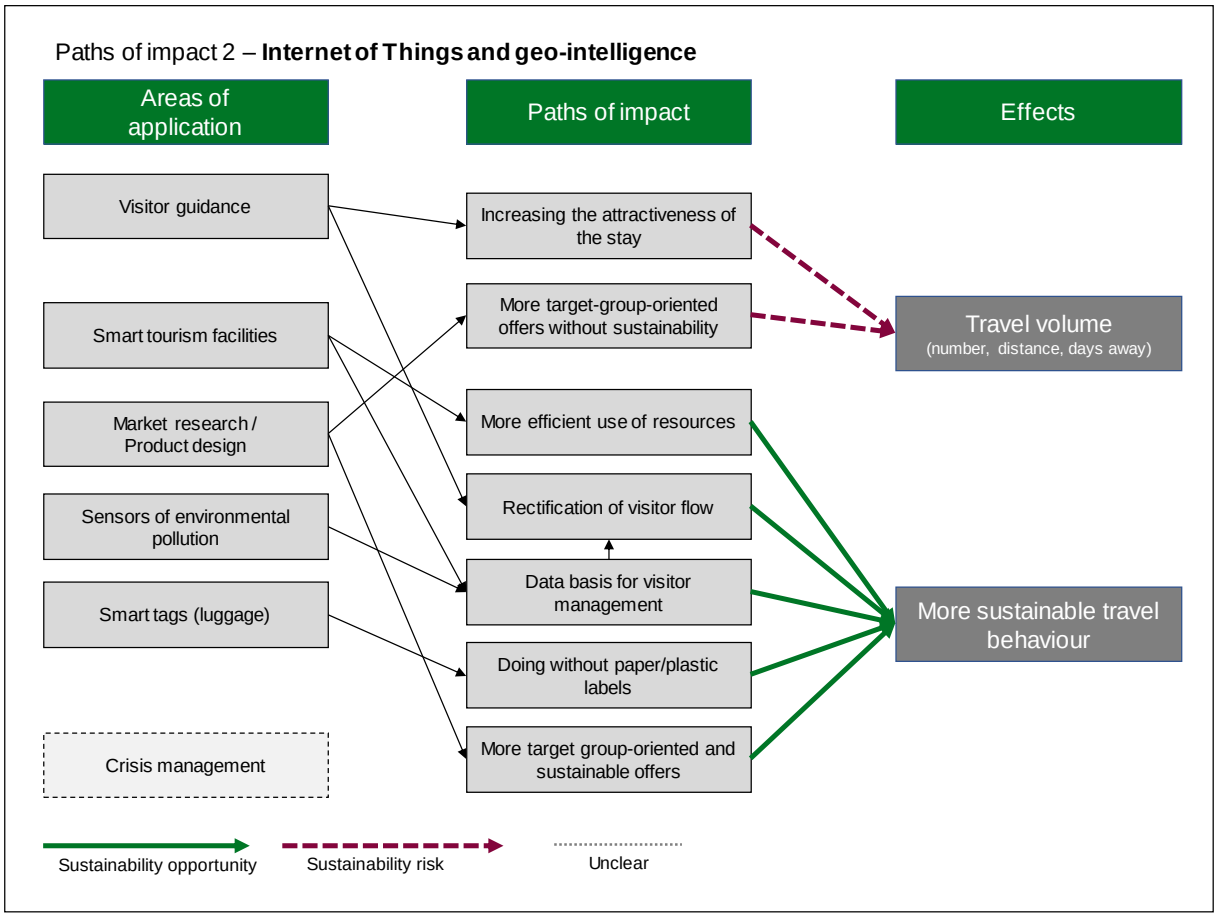
4.3.2 Internet of Things and geo-intelligence

Basic information on the "Internet of Things and geo-intelligence" category

The description of this category with examples is given above starting on page 59 in Section 3.2.2

In this category we have identified five areas of application with impact potential (Figure 13). Two of these (visitor guidance and market research / product design) have already been discussed in the "big data analytics" category and will not be discussed again.

Figure 13: Paths of impact of the category Internet of Things and geo-intelligence



Source: Own design

4.3.2.1 Smart tourism facilities

Smart facilities and "intelligent" infrastructure facilities are generally interconnected. Smart tourism facilities are such facilities for tourist use. These can be found in buildings (e. g. accommodation establishments, indoor leisure facilities) as well as mobility facilities (such as railway stations) and outdoor leisure facilities (such as ski lifts or amusement parks). At the moment, however, we believe that most of these facilities can be found in buildings.

In building automation, the main focus is on frequency- and load-based sensors and actuators, which can help to increase energy efficiency and reduce water consumption. While the fairly high level of impact is not particularly tourism-specific, it does have an effect on tourism.

The existing sensor technology can also be used as a basis for more efficient visitor management and therefore correction, i.e., a more even resource utilisation. We have already discussed this aspect under "big data analytics".

Table 16: Opportunity: smart facilities – more efficient resource utilisation – more sustainable travel behaviour

Category: Internet of Things and geo-intelligence

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact										●	
Probability of realisation										●	
Time-scale of realisation								●			
Reliability of assessment										●	

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.3.2.2 Sensors of environmental pollution

Sensors of environmental pollution are about more efficient visitor management, but with a special kind of data basis, which is why it is discussed separately here.

Environmental data can relate to different aspects, such as the weather or, over the long term, climate development. The environmental data published on the website of the Federal Environment Agency[12] or the "Environmental Data Cloud" planned by the federal government as part of its AI strategy illustrates the wide range of applications (Bundesregierung 2018, 31). In a tourism context, visitor guidance in particular, the measurement of tourism-induced emissions and the possibility of influencing them is relevant. Examples include the measurement of ship or bus exhaust gases.

Table 17: Opportunity: sensors of environmental pollution – data basis for visitor management – more sustainable travel behaviour

Category: Internet of Things and geo-intelligence

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact										●	
Probability of realisation										●	
Time-scale of realisation								●			
Reliability of assessment										●	

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.3.2.3 Smart tags

Permanent smart tags, RFID tags on luggage in particular, means that disposable paper and plastic labels can be dispensed with. Such tags are used in the aviation industry as well as by tour operators for all types of travel (Hozak 2012).

This is of course offset by the resources consumed in programming and reading out the information and the procuring of hardware. The production of an NFC chip, for example, also uses a

[12] www.umweltbundesamt.de/daten, accessed 16 September 2019

lot of resources. The tags differ significantly depending on design, and the problems they present when it comes to raw materials use and recycling have been discussed for some time (Erdmann and Hilty 2009; Kreibe et al. 2017). However, this aspect falls under cross-category impacts (see Section 4.2.3) and will not be discussed again here.

It remains questionable whether, on balance, RFID tags actually make a positive contribution to sustainability compared with paper labels. It has been argued that RFID tags only really make sense in the context of a recycling economy. Therefore, we have marked the already low level of impact with a weaker symbol.

Table 18: Opportunity: smart tag - forgoing paper/plastic labels – more sustainable travel behaviour

Category: Internet of Things and geo-intelligence

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact					○						
Probability of realisation										●	
Time-scale of realisation										●	
Reliability of assessment										●	

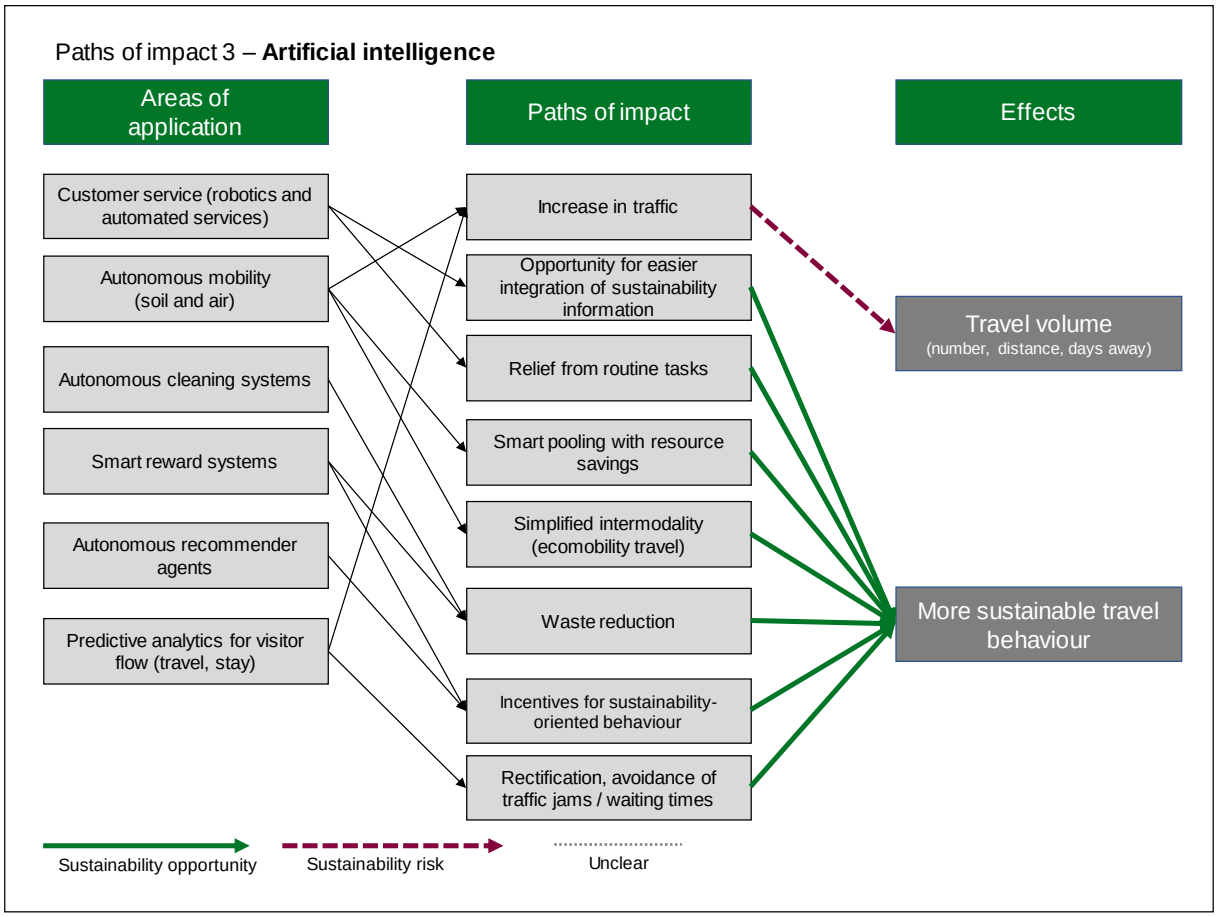
Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.3.3 Artificial intelligence

Basic information on the "artificial intelligence" category
The description of this category with examples is given above starting on page 59 in Section. 3.2.3

In this category we identified six areas of application that have the potential for more sustainable travel behaviour (Figure 14). Most of these areas of application relate to autonomous systems and have therefore been classified in this category.

Figure 14: Paths of impact of the artificial intelligence category



Source: Own design

4.3.3.1 Customer service (robotics / automated services)

It is to be expected that automated services will become more widespread in the hospitality industry simply because of the increasing shortage of skilled workers. It is also foreseeable that today's more or less "intelligent" check-in machines will be replaced by autonomous, AI-supported automated services.

There is a chance that these systems will be able to point to sustainable behaviours at the destination in autonomous customer advice services – if they are given the right training. However, we consider this opportunity for easier integration of sustainability information to be fairly small, as it requires the will and ability on the part of providers to create and prioritise such content for an AI system. Here, the mechanism of action discussed above applies again: It will mainly be larger companies that will be able to use such techniques and secure the necessary financing. But for them, sustainability is generally not high on the list of priorities. Whether and to what extent this will change is hard to judge at present. However, a more intense public debate about sustainability can also lead to large platforms changing their strategy if this means they better meet customer requirements this way. But this presupposes precisely this: Customers have to be interested in and actively seek out sustainable alternatives and reward their presence on platforms. As long as this is not the case, platforms will not act.

Table 19: Opportunity: customer service (robotics and automated services) – opportunity for easier integration of sustainability information – more sustainable travel behaviour

Category: Artificial intelligence

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact					●						
Probability of realisation							●				
Time-scale of realisation							●				
Reliability of assessment							●				

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

In this area of application, there is a second path of impact on a social dimension, namely freeing up staff from the burden of routine tasks. This aspect is primarily discussed in the context of Industry 4.0, but it can of course also be applied in tourism, such as in customer service or building maintenance. We consider this path of impact to be somewhat more relevant, although the target group here are not tourists, but rather people employed in the tourism industry.

However, we would like to point out that this path of impact does not offset potential job losses due to digitisation. We addressed this when we discussed the efficiency effects as general paths of impact (see Section 4.2.2.2 on page 81).

Table 20: Opportunity: customer service (robotics and automated services) – relief from routine tasks – more sustainable travel behaviour

Category: Artificial intelligence

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact							●				
Probability of realisation										●	
Time-scale of realisation									●		
Reliability of assessment									●		

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.3.3.2 Autonomous mobility (ground and air)

In the area of autonomous mobility, be it the ground-based sector (road, rail) or unmanned aerial vehicles (UAV), there are two conceivable paths of impact: Firstly, better utilisation of transport routes and avoidance of traffic jams, waiting times and – in this sense unnecessary – consumption of resources and, secondly, making intermodal transport (not by card) to the destinations easier.

The first case presents opportunities (such as the option to pool or share demand (car sharing) and therefore a better capacity utilisation of transport routes and vehicles) but also an increase in traffic because, on balance, transport routes and vehicles will be used more (Cohen and

Hopkins 2019; Kellerman 2018). Here, we consider the opportunities to be greater than the risks.

Table 21: Opportunity: autonomous mobility (ground and air) – smart pooling with resource savings – more sustainable travel behaviour

Category: Artificial intelligence

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact									●		
Probability of realisation										●	
Time-scale of realisation					●						
Reliability of assessment									●		

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

Table 22: Risk: autonomous mobility (ground and air) – increase in traffic – travel volume

Category: Artificial intelligence

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact						●					
Probability of realisation						●					
Time-scale of realisation					●						
Reliability of assessment									●		

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

The path of impact in the latter case is the fact that eco-mobility travel is easier when mobility at the destination is ensured. This last aspect is closely linked to the "digital platforms" category and to the set of topics related to the sharing economy.

Table 23: Opportunity: autonomous mobility (ground and air) – simplified intermodality (ecomobility travel) – more sustainable travel behaviour

Category: Artificial intelligence

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact									●		
Probability of realisation									●		
Time-scale of realisation						●					
Reliability of assessment										●	

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.3.3.3 Autonomous cleaning systems

Unlike the first path of impact, this is not primarily about indoor applications (such as room cleaning in hotels), but rather the cleaning of public infrastructure. The opportunity here lies in the fact that autonomous systems clean beaches, squares or parks by clearing waste and thus removing it from the natural environment. The reason will generally be a better experience for tourists, with the environmental benefit being a side effect, so to speak.

Table 24: Opportunity: autonomous cleaning systems – waste reduction – more sustainable travel behaviour

Category: Artificial intelligence

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact						●					
Probability of realisation									●		
Time-scale of realisation								●			
Reliability of assessment									●		

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.3.3.4 Smart reward systems

Smart reward systems are AI applications where the desired behaviour (e. g. choosing a more sustainable alternative) is rewarded by the AI system. Similar to *nudging* (Thaler and Sunstein 2008; Hall 2013; Schmücker et al. 2018), this is also about the deliberate influencing of customer behaviour. The difference is that here it is not done by changing the information architecture, but with the help of a reward. The reward can be in the form of immediate feedback ("well done"), but also by improving someone's online reputation or giving more incentive points. The reward mechanism does have a high potential in principle, even if there are not as yet many tourism-specific applications.

Table 25: Opportunity: smart reward systems – incentivisation for sustainability-oriented behaviour – more sustainable travel behaviour

Category: Artificial intelligence

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact										●	
Probability of realisation								●			
Time-scale of realisation								●			
Reliability of assessment										●	

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.3.3.5 Autonomous recommender agents

Unlike the automated services discussed above, autonomous recommender agents are used for travel planning and providing travel information on websites and mobile devices, etc. This makes them easier to design in principle, because design and mobility issues can be limited to a graphical user interface and do not require a customer contact point in the real world (such as a robot). This is why their level of impact is estimated to be somewhat higher.

Here, too, the path of impact consists in providing incentivisation for sustainability-oriented behaviour, and the reservations are the same as those described above: The companies that are able to implement such systems generally (still) have priorities other than promoting sustainability.

Table 26: Opportunity: autonomous recommender agents – incentivisation for sustainability-oriented behaviour – more sustainable travel behaviour

Category: Artificial intelligence

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact								●			
Probability of realisation						●					
Time-scale of realisation								●			
Reliability of assessment							●				

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.3.3.6 Predictive analytics for visitor flow (travel and stay)

Predictive analytics is a basic enabler of big data. It contains elements of artificial intelligence for predicting events. In tourism, these analyses concern large parts of the customer journey and can have a strong influence on travel behaviour. Traffic flow is already changing significantly, for example, as a result of traffic flow predictions. They can correct traffic flow and reduce traffic jams and waiting times, but they can also lead to a capacity expansion of transport routes and vehicles.

Table 27: Opportunity: predictive analytics – correction, avoiding traffic jams / waiting times – more sustainable travel behaviour

Category: Artificial intelligence

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact								●			
Probability of realisation								●			
Time-scale of realisation								●			
Reliability of assessment					●						

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

Table 28: Risk: predictive analytics – increase in traffic – more sustainable travel behaviour

Category: Artificial intelligence

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact						●					
Probability of realisation							●				
Time-scale of realisation							●				
Reliability of assessment					●						

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.4 Data infrastructure

In the area of data infrastructure, we discuss possible effects on tourism travel volumes and more sustainable travel behaviour in the "smart mobile devices and digital payment", "extended reality (AR, VR, MR)", "security, data protection and blockchain" and "digital accessibility and open data" categories. No relevant paths of impact have emerged for the cloud computing category, because it is more of a hygiene factor that creates the necessary conditions for many other applications; for this reason, this is *explained* in this section rather than *assessed*.

4.4.1 Smart mobile devices and digital payment

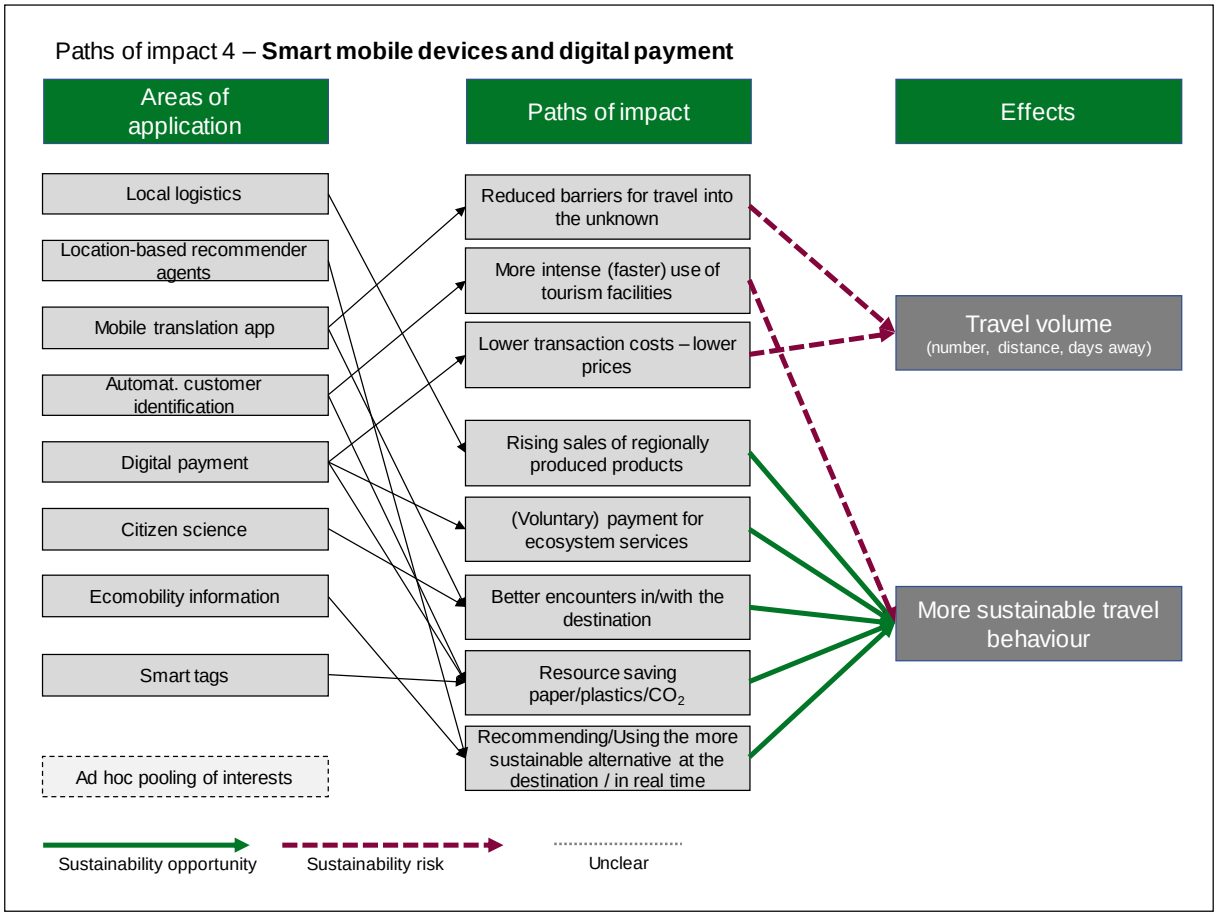
Basic information on the "smart mobile devices and digital payment" category

The description of this category with examples is given above starting on page 64 in Section 3.3.1.

Nine areas of application were identified in the "smart mobile devices and digital payment" category, seven of which will be assessed below.

1. Local logistics
2. Location-based recommender agents
3. Mobile translation app
4. Automated customer identification
5. Digital payment
6. Citizen science
7. Information on alternatives to motorised private transport
8. Smart tags (already discussed in Section 4.3.2.3)
9. Ad hoc pooling of interests (path of impact not clear, which is why no assessment is given)

Figure 15: Paths of impact of the smart mobile devices and digital payment category



Source: Own design

4.4.1.1 Local logistics

Local logistics refers to the use of mobile devices to order local products, such as regional delivery services that you can order from while on the move (for example, just before you arrive at a holiday home, camp-site or marina).

However, such deliveries are of course not limited to regional or sustainably produced products, which means this path of impact is fairly limited.

Table 29: Opportunity: local logistics – rising sales of regionally produced products – more sustainable travel behaviour

Category: Smart mobile devices and digital payment

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact						●					
Probability of realisation									●		
Time-scale of realisation									●		
Reliability of assessment										●	

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.4.1.2 Location-based recommender agents

Location-based recommender agents are systems that provide tourists with real-time position-specific suggestions and recommendations for their trip via their mobile devices. This area of application significantly overlaps with "visitor guidance" described in Section 4.3.1.1 (big data analytics category), except in the current case tourists are influenced in real time.

The opportunities are based on the fact the the more sustainable alternative can be recommended. This can in particular refer to the avoidance of negative social or ecological consequences (overuse, emissions, etc.). Here, the "geofencing" technology (which was also emphasised during the expert meeting in January 2019) can also be relevant, for example, when it comes to virtually marking protected areas. This is currently used to mark no-fly zones for drones (Schrader 2017), but it could be also be used in tourism in the future: When a visitor enters a protected zone they receive a message, thus creating awareness or steering them in a certain direction.

Table 30: Opportunity: location-based recommender agents – recommending a more sustainable alternative on location / in real time – more sustainable travel behaviour

Category: Smart mobile devices and digital payment

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact									●		
Probability of realisation									●		
Time-scale of realisation								●			
Reliability of assessment					●						

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.4.1.3 Mobile translation app

Mobile translation apps are already available on the market and are expected to become more widespread. In tourism, these apps can improve encounters between people (because they allow them to talk to each other) as well as communicate sustainability-relevant information and socio-cultural and ecological information. It can be assumed that these apps will be widely used and that tourism will also benefit from them.

Table 31: Opportunity: mobile translation app – better encounters – more sustainable travel behaviour

Category: Smart mobile devices and digital payment

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact							●				
Probability of realisation										●	
Time-scale of realisation									●		
Reliability of assessment							●				

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

At the same time, this type of app may also create a volume effect: By reducing the barriers to travel to foreign countries with an unfamiliar script and language.

Table 32: Risk: mobile translation app – reduced barriers for travel to unfamiliar places – travel volume

Category: Smart mobile devices and digital payment

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact								●			
Probability of realisation									●		
Time-scale of realisation									●		
Reliability of assessment						●					

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.4.1.4 Automated customer identification

Automated customer identification technology is used to identify individuals via their mobile device. This can, for example, lead to better service quality (direct interaction, recognition) as well as to a saving of resources such as paper or plastic, because no real-life tickets or vouchers are needed. This area of application significantly overlaps with the "smart tags" area of application discussed in Section 4.3.2.3 (Internet of Things and geo-intelligence category). We refer the reader to the assessment there.

However, automated customer identification technology can also lead to a more intensive (faster) use of tourism facilities and public attractions (for example, because customers at airports or generally when passing through control stations can be identified and transported more quickly). This can lead to more intensive use and thus to a further overload of hotspots as a result.

Table 33: Risk: automated customer identification – more intensive (faster) use of tourism facilities – more sustainable travel behaviour

Category: Smart mobile devices and digital payment

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact						●					
Probability of realisation										●	
Time-scale of realisation								●			
Reliability of assessment								●			

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.4.1.5 Digital payment

Digital payment, i.e., paying with your mobile device and without cash or debit or credit cards, saves resources such as metal, plastic and paper. In this sense there are significant overlaps with the "smart tags" area of application discussed in Section 4.3.2.3 (Internet of Things and geo-intelligence category).

It is conceivable that digital payments in the broader sense (i.e., paying without cash) can have positive effects on CO_2 emissions. Recent Dutch studies estimate the environmental impact of a cash payment using the ReCiPe method at 637 µPt (Hanegraaf et al. 2018, 15), while the environmental impact of a debit card transaction is only 470 µPt (including the necessary computer centre infrastructure) (Lindgreen et al. 2017, 2018) . No reliable data is available about non-card-based payment formats.

On the other hand, digital payment can lead to an increase in expenditure (reduced payment barrier for the customer) or to a reduction in transaction costs on the provider side and thus, if the savings are passed on to customers, to lower prices. Given the cost structures in tourism companies, this path of impact is considered to have a relatively small impact.

Table 34: Risk: Digital payment – lower transaction costs / lower prices – travel volume

Category: Smart mobile devices and digital payment

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact						●					
Probability of realisation									●		
Time-scale of realisation									●		
Reliability of assessment						●					

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

The possibility of digital payment methods to specifically set off the utilisation of (protected) nature can be seen as an opportunity for sustainability. In the context of geofencing, for example, a tourist could be asked to make a voluntary contribution when entering areas that offer access to special ecosystem services (cf. Section 4.4.1.2). The possibility to do this already exists today; however, mobile device payments could also lead to a reduction in the propensity to pay (because not everyone has a device that can be used to make payments with them). But the payment barrier could be reduced for people who do have such end devices. Its application in city tourism is also conceivable. The example of Venice shows that day tourists can also be obliged to pay a contribution, not least in order to correct visitor flow, provided these payments are linked to access authorisation to certain places or permit access at certain times.

Table 35: Opportunity: digital payment – (voluntary) payment for ecosystem services – more sustainable travel behaviour

Category: Smart mobile devices and digital payment

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact									●		
Probability of realisation									●		
Time-scale of realisation									●		
Reliability of assessment									●		

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.4.1.6 Citizen science

Citizen science is described as measures in which laypeople generate scientifically useful data. In a broader sense, this could also describe the documentation of nature, the environment and society by tourists at a destination – not necessarily for scientific purposes, but also for purely application-oriented research on site.

This can include photos and films taken with mobile devices and uploaded to a platform, possibly tagged with a geographical location (geotag). Examples include both large commercial platforms (Instagram, Facebook, etc.) and platforms specifically set up by or for a destination (such as "Mein Glücksmoment" in Schleswig-Holstein). This is, to an extent, comparable to blueprinting as applied in quality and satisfaction research and adapted to mobile devices (cf. the application Experiencefellow[13]).

From a sustainability point of view, this special type of crowdsourcing offers the opportunity to collect information about problems or particularly positive aspects about the environment, nature and society from the perspective of tourists in order to be able to react to them.

However, the benefits of such applications seem rather sporadic and unlikely to be found across the breadth of tourist travel activities, which is why we assessed their potential level of impact as being in the medium range.

[13] http://www.experiencefellow.com, accessed 8 April 2019

Table 36: Opportunity: citizen science – better encounters at/with the destination – more sustainable travel behaviour

Category: Smart mobile devices and digital payment

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact					●						
Probability of realisation									●		
Time-scale of realisation										●	
Reliability of assessment								●			

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.4.1.7 Ecomobility information

In addition to cycling and walking, ecomobility at the destination primarily includes public transport. Mobile apps make it easier to access price and, in particular, timetable information and can thus create an opportunity for sustainability because motorised private transport (MPT) could be replaced. This significantly improves the possibilities of intermodal passenger transport. Apps like Free2Move[14] already show how a combination of different means of transport can be coordinated in cities.

However, despite these possibilities a profound change, particularly in local tourism transport, is unlikely. Especially in rural areas in Germany and abroad, a major obstacle to public transport use is likely to be its availability (rather than the availability of information about it). Even if there is a well-coordinated option to switch from one mode of transport to another, tourists will at the same time still face the problem that their luggage has to be reloaded, which is an obstacle. In the future, it would be conceivable to expand the separate baggage transport option that is already offered today (e. g. also in combination with smart tags), but such a development and its resource balance is currently difficult to assess.

We therefore assume that there may be a change in mobility behaviour with a corresponding level of impact, but we are uncertain about what this will look like in practice, which is reflected in the low value assigned to "reliability of assessment".

[14] de.free2move.com/app, accessed on 8 April 2019

Table 37: Opportunity: ecomobility information – using the more sustainable alternative at the destination – more sustainable travel behaviour

Category: Smart mobile devices and digital payment

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact								●			
Probability of realisation										●	
Time-scale of realisation										●	
Reliability of assessment			●								

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.4.2 Extended reality (AR, VR, MR)

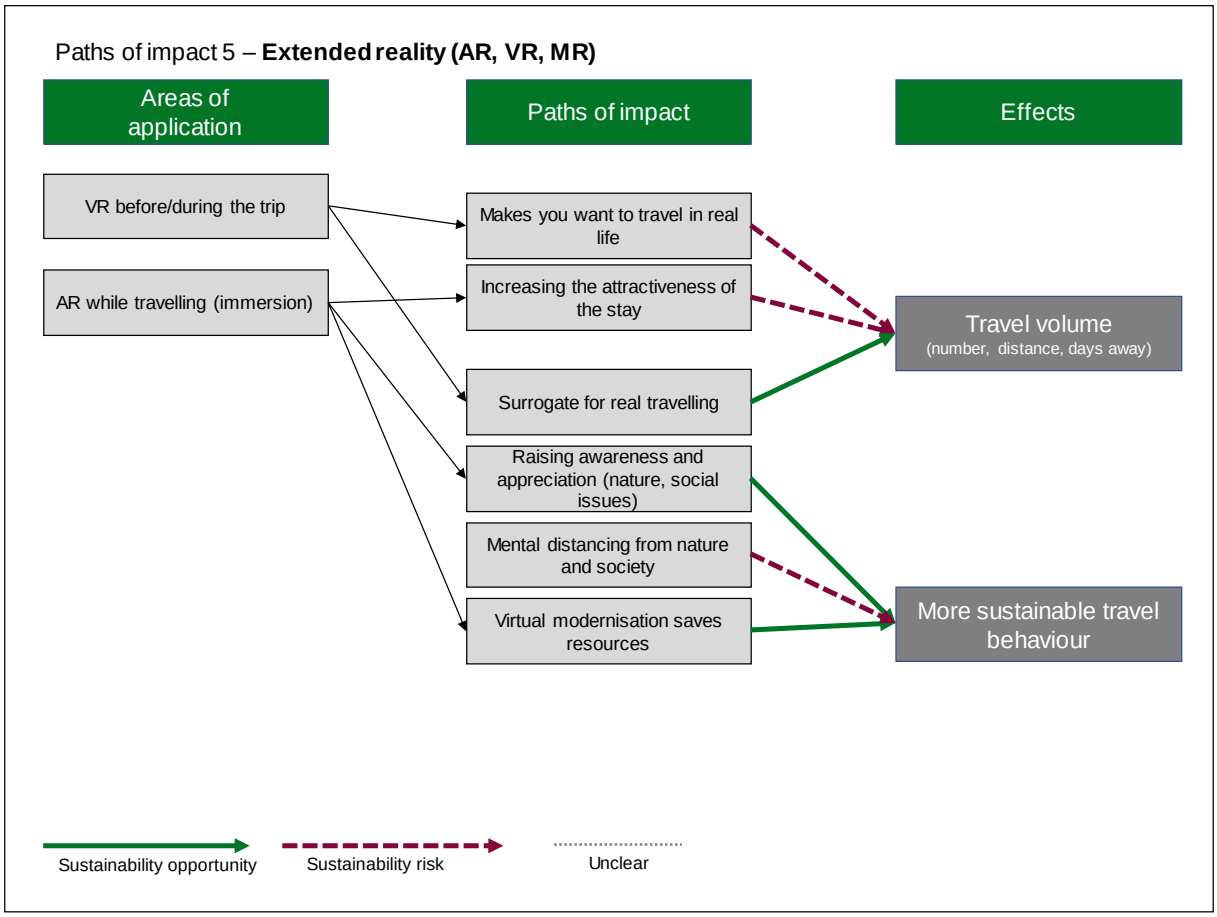
Basic information on the "extended reality (AR, VR, MR)" category

The description of this category with examples is given above starting on page 66 in Section. 0

Extended reality refers to the application of the augmented reality (AR), virtual reality (VR) and mixed reality (MR) technologies in a tourism context.

We have identified two main areas of application here, each with several paths of impact: VR before and during the trip and AR applications during the trip (Figure 16).

Figure 16: Paths of impact of the extended reality (AR, VR, MR) category



Source: Own design

4.4.2.1 VR before/during the trip

Two paths of impact can be distinguished when using virtual reality applications before (and during) the trip: Firstly, using VR can lead to a real trip (when it is used before the trip) or a real outing (when it is used during the trip) not taking place. In this case, the virtual reality is a substitute (surrogate) for the real trip.

Table 38: Opportunity: VR before/during the trip – surrogate for real travel – travel volume

Category: Extended reality (AR, VR, MR)

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact					●						
Probability of realisation										●	
Time-scale of realisation										●	
Reliability of assessment								●			

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

On the other hand, looking at a destination using VR can make you want to see the original even more – and therefore increase the volume of travel. We consider this effect to have a greater

level of impact than the surrogate effect, but with considerable uncertainties. Since VR applications, when used to convey information about travel destinations, are just a more modern and realistic presentation method (such as compared with a film documentary), we consider its level of impact to be fairly low.

Table 39: Risk: VR before/during the trip – makes you want to travel – travel volume

Category: Extended reality (AR, VR, MR)

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact					●						
Probability of realisation									●		
Time-scale of realisation											●
Reliability of assessment								●			

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.4.2.2 AR while travelling (immersion)

Augmented reality has conquered the mass market ever since *Pokémon Go*. In the area of sustainable tourism, we see a path of impact that includes an opportunity for sustainability through awareness raising and an appreciation of nature and social issues. We consider the potential level of impact to be quite high, provided that providers can be persuaded to communicate sustainability content in an attractive way.

Table 40: Opportunity: AR during the trip (immersion) – raising awareness and appreciation (nature, social issues) – more sustainable travel behaviour

Category: Extended reality (AR, VR, MR)

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact								●			
Probability of realisation									●		
Time-scale of realisation							●				
Reliability of assessment									●		

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

In contrast to the opportunity-oriented awareness and appreciation path of impact, a risk-oriented path of impact of mental distance from the authentic experience through the use of AR or VR during the journey is also conceivable. Through virtualisation and the accompanying "artificialisation" of the experience, an appreciation for the good, the genuine and the real could decline. However, we consider the level of impact of this path to be lower than that of the opportunities.

Table 41: Risk: AR during the trip (immersion) – mental distancing (nature, social issues) – more sustainable travel behaviour

Category: Extended reality (AR, VR, MR)

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact					●						
Probability of realisation								●			
Time-scale of realisation								●			
Reliability of assessment						●					

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

Another path of impact involves the avoidance of resource consumption through enhancing the attractiveness of leisure attractions by modernising them virtually rather than in the real world. However, we consider this path of impact to be less powerful.

Table 42: Opportunity: AR during the (immersion) – virtual modernisation saves resources – more sustainable travel behaviour

Category: Extended reality (AR, VR, MR)

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact							●				
Probability of realisation									●		
Time-scale of realisation									●		
Reliability of assessment									●		

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

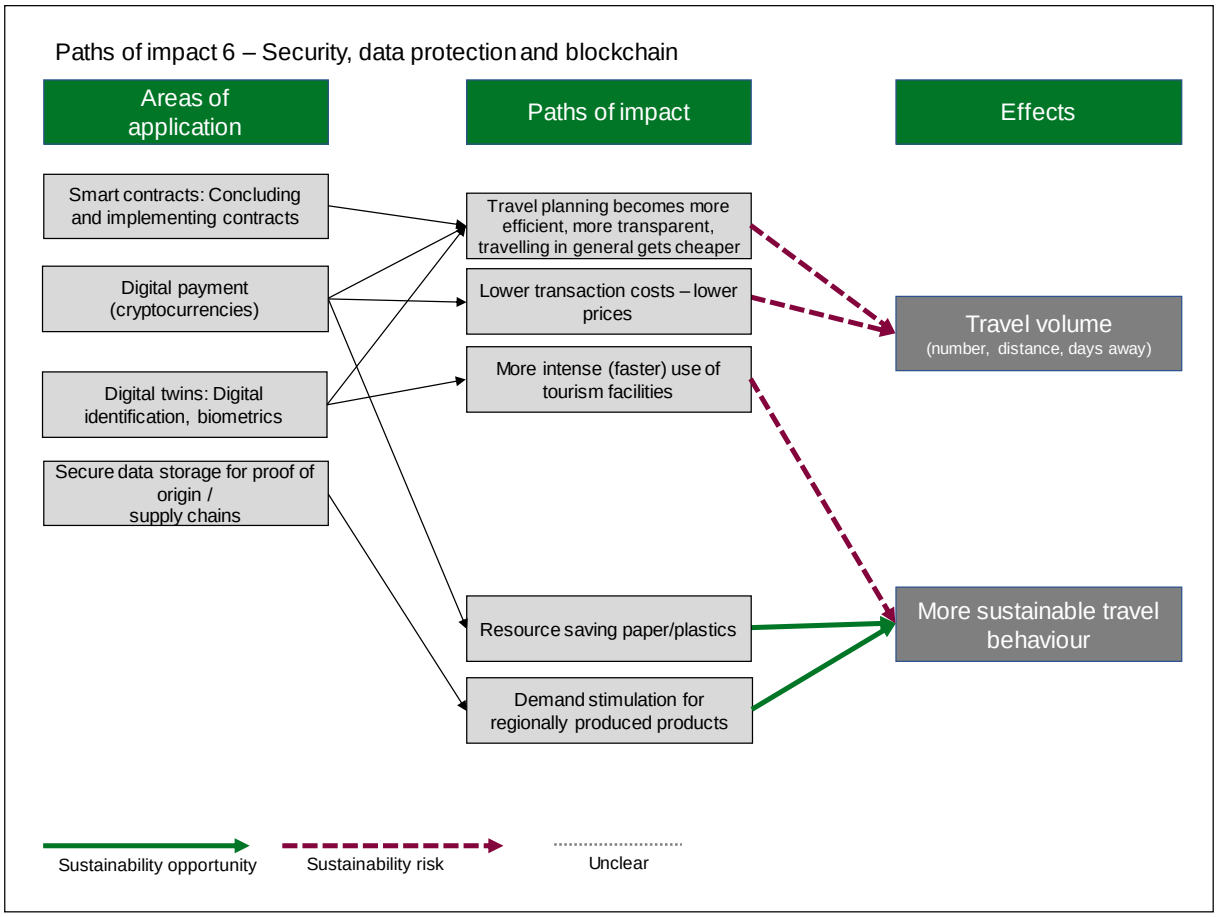
4.4.3 Security, data protection and blockchain

Basic information on the "security, data protection and blockchain" category

The description of this category with examples is given above starting on page 67 in Section. 3.3.3

In the context of tourism and with a view to sustainability, the blockchain will above all have to be looked at with regard to safety aspects: The areas of application we have identified here are secure contracts, secure payments, secure identification and data storage.

Figure 17: Paths of impact of the "security, data protection and blockchain" category



Source: Own design

The question of data security (in particular protection against unauthorised use of one's own data including identity theft, etc.) is of great importance for the future of digitisation as a whole and in tourism. Network access (mobile phone and WiFi networks) on the move is one thing that needs to be considered. However, it is difficult to identify specific sustainability opportunities or risks in this context.

4.4.3.1 Smart contracts

Smart contracts can lead to considerable flexibility and thus also a potential increase in efficiency in the tourism industry. As a result, travel could become cheaper and travel volume could increase. This path of impact is listed separately here because it differs from the general efficiency gain in the tourism sector described in the general effects in that it also explicitly includes the customer's perspective.

Table 43: Risk: smart contracts: concluding and implementing contracts – travel planning becomes more efficient, more transparent, travelling in general gets cheaper – travel volume

Category: Security, data protection and blockchain

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact									●		
Probability of realisation									●		
Time-scale of realisation								●			
Reliability of assessment				●							

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

Another path of impact with positive and negative effects is the improved sharing possibilities through efficient smart contracts. This aspect will be discussed and assessed in Section 4.5.1.

4.4.3.2 Digital payment (cryptocurrencies)

This path of impact (saves resources such as metal, paper and plastic and lowers prices which stimulates demand) has already been discussed and assessed in Sections 4.4.1.5 and 4.3.2.3.

4.4.3.3 Digital twins (digital identification, biometrics)

The two main paths of impact of digital identification (up to the formation of digital twins) have already been described in Section 4.4.1.4 and apply mutatis mutandis here.

4.4.3.4 Secure data storage for proof of origin / supply chains

The use of the blockchain as secure data storage for certificates of origin and supply chains is discussed in the context of Industry 4.0. In the tourism context, which is also dependent on (regional) products and (sustainably produced) equipment, there is at most an indirect effect. Although transparency ensures confidence in product origin, the direct relevance for tourism is very limited. This is therefore assessed as being of fairly low relevance.

Table 44: Opportunity: secure data storage for proof of origin / supply chains – transparency ensures trust, increased demand for regional/sustainable products – more sustainable travel behaviour

Category: Security, data protection and blockchain

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact					●						
Probability of realisation										●	
Time-scale of realisation										●	
Reliability of assessment									●		

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.4.4 Digital accessibility and open data

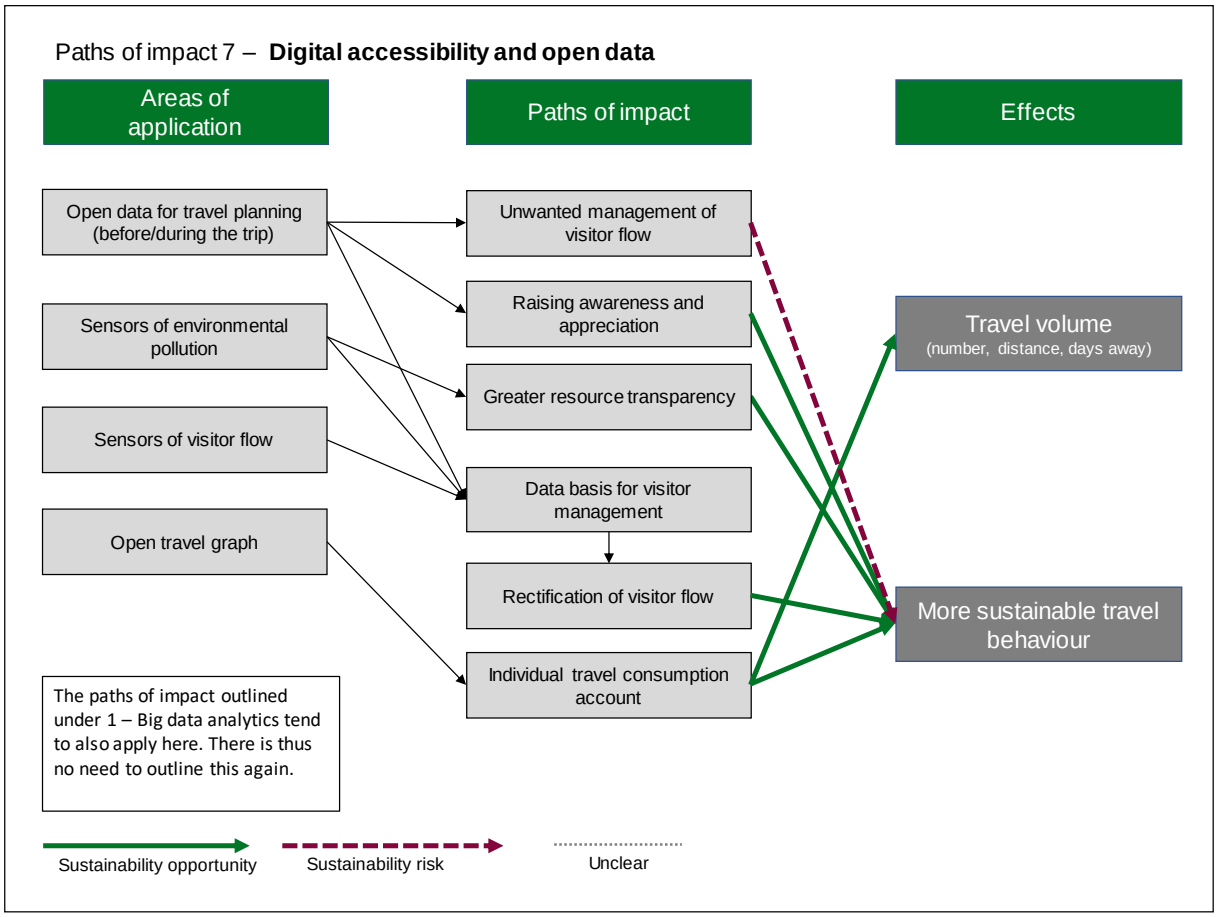
Basic information about the "digital accessibility and open data" category

The description of this category with examples is given above starting on page 67 in Section 3.3.4.

The "digital accessibility and open data" category is closely linked to the "big data analytics" category, because the availability and accessibility of data are the basic requirements of big data analytics. We therefore refer the reader to the assessments made in Section 4.3.1. Nevertheless, there are a number of specific paths of impact for three areas of application, which are discussed here (Figure 18):

1. Open data for travel planning (before and during the trip)
2. Sensors of environmental pollution
3. Sensors of visitor flow
4. Open travel graph

Figure 18: Paths of impact of the digital accessibility and open data category



Source: Own design

4.4.4.1 Open data for travel planning

Open data for travel planning is currently being discussed intensively, especially in destination management. The requirement for destinations to make all relevant data freely, structurally and digitally accessible can lead to potential tourists engaging with the destination and its natural and social characteristics in more depth before the trip, which in turn can lead to greater awareness and more appreciation of the destination.

However, this effect can only come about if the destinations make the relevant open data available (on the environment or visitor volume). Tourists can also generate this data themselves using mobile devices (cf. "citizen science" section on p. 103).

Table 45: Opportunity: open data for travel planning – raising awareness and appreciation (nature, social issues) – more sustainable travel behaviour

Category: Digital accessibility and open data

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact							●				
Probability of realisation								●			
Time-scale of realisation								●			
Reliability of assessment									●		

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

There may be a risk here. The availability of open, user-generated and not (fully) *curated* data carries the risk of misinformation.

Curating here refers to the selection (especially according to correctness) and contextualising of data from other sources. This task must also be carried out for open, user-generated data, remunerated (financially or through a gain in reputation) and performed continuously and to an appropriate extent. If these tasks are not performed, tourists may, for example, use areas that they are not supposed to or are not allowed to use (travellers are misdirected). Examples were also talked about during the expert meeting in January 2019, such as from the field of user-generated information on electronic cards. This can become a problem for local and regional nature conservation in particular. It must also be pointed out that this problem cannot be measured by the degree of data openness, but rather by uncontrolled or non-curated generation on the part of the users.

Table 46: Risk: open/user-generated data for travel planning – undesirable steering of visitor flow – more sustainable travel behaviour

Category: Digital accessibility and open data

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact							●				
Probability of realisation										●	
Time-scale of realisation									●		
Reliability of assessment									●		

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.4.4.2 Sensors of environmental pollution

With regard to sensor technology and the open availability of environmental data and its use in enduser online systems (e. g. in CO_2 calculators), we consider the potential level of impact to be somewhat higher: This in particular concerns the possibilities for comparison of the various travel options, but also the emission comparison of accommodation establishments. (Grimm et al. 2009; Günther, Grimm, and Havers 2013).

Table 47: Opportunity: sensors of environmental pollution (CO_2 calculator) – greater resource transparency – more sustainable travel behaviour

Category: Digital accessibility and open data

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact										●	
Probability of realisation										●	
Time-scale of realisation								●			
Reliability of assessment									●		

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.4.4.3 Sensors of visitor flow

The path of impact regarding the correction of visitor flow is closely linked to visitor guidance by big data analytics discussed in Section 4.3.1.1. We refer the reader to the assessment there.

4.4.4.4 Open travel graph

The basic idea of the (to date non-existent) individual open travel graph is a personal travel balance based on open data, which is updated as the years go by. This would allow consumers to measure their long-term travel behaviour against objective standards. For example, it would be conceivable that the holiday travel-related CO_2 emissions (or CO_2 equivalents that also take other harmful gases into account) would be recorded and evaluated in order, for example, to point out alternatives for further trips.

Open travel graph

People's awareness of their personal impact on resource use, pollution and climate change seems to be growing slowly but surely in our society. Nevertheless, there is still a big gap for many people between perception and real behavioural change. One reason for this seems to be the high degree of abstraction between our own actions and the resulting effects on the environment. We are directly confronted with the consequences of our behaviour too rarely.

Only when you see yoghurt pots, washing powder bottles and various plastic bags floating in the water on your favourite beach, you may get an idea of the consequences of your own consumer activities. Why do we find it so difficult, given the real environmental and climate crisis, to connect our own actions and their consequences with the existing threats? One reason for this could be the lack of cause and effect transparency, which still makes ignoring these things all too easy.

While thinking about this, I had the idea of the Green Open (Travel) Graph, which, like the Face-book Open Graph, "logs" our behaviour and preferences with regard to sustainability aspects, enables contextual transactions, and could also be transferred to other industries. Possible appli-cations in tourism would be, for example, a personal "environmental footprint" card that measures/displays the travel behaviour of the consumer, or the preference-based offering of more sustainable alternatives or compensatory measures for personal travel activities by companies.

This would be based on the creation of a data model based on objective standards and criteria. It remains to be seen whether such a model and the Green Open (Travel) Graph have realistic chances of being implemented. However, what seems important to me is the focus on a more

incentive-based or motivational process that rewards positive aspects and developments rather than being demotivating with negativity or pillorying people for their social sins.

Thorsten Reich, Netzvitamine, Hamburg

Such an Open Travel Graph is conceivable and was addressed by Thorsten Reich as an impulse from the expert meeting in January 2019 (see Infobox), but it has not yet been implemented; we have therefore not evaluated its potential impact, but rather just mentioned it as a possibility.

4.4.5 Cloud computing

Basic information on the "cloud computing" category

The description of this category with examples is given above starting on page 70 in Section. 3.3.5

According to our initial assessment cloud computing, i.e., the distributed storage and availability of data volumes, will not have an impact on the volume of tourism or more sustainable travel behaviour. Paths of impact can be constructed via "data availability" as a vehicle. However, these are not fundamentally part of the "cloud computing" category, but are already found in the 1 – big data analytics, as well as 7 – digital accessibility and open data categories.

Nevertheless, the general area of electricity and resource consumption has a particular impact here, as server farms require large amounts of energy (cf. Section 4.2.3).

4.5 Data ecosystem

In data ecosystem we deal with digital platforms, social networks and the reputation management based on them, as well as the so-called sharing economy (which occupies the largest space here). It is difficult to clearly distinguish between these three categories. Because digital platforms include social networks and the business models that emerge from them are often, especially in the context of sustainability, also to be assigned to the sharing economy. We have thus treated the categories as one, but described them separately in Sections 3.4.1 and 3.4.2.

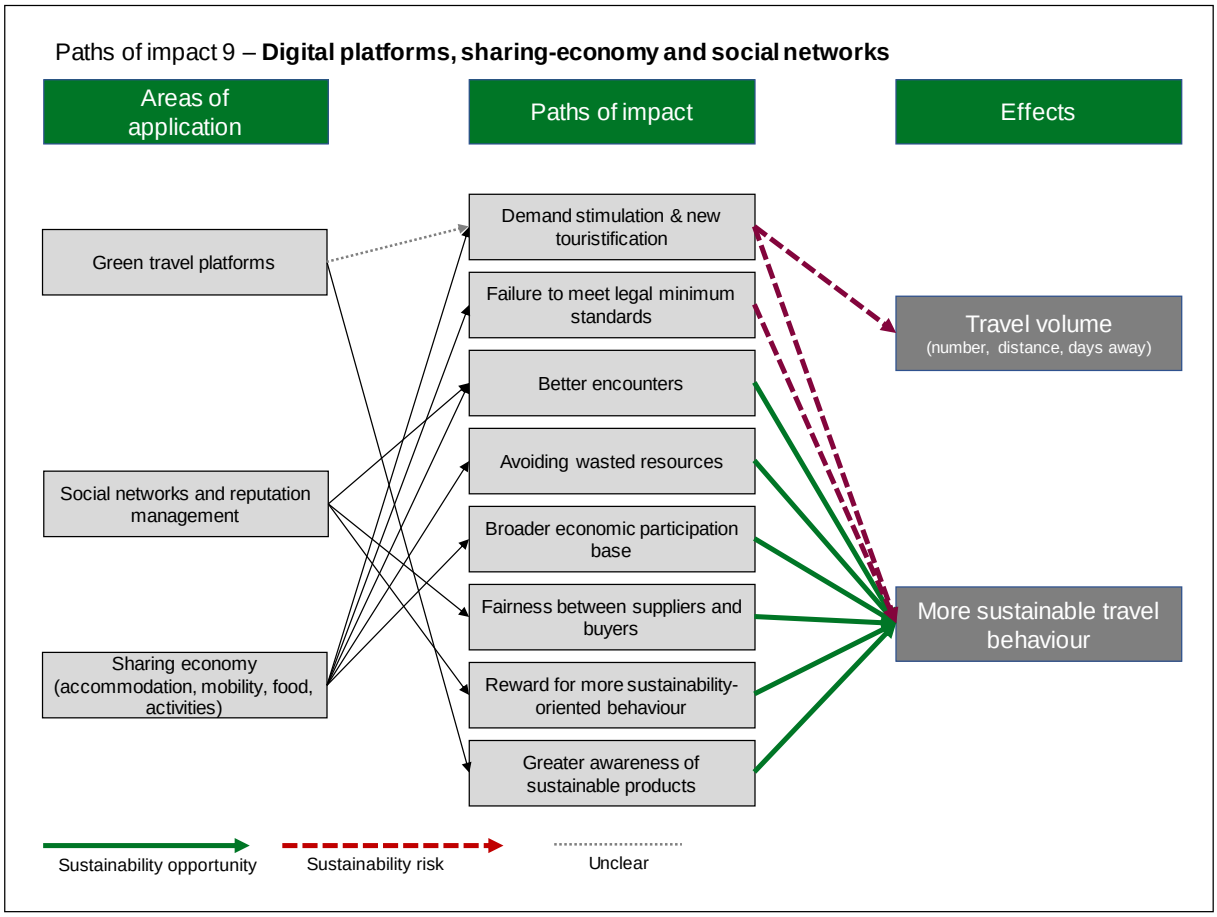
Basic information on the "data ecosystem" category (digital platforms, social networks and sharing economy)

The description of this category with examples is given above starting on page 73 in Section. 3.4

In this sphere we find three main areas of application, which, however, due to the fact that they could also have been a separate category, each entail a whole series of paths of impact:

1. Green travel platforms
2. Social networks and reputation management
3. Sharing economy (accommodation, mobility, food, activities)

Figure 19: Paths of impact of the digital platforms, sharing economy and social networks category



Source: Own design

4.5.1 Green travel platforms

The number of online platforms attempting to stimulate demand through greater transparency is increasing (e. g. www.green-travel.de, www.bookitgreen.de, greentravelindex.com, www.bookdifferent.com) and established platforms also sometimes set up "green" subsidiaries. The opportunities for sustainable travel behaviour are obvious. There is on the one hand an improved perception of sustainable products because the platforms explicitly focus on them. On the other hand, this niche offering can also result in increased demand and possibly the touristification of previously unknown destinations if they specialise in providing a sustainable range of travel offers. Since these platforms are still offers for a very specific target group, we see their level of impact as moderate.

Table 48: Opportunity: green travel platforms – improved perception of sustainable products – more sustainable travel behaviour

Category: Digital platforms, sharing economy and social networks

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact							●				
Probability of realisation										●	
Time-scale of realisation									●		
Reliability of assessment										●	

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.5.2 Social networks and reputation management

The management of online reputation in social media can ensure fairness between providers and consumers and thus better social encounters. After all, the rating of hosts and guests after the journey is no longer anonymous; both hosts and guests often know who does the rating. People are increasingly more aware of this fact (whether they are commercial providers, private landlords or the guests themselves). Such awareness raising alone can result in respectful interaction with one another. This in turn can lead to a change in perspective and, in positive cases, to understanding rather than complaints.

Table 49: Opportunity: reputation management – better encounters, fairness be providers and consumers – more sustainable travel behaviour

Category: Digital platforms, sharing economy and social networks

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact						●					
Probability of realisation										●	
Time-scale of realisation										●	
Reliability of assessment										●	

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

Another path of impact from this spectrum is the risk of social punishment for unsustainable or at least contradictory behaviour. However, we consider the potential level of impact to be fairly low. Nevertheless, the structure of the reputation system is always the responsibility of the respective platform on which the rating was made. It is difficult to imagine today that these digital pure players will focus on sustainability aspects. Especially because these mostly young but fast-growing companies (Airbnb, for example, has only been active since 2008) are often characterised by unconditional customer orientation; this would only require a reaction on the part of the companies when a rating by an individual user that focuses on aspects of sustainability is perceived as common sense by the general public.

Table 50: Opportunity: reputation management – social punishment for unsustainable behaviour – more sustainable travel behaviour

Category: Digital platforms, sharing economy and social networks

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact						●					
Probability of realisation									●		
Time-scale of realisation										●	
Reliability of assessment										●	

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

4.5.3 Sharing economy (accommodation, mobility, food, activities)

The so-called sharing economy pools four primary tourism services: accommodation (*shared accommodation*), mobility (travel there and back and mobility at the destination), eating (e. g. Eatwith) and activities at the destination such as the use of guides (UNWTO World Tourism Organisation 2017; Busch et al. 2018).

It can be assumed that sharing offers increases market capacities and can therefore lead to an increase in demand, which can be assessed as a sustainability risk in terms of travel volume. This risk is to be regarded as relatively high, since *shared accommodation* in particular appeals to a different type of traveller than classic accommodation offers (Airbnb 2019; Schmücker, Sonntag, and Wagner 2018; Kagermeier, Köller, and Stors 2015; Sonntag, Schmücker, and Wagner 2018; Orgaz et al. 2018; Guttentag 2016). These travellers are often younger, more open-minded and more price-sensitive than the average holidaymaker. It is to be assumed that cheaper flights appeal to this group. Budget flights are highly supply-driven: Sufficient capacity at very competitive prices regularly leads to higher demand regardless of the destination.

Table 51: Risk: sharing economy – demand stimulation – travel volume

Category: Digital platforms, sharing economy and social networks

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact								●			
Probability of realisation											●
Time-scale of realisation											●
Reliability of assessment										●	

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

Another potential risk lies in the so-called touristification of areas that have not been, or not often used for tourism. This development has been investigated several times, especially in urban areas (Koens 2017); however, under the keyword of "Instagrammability" it also affects non-urban spaces (cf. the beach of Ko Phi Phi Le or #Superbloom at Walker Canyon). The use of living space (which is in scarce supply in many cities) for short-term rental should also be viewed in this context.

We consider this risk to have a potentially higher level of impact than the increase in volume. However, it can be assumed that it primarily affects cities and towns that are already in strong demand by tourists.

Table 52: Risk: sharing economy – touristification – more sustainable travel behaviour

Category: Digital platforms, sharing economy and social networks

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact									●		
Probability of realisation											●
Time-scale of realisation											●
Reliability of assessment										●	

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

A further risk cited in the context of sharing economy is the possible violation of legal regulations and standards or even an alleged increase in tax evasion (UNWTO World Tourism Organisation 2017). Case reports about Uber drivers running up work-related debts illustrate this risk group. The sharing economy does in fact appear to be less regulated than other accommodation or transport sectors, not only in Germany, but also worldwide (UNWTO World Tourism Organisation 2017). However, it is difficult to establish a systematic connection to digitisation here, because the problems related to bogus self-employment or regulating private rentals did not of course come about with the platform economy. Nevertheless, networking possibilities (between private providers and consumers) make this topic more relevant. It can also be assumed that policy-makers will address this issue and create the necessary framework conditions. In view of this, we consider this complex to have a fairly low impact potential.

Table 53: Risk: sharing economy – failure to meet legal minimum standards – more sustainable travel behaviour

Category: Digital platforms, sharing economy and social networks

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact						●					
Probability of realisation											●
Time-scale of realisation											●
Reliability of assessment										●	

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

The opportunities here, which could be described as the flip side of touristification, are "better encounters". This means that tourists can avoid "ghettoisation" and instead achieve a positive social effect for both sides through authentic encounters (NECSTouR 2016; Mody, Suess, and Dogru 2018).

Table 54: Opportunity: sharing economy – better encounters – more sustainable travel behaviour

Category: Digital platforms, sharing economy and social networks

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact								●			
Probability of realisation											●
Time-scale of realisation											●
Reliability of assessment										●	

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

Avoiding unused resources or the more efficient use of existing resources via the sharing economy should also be seen as an opportunity. Instead of constantly procuring and building new vehicles, flats or restaurants, the sharing economy can help to make more intensive use of existing resources. This also includes the pooling of transport by demand and the associated saving of resources, for example, through car-sharing exchanges such as Blablacar. Another consequence of the sharing economy, insofar as it actually refers to the private provision of tourism services, is the broader economic basis for participation. The lower entry barriers allow people to participate economically and socially in tourism in a way they were not able to previously (UNWTO World Tourism Organisation 2017; Busch et al. 2018).

Table 55: Opportunity: sharing economy – avoiding wasted resources / broader economic participation basis – more sustainable travel behaviour

Category: Digital platforms, sharing economy and social networks

Scale	0	1	2	3	4	5	6	7	8	9	10
Potential level of impact								●			
Probability of realisation										●	
Time-scale of realisation									●		
Reliability of assessment										●	

Potential level of impact: 0: no impact, 1: very low impact, 10: very large impact; probability of realisation: 0: impossible, 1: very unlikely, 10: already exists; time-scale of realisation: 0: never, 1: in the distant future, 10: already exists; reliability of assessment: 0: we feel very certain about our assessment; 10: we feel very certain about our assessment.

5 Conclusion and courses for action

5.1 Analysis of the paths of impact and relevance assessments

In this study we described a total of 51 paths of impact, 49 of which we evaluated with regard to potential level of impact, probability of realisation and time-scale of realisation.

It was not possible to evaluate the two general negative paths of impact on energy and resource consumption (cf. Section 4.2.3 on page 82) and on demand growth because of a digitalisation-induced efficiency effect (cf. Section 4.2.2.1 on page 81) because of a lack of sufficient data. What's more, no assessments were made for the "cloud computing" category (cf. Section 4.4.5 on page 115).

The following overviews summarise the results of the assessments for the remaining 50 paths of impact.

Overall, significantly more positive (34) than negative (16) paths of impact were identified. With regard to the two major target values of "travel volume" and "travel behaviour", we see more negative paths of impact for volume and more positive paths of impact for travel behaviour (Table 56).

Table 56: Number of paths of impact per target value

Category	Travel volume	Travel behaviour	Total
Number of positive paths of impact	2	32	34
Number of negative paths of impact	9	7	16
Total number of paths of impact	**11**	**39**	**50**

Data basis: Chapter 4

The most paths of impact were identified in the "artificial intelligence", "smart mobile devices and digital payment", "digital platforms" and "big data analytics" categories (Table 57).

If one considers not only the number of paths of impact, but also their relevance assessment, then the positive average ratings (6.4) have a slightly higher level of impact than the negative average ratings (6.2) (Table 58); however, this difference is not very pronounced. If we calculate the sum per category using the negative or positive relevance assessments ("score" in Table 58), we find the highest positive value (54) in the "artificial intelligence" category and the highest negative value (23) in the "big data analytics" category.

The diagram in Figure 20 shows an overview of the assessment of all 50 paths of impact. It shows that the positive paths of impact can primarily be found in the travel behaviour category, while for volume, the negative paths of impact predominate. This is more evenly balanced when it comes to level of impact. It also becomes clear that the very low and very high levels of impact are not covered much or not at all. In the case of the very low values (0-3), this is due to the fact that the authors have excluded aspects that seemed to be irrelevant from the outset using the *horizon scanning* technique (cf. Section 2).

Table 57: Number of paths of impact per category

Category	Number of paths of impact	Number of positive paths of impact	Number of negative paths of impact
0 General effects	2 (+2)	1	1 (+2)
1 Big data analytics	7	4	3
2 Internet of Things and geo-intelligence	3	3	0
3 Artificial intelligence	10	8	2
4 Smart mobile devices and digital payment	9	6	3
5 Extended reality (AR, VR, MR)	5	3	2
6 Security, data protection and blockchain	2	1	1
7 Digital accessibility and open data	3	2	1
8 Cloud computing	-	-	-
9 Digital platforms, sharing economy and social networks	9	6	3
All categories together	**49**	**34**	**15**

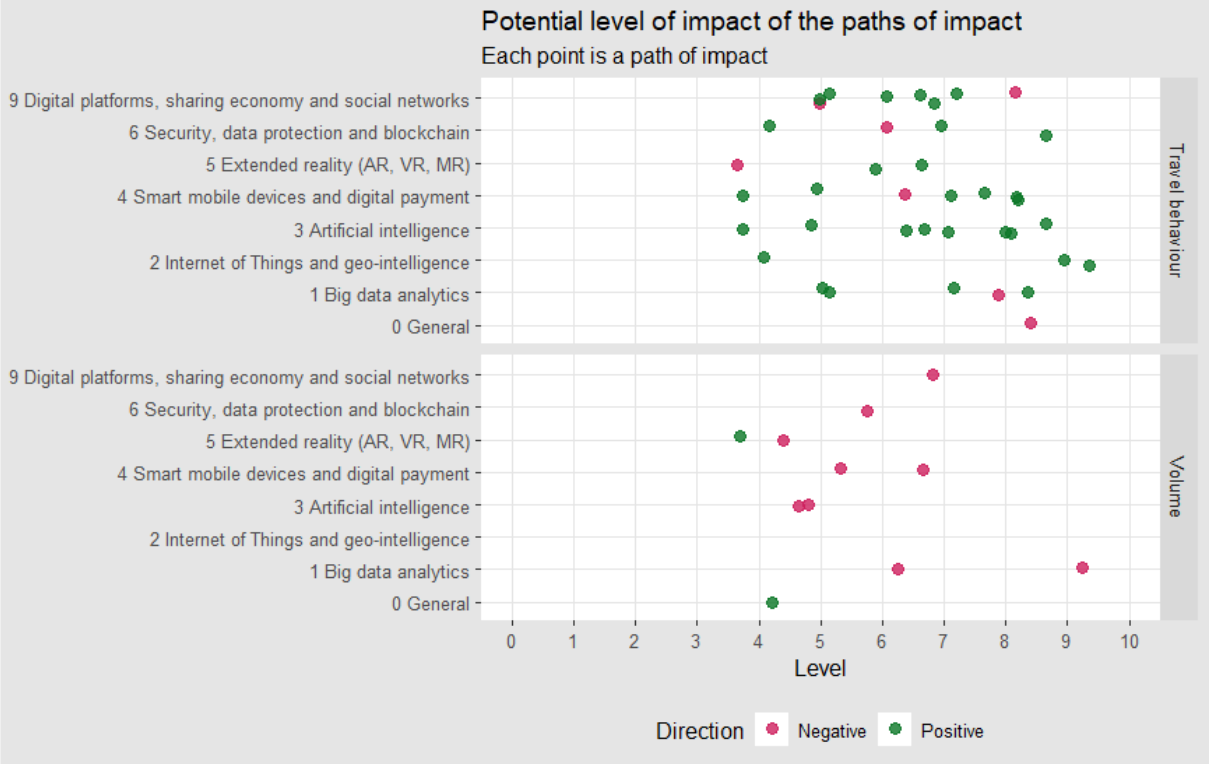
Data basis: Chapter 4

Table 58: Negative and positive levels of impact per category

Category	Medium positive level of impact	Medium negative level of impact	Score positive	Score negative
0 General effects	4.0	8.0	4	8
1 Big data analytics	6.3	7.7	25	23
2 Internet of Things and geo-intelligence	7.3	-	22	0
3 Artificial intelligence	6.8	5.0	54	10
4 Smart mobile devices and digital payment	6.7	6.0	40	18
5 Extended reality (AR, VR, MR)	5.7	4.0	17	8
6 Security, data protection and blockchain	4.0	6.0	4	6
7 Digital accessibility and open data	8.0	6.0	16	6
8 Cloud computing	-	-	-	-
9 Digital platforms, sharing economy and social networks	6.2	6.7	37	20
All categories together	**6.4**	**6.2**	**219**	**99**

Data basis: Chapter 4

Figure 20: Potential level of impact of the paths of impact



Source: Own design, data basis: Chapter 4

With regard to travel behaviour, the *average* levels of impact of the positive and negative paths of impact are more evenly balanced; however, there are significantly more positive than negative paths of impact. With regard to travel volume, the negative paths of impact not only have a higher level of impact, there are also more of them (Table 59).

Table 59: Average negative and positive levels of impact per target value

Category	Travel volume		Travel behaviour		Together	
	Number of paths of impact	Average level of impact	Number of paths of impact	Average level of impact	Number of paths of impact	Average level of impact
Positive paths of impact	2	4.0	32	6.6	34	6.4
Negative paths of impact	9	6.0	7	6.5	16	6.2

Data basis: Chapter 4

In our opinion, the paths of impact with the greatest potential level of impact on the positive side are more efficient use of resources through *smart facilities* and the possibilities of changing consumer behaviour with digital methods – either by managing and steering people or through incentive systems (*nudging*). The 34 positive paths of impact are shown in order of level of impact; shown in Table 60, the 16+2 negative paths of impact are shown in Table 61.

Table 60: The 34 positive paths of impact

Category	Area of application / Path of impact	Target value	potential level of impact
2 Internet of Things and geo-intelligence	Smart facilities – more efficient use of resources	Travel behaviour	9.0
2 Internet of Things and geo-intelligence	Sensors of environmental pollution – visitor management	Travel behaviour	9.0
3 Artificial intelligence	Smart reward systems – incentivisation	Travel behaviour	9.0
7 Digital accessibility and open data	Sensors of environmental pollution – resource transparency	Travel behaviour	9.0
1 Big data analytics	Visitor guidance – correction	Travel behaviour	8.0
3 Artificial intelligence	Autonomous mobility – simplified intermodality at the destination	Travel behaviour	8.0
3 Artificial intelligence	Autonomous mobility – smart pooling	Travel behaviour	8.0
4 Smart mobile devices and digital payment	Location-based recommender agents – recommending the more sustainable alternative	Travel behaviour	8.0
4 Smart mobile devices and digital payment	Mobile translation app – better encounters	Travel behaviour	8.0
4 Smart mobile devices and digital payment	Voluntary payment for ecosystem services	Travel behaviour	8.0
1 Big data analytics	Market research / Product design – more sustainable offers	Travel behaviour	7.0
3 Artificial intelligence	Autonomous recommender agents – incentivisation	Travel behaviour	7.0
3 Artificial intelligence	Predictive analytics – correction, traffic jams, waiting times	Travel behaviour	7.0
4 Smart mobile devices and digital payment	Ecomobility information – using the more sustainable alternative at the destination	Travel behaviour	7.0
5 Extended reality (AR, VR, MR)	AR while travelling (immersion) – raising awareness	Travel behaviour	7.0
7 Digital accessibility and open data	Open data – raising awareness	Travel behaviour	7.0

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…continuing from previous page

Category	Area of application / Path of impact	Target value	potential level of impact
9 Digital platforms, sharing economy and social networks	Sharing economy – better encounters	Travel behaviour	7.0
9 Digital platforms, sharing economy and social networks	Sharing economy – avoiding unused resources	Travel behaviour	7.0
9 Digital platforms, sharing economy and social networks	Sharing economy – broader economic participation	Travel behaviour	7.0
3 Artificial intelligence	Customer service – relief from routine tasks	Travel behaviour	6.0
5 Extended reality (AR, VR, MR)	AR while travelling (immersion) – virtual modernisation	Travel behaviour	6.0
9 Digital platforms, sharing economy and social networks	Green travel platforms – improved perception of sustainable products	Travel behaviour	6.0
1 Big data analytics	Communication/Sales – more transparent customer information	Travel behaviour	5.0
1 Big data analytics	Visitor guidance – new encounters	Travel behaviour	5.0
3 Artificial intelligence	Autonomous cleaning systems – waste reduction	Travel behaviour	5.0
4 Smart mobile devices and digital payment	Local logistics – regional products	Travel behaviour	5.0
9 Digital platforms, sharing economy and social networks	Reputation management – better encounters	Travel behaviour	5.0
9 Digital platforms, sharing economy and social networks	Reputation management – social punishment	Travel behaviour	5.0
0 General	Surrogate effect	Volume	4.0
2 Internet of Things and geo-intelligence	Smart tags – forgoing paper and plastic labels	Travel behaviour	4.0
3 Artificial intelligence	Customer service – integration of sustainability information	Travel behaviour	4.0
4 Smart mobile devices and digital payment	Citizen science – better encounters at/with the destination	Travel behaviour	4.0
5 Extended reality (AR, VR, MR)	VR before/during the trip – surrogate	Volume	4.0
6 Security, data protection and blockchain	Proof or origin – demand for regional products	Travel behaviour	4.0

Table 61: The 16+2 negative paths of impact

Category	Area of application / Path of impact	Target value	potential level of impact
0 General	Efficiency effect Increase in demand	Volume	n.a.
0 General	Energy and resource consumption	direct environmental impact	n.a.
1 Big data analytics	Market research / Product design – less sustainable offers	Volume	9.0
0 General	Staff productivity and jobs	Travel behaviour	8.0
1 Big data analytics	Communication/Sales – more transparent customer information	Travel behaviour	8.0
9 Digital platforms, sharing economy and social networks	Sharing economy – touristification	Travel behaviour	8.0
4 Smart mobile devices and digital payment	Mobile translation app – reduced barriers	Volume	7.0
9 Digital platforms, sharing economy and social networks	Sharing economy – demand stimulation	Volume	7.0
1 Big data analytics	Visitor guidance – increased attractiveness	Volume	6.0
4 Smart mobile devices and digital payment	Autom. customer identification – more intensive use of tourism facilities	Travel behaviour	6.0
7 Digital accessibility and open data	Open/User-generated data for travel planning – undesirable steering of visitor flow	Travel behaviour	6.0
6 Security, data protection and blockchain	Smart contracts – more efficient travel planning	Volume	6.0
3 Artificial intelligence	Predictive analytics – increase in traffic	Volume	5.0
3 Artificial intelligence	Autonomous mobility – increase in traffic	Volume	5.0
4 Smart mobile devices and digital payment	Falling transaction costs – falling prices	Volume	5.0
9 Digital platforms, sharing economy and social networks	Sharing economy – failure to meet legal minimum standards	Travel behaviour	5.0
5 Extended reality (AR, VR, MR)	VR before/during the trip – makes you want to travel	Volume	4.0
5 Extended reality (AR, VR, MR)	AR while travelling (immersion) – mental distancing	Travel behaviour	4.0

5.2 Summary assessment of paths of impact and relevance assessments

If we summarise the analysis of the 49 paths of impact and relevance assessments (+ two general paths of impact not assessed), we can draw the following key conclusions:

1. With regard to sustainability impact, we were able to identify significantly more positive than negative paths of impact. A positive path of impact is interpreted as an opportunity, and a negative path of impact as a sustainability risk (cf. Section 2.4.3 on page 48). It thus follows: **Digitisation holds more opportunities than risks for the sustainable development of tourism.**
2. We identified two key target values for the effect of digitisation: The change in travel volume and the change in travel behaviour (cf. Figure 5 on page 47). The **sustainability opportunities identified by us predominantly relate to travel behaviour** and only in exceptional cases (namely two) to travel volume.
3. The **sustainability risks identified by us relate to both travel volume and travel behaviour**. The general efficiency effect of digitisation that we were not able to assess (cf. Section 4.2.2.1 on page 81) is also assigned to the "sustainability risk for travel volume" category.
4. The risks also include energy and resource consumption by digital networks and devices (which can also not be assessed); their relevance is to be rated as higher rather than lower (cf. Section 4.2.3 on page 82).
5. The **greatest opportunities for sustainability lie in the "artificial intelligence" category:** It has the most positive paths of impact (8), which in addition have a high average relevance (7.0). **The greatest sustainability risks lie in the "big data analytics" category** with three paths of impact and an average relevance of 7.7. However, it must be emphasised that assigning individual applications to categories is not an exact science (cf. Section 0 on page 53). The categories are intertwined to such an extent that there are few applications that can only be assigned to a single category.
6. **Many applications hold opportunities and risks at the same time.** One not very efficacious example is the use of virtual reality before travelling: This can lead to the trip not being taken in the first place because the virtual world serves as a substitute. It is just as conceivable, however, that engaging with and exploring the destination virtually makes someone want to travel in order to not only experience the virtual substitute, but also the destination itself. Big data applications in product design or sales communication, for example, are to be viewed in a similar way, although they have a higher level of impact: They can be used to make travel more sustainable and for selling. But they can also be used to design and sell less sustainable trips, and more of them (we consider the latter to be more likely).
7. Significant **sustainability risks** result from the fact that **large companies in the tourism industry** that are not particularly geared to sustainability use the **potential of digitisation to increase volume (more and more trips) faster** than the industry as a whole can realise the sustainability opportunities of digitisation with regard to travel behaviour. This potential primarily lies in the more efficient production and marketing of travel using big data-driven applications (paths of impact via market research and product design as well as more efficient target-group-oriented customer information). Companies that are able to use such technologies efficiently and effectively, especially due to their size, are better able to identify and monetise the needs of their customers and can do so faster. Furthermore, there is a risk for the employees in the tourism indus-

try, whose **jobs are in jeopardy due to digitally automated** customer support and service.

8. Digitisation first of all makes *travelling seamless*, because airport check-ins are straightforward with digital technologies, digital payment systems make foreign currency exchange obsolete and *translation-on-demand services* overcome language barriers. Secondly, supply and demand can easily be linked via digital platforms. Niche offers can become more visible and even private individuals can offer their services as part of the sharing economy. **All these developments tend to lead to more rather than less travel and therefore, on balance, to more environmental impact**, which we identified as the general efficiency effect.
9. However, the risks are offset by **numerous opportunities**. The opportunities here can be found in the sphere of **digital mobility**, such as self-regulating, corrected traffic systems. In this context, possible savings through the **optimised utilisation of mobility, accommodation and leisure resources (*sharing*)** also deserve a mention. We see another opportunity of digitisation in the spread **of resource-saving smart facilities** (hotels and other accommodation establishments, leisure facilities). But there is an ambivalence here again: More efficient use and the new concepts associated with it can, but do not have to, lead to a reduction in consumption. It remains to be seen whether new mobility concepts will on balance lead to savings or simply to even more mobility because access to it will become easier and there will be more of it.
10. We believe that the most high-impact opportunities result from digitisation's potential to change the **behaviour of consumers**. **More transparent real time information** (such as about the capacity utilisation of attractions or the current weather and environmental situation) **combined with intelligent recommendations (recommender agents) of the more sustainable alternative** have the potential to encourage behavioural changes. Digitisation offers numerous opportunities to provide incentives for choosing the more sustainable alternative – through reward systems, real-time benefit promises, transparent information, awareness-raising or (*nudging*). The Internet of Things is about the collection of data using sensors and their interconnections. Conversely, this also means that the measuring and analysing of a wide variety of variables has enormous potential for sustainable development in tourism. In the case of the identified examples that are assigned to this area, the analysis of the behaviour within the action space is particularly significant. Visitor flow and the consumption of resources associated with these movements and the activities of visitors can be measured more easily in the future, and resource-saving measures can be derived from this. These examples illustrate that awareness can be raised among visitors by making consumption transparent. This also means that tourists can be encouraged to choose an alternative behaviour. In our view, this is the **biggest set of opportunities for sustainable tourism development** through digitisation.

5.3 Possible courses of action

The aim of this study is to provide an orientation as to which topics are particularly relevant in the area of tension between digitisation and sustainable tourism development and which make further investigation seem worthwhile. This study does not aim to derive any specific courses of action from this, although it does seek to offer a general outlook.

The **sustainability opportunities and risks identified in this study do not come about automatically**. Many if not all applications cited here are about organisational possibilities.

Ultimately, it depends on whether the possibilities of digitisation are taken advantage of to facilitate sustainability or whether sustainability is not taken into account. **A priori, digitisation is neither positive nor negative**. Rather, these are technologies which, by being implemented in applications, can be used to positively or negatively influence tourism sustainability or to be accepted by visitors. This outlook is based on a principle employed in the WBGU report "Unsere gemeinsame digitale Zukunft" (our common digital future): "*However, digital resources and projects have thus far primarily been used for conventional growth in established markets in international competition. The purpose of digital progress in these contexts is not primarily sustainability; aspects such as entertainment, convenience, security and not least short-term financial gains dominate. Overall, digitisation processes today tend to accelerate existing non-sustainable trends, i.e., the overexploitation of natural resources and growing social inequality in many countries.*"(WBGU 2019)

In principle, technological progress opens up new possibilities for travel arrangement and the management of travel processes. This will always depend, however, on the extent to which aspects of sustainability are consciously taken into account in the individual processes. The basic requirement is that the issue of sustainability gains more relevance in society, because only then will policy-makers, researchers and companies take sufficient account of ecological and social aspects of sustainability in the development and use of digital technologies.

The examples provided show that tourism makes use of a variety of digital developments that were **not originally developed for tourism**. The many topics of mobility are mentioned here as an example. Many of these topics are primarily developed and discussed with a view to their use in conurbations, without taking into account the concerns of tourism and possible applications. So far, we have hardly at all managed to examine tourism-related issues in the context of urban development (focus on residents and business). We thus need significantly more coordination and cooperation. On the other hand, stakeholders in tourism should become much more involved in the discussion of digital issues in other areas.

Tourism providers, in particular tourism-relevant companies in the mobility, accommodation, leisure and tourism marketing sectors, can, however, take advantage of the presented opportunities. The **digital platforms as *gatekeepers* to the customer** play a particularly important role here. It is therefore crucial how these platforms develop and what the implications are. It is noteworthy that such platforms tend to form monopolies through network and lock-in effects and develop strongly in line with user expectations. However, due to the generally non-altruistic and one-sided economic orientation of business objectives it is not to be expected that companies will volunteer to offer more sustainable products without an economic incentive.

A central element of such economic incentives is changing demand behaviour. Such a change can be observed in the market, but it is currently proceeding very slowly (cf. Section 1.3 from page 31). Nevertheless, companies that wish to take advantage of this change in demand can utilise all of the digitisation-based opportunities examined here. On the one hand, this can result in a self-reinforcing process. On the other hand, large and small companies can take advantage of the resulting demand potential and (either through long tail or by going mainstream) profit from the sustainability-oriented demand. However, it can be assumed that (commercial) tourism providers have very little inherent interest in specifically sustainable tourism development and will (only) use digitisation in the short to medium term for the commercial development of their companies.

At the operational level, smart facility applications are particularly worth mentioning in this context, as they offer enormous saving potentials, especially for the hotel and catering industries; these should be exploited from an economic perspective alone, regardless of sustainability

interests. However, this potential (especially heating systems and their self-learning temperature control upgrades as well as "smart" showers that reduce water consumption) is often not sufficiently recognised or the initial investment in such systems is still high. Furthermore, visitors are not usually aware of such innovations, which means visitor feedback cannot be an incentive.

This brings into focus two groups that (can) have an independent interest in sustainable tourism development, namely **policy-makers and administrators** on the one hand and **destination management** on the other. Both are to some extent committed to the common good and both have the opportunity to take advantage of the opportunities identified in this study.

This particularly includes the **support and implementation of (pilot) projects** from the categories shown here, especially in the area of **visitor management and guidance**. The utilisation of big data (e. g. from mobile radio networks and other mobile device sensors) and their transfer to management and guidance measures via mobile devices is still in its infancy. This also includes testing of tourism incentive and reward systems, pooling systems in the field of (intermodal) mobility, incentive processes for voluntary payments for ecosystem services or the potential of open data.

So far, we are only at the beginning of a development. While until now, considerations regarding digitisation mainly related to the periods before and after the trip, a clear change is emerging: Questions concerning digitisation are now increasingly about the trip itself. This is why many upheavals can currently be observed at the destinations and in the tourism companies. What matters now is how these questions are answered and how the destinations and businesses themselves are organised. This study provides a basis on which to build. The findings of this study are to provide the necessary understanding that aspects of sustainability should be taken into account before implementing digitisation.

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A Appendix: Participants of the expert meeting in January 2019

The expert meeting was held on 16 January 2019 at the Berlin site of the Federal Environment Agency.

- Busche, Dorothea, DRV Deutscher ReiseVerband e.V., Berlin
- Ceron Baumann, Susana, Ventura TRAVEL GmbH, Berlin
- Herrmann, Hans-Joachim, Federal Environment Agency, Dessau-Roßlau
- Inninger, Wolfgang, Fraunhofer IML, Prien
- Jäger, Laura, Tourism Watch, Brot für die Welt e.V., Berlin
- Cologne, Marina, Federal Environment Agency, Dessau-Roßlau
- Krack, Juri, Federal Environment Agency, Dessau-Roßlau
- Kuczmierczyk, Gabriele, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Berlin
- Neff, Dr Christian, DB Regio Bus, Ingolstadt
- Quack, Prof. Heinz-Dieter, the federal government's tourism competence centre (Kompetenzzentrum Tourismus des Bundes), Salzgitter
- Reich, Thorsten, Netzvitamine GmbH, Hamburg
- Schäfer, Cornelius, DRV Deutscher ReiseVerband e.V., Berlin
- Soutschek, Martin, Outdooractive GmbH & Co. KG, Immenstadt
- Strasser, Maritta, NaturFreunde Deutschlands e.V., Berlin
- Thomas, Petra, Forum Anders Reisen e.V., Hamburg
- Veenhoff, Sylvia, Federal Environment Agency, Dessau-Roßlau
- Wachotsch, Ulrike, Federal Environment Agency, Dessau-Roßlau
- Zeiss, Prof. Harald, Futouris e.V., Berlin

B Appendix: Example applications and application examples

B.1 Big data analytics

B.1.1 City map shows insider tips from residents

The data artist Eric Fischer uses geo tags of photos to indicate on city maps where you mainly find tourists and where you find the locals. If, for example, a person takes photos in one and the same city over the course of several months, they are classified as a local and their geo tags are shown in blue. Geo tags from tourists are red. Eric Fischer compiles these coloured tags on city maps to show what the locals are really interested in in their city. Holidaymakers can use these interactive maps as travel guides to find insider tips.

- Category: 1 – Big data analytics
- Area of application: Visitor guidance, visitor management (improving preparation for visitors and forecasting demand, visitor behaviour and visitor flow)
- Phase of the customer journey: In general for all phases
- Primary segments: Destination / B2B, B2C application
- Positive impact potentials: Improved visitor guidance to relieve cities / the environment
- Negative impact potentials: Touristification of unknown places (insider local tips are no longer secret)
- State of development: Adoption in tourism (C)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 1/BD-2
- Source: https://www.mapbox.com via www.trendexplorer.com of TrendOne GmbH

B.1.2 Peak times and duration of visits to restaurants, shops, etc.

Google has enhanced its "popular times" feature, which means visit durations and peak times are now updated in real time. Until recently, Google used aggregated and anonymous user data and a peak times diagram to show at which times restaurants and shops are busy. Based on the Google location history of smartphones activated for this purpose, the diagram now highlights in colour how many visitors are currently visiting the location – compared to the usual number of visitors. Shop operators can decide for themselves whether they wish to release their location data and the number of visitors.

- Category: 1 – Big data analytics
- Area of application: Visitor guidance, visitor management (improving preparation for visitors and forecasting demand, visitor behaviour and visitor flow)
- Phase of the customer journey: During the trip
- Primary segments: Destination / B2C application
- Positive impact potentials: Avoidance of traffic jams; increased efficiency
- Negative impact potentials: Prevention of idle periods with low utilisation (rest)
- State of development: High prevalence (D)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 2/BD-3
- Source: support.google.com via www.trendexplorer.com of TrendOne GmbH

B.1.3 Amsterdam City Card: Analysing the behaviour of tourists to manage queues at attractions

In order to better understand and manage Amsterdam's growing visitor flow, the city uses the Amsterdam City Card to collect visitor data on tourist behaviour, which in combination with the Discover the City app is used to manage queues to attractions, expand product offers based on customer preferences and offer suggestions for alternative attractions. The city uses other developments such as a future AI solution for the city to counter the challenges of over-tourism without restricting tourists.

- Category: 1 – Big data analytics
- Area of application: Visitor guidance, visitor management (improving preparation for visitors and forecasting demand, visitor behaviour and visitor flow)
- Phase of the customer journey: During the trip
- Primary segments: Destination / B2C application
- Positive impact potentials: Avoidance waiting times; increased efficiency
- Negative impact potentials: Greater total volume of tourists
- State of development: Adoption in tourism (C)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 3/BD-4
- Source: https://www.independent.co.uk/travel/news-and-advice/amsterdam-overtourism-solution-tourists-technology-van-gogh-museum-canal-boat-rides-a8015811.html

B.1.4 Google Maps supports commuters in real time

With its commute tab, Google Maps gives commuters in 80 cities worldwide access to real-time traffic and transit information as well as notifications of delays and congestion. Commuters who use their own car in combination with public transport can obtain information including traffic disruptions, train departure times and walking times for each section of the route. They can track their train or bus in real time. Sydney residents can even find out how full a particular bus or train is.

- Category: 1 – Big data analytics
- Area of application: Visitor guidance, visitor management (improving preparation for visitors and forecasting demand, visitor behaviour and visitor flow)
- Phase of the customer journey: Before and during the trip
- Primary segments: Transport / B2C application
- Positive impact potentials: Avoiding traffic jams and waiting times; increased efficiency; satisfaction of road users
- Negative impact potentials: Encouraging the use of cars and public transport on short routes (in the city) instead of sustainable alternatives such as cycle paths.
- State of development: First pilot projects (B possibly soon C)
- Development perspective: Absolutely transformative (C+D)
- Sequential number and code: 4/BD-12
- Source: https://www.blog.google via www.trendexplorer.com of TrendOne GmbH

B.1.5 Uber shares anonymous user data with cities

The Uber taxi service provides the city of Boston with anonymous data on its customers' movement patterns for the development of traffic concepts. The data includes information such as time, duration and length of the trips as well as the postcode of the start and end points. The

administrative bodies can use the data to find anomalies and integrate the findings in the planning of transport routes and public transport. The cooperation is to be extended to include other cities to improve the opinion local politicians have of Uber's business concept.

- Category: 1 – Big data analytics
- Area of application: Visitor guidance, visitor management (improving preparation for visitors and forecasting demand, visitor behaviour and visitor flow)
- Phase of the customer journey: In general for all phases
- Primary segments: Destination/Transport/B2B application
- Positive impact potentials: Better understanding of customer needs; development of a sustainable transport concept
- Negative impact potentials: Encouraging the use of cars and public transport on short routes (in the city) instead of sustainable alternatives such as cycle paths.
- State of development: First pilot projects (B)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 5/BD-14
- Source: http://www.bostonherald.com via www.trendexplorer.com of TrendOne GmbH

B.1.6 Visualising our national parks

In his final year at NY University, John Farrell used Instagram posts to study the three best-known national parks in the US: Yellowstone, Grand Canyon and Great Smoky Mountains. To do this, he looked for the most commonly used hashtags for the parks and pulled a total of 40,000 files from the Instagram API. He analysed the API to determine the number of posts per day and the specific locations of the photos and used the results to create maps and diagrams. What John's impressive research showed was at which times the parks are busy and where visitors spend most of their time. However, the data did not reveal where the individual visitor groups come from, which John had hoped he would be able to find out.

- Category: 1 – Big data analytics
- Area of application: Visitor guidance, visitor management (improving preparation for visitors and forecasting demand, visitor behaviour and visitor flow)
- Phase of the customer journey: During the trip
- Primary segments: Destination / B2B application
- Positive impact potentials: Understanding the degree of utilisation of the resources and offering more sustainable alternatives
- Negative impact potentials: Improvements attract more visitors
- State of development: First attempts / Prototype (A)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 6/BD-19
- Source: https://medium.com/i-data/visualizing-our-national-parks-2e47efc0dfb4

B.1.7 Surfboard fin collects data

The Smartfin initiative has developed fins of the same name with integrated sensor technology that is attached to surfboards to test the water quality. To do this, they collect data on salt content and acidity as well as on swell. This data allows conclusions to be drawn about the overall condition of a body of water. The data is transferred to a smartphone via Bluetooth and then sent to the "Smartfin" cloud. The initiative cooperates with the Scripps Institution of Oceanography; as part of the cooperation, the information is entered into a database to get a long-term overview of individual bodies of water.

- Category: 1 – Big data analytics
- Area of application: Crisis management (observations of environmental conditions and impacts of natural disasters to identify the need for action and to plan capacities and resources)
- Phase of the customer journey: In general for all phases
- Primary segments: Destination / B2B application
- Positive impact potentials: Identification of water status and the resulting need for action; better information for tourists (integrated in process)
- Negative impact potentials: Sensor technology interferes with the water world
- State of development: First applications (B)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 7/BD-15
- Source: http://smartfin.org via www.trendexplorer.com of TrendOne GmbH

B.1.8 Automated travel research for travel agencies

The Seattle-based start-up Qalendra has developed technology to automate travel research by collecting data from multiple sources, comparing destinations and determining the best travel terms up to four months in advance. Qalendra does not address consumers directly, but rather online B2B travel agencies that can use the technology via a programming interface. Travel rating portals such as TripAdvisor, on the other hand, are not based on the analysis of data, but on user reviews, which are often unreliable.

- Category: 1 – Big data analytics
- Area of application: Marketing, sales and travel planning (improving the plannability of trips with a high performance promise (cheapest offer))
- Phase of the customer journey: Before the trip (influencing the travel decision)
- Primary segments: Travel agents / B2B application
- Positive impact potentials: Avoidance waiting times; increased efficiency
- Negative impact potentials: Greater total volume of tourists
- State of development: Adoption in tourism (C)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 8/BD-1
- Source: www.qalendra.com via www.trendexplorer.com of TrendOne GmbH

B.1.9 London-based start-up Whimsy: Choose your holiday destination based on the weather

London-based start-up Whimsy finds the best destinations using an algorithm that combines the cheapest flights with past weather data. Users of their algorithm will primarily be able to find unusual destinations away from the main tourist areas while also being assured that the weather will be good. All they have to do is enter their hometown, and Whimsy will find cheap flights to various destinations. The software allows users to find out about places they may not have known about while making it easy to book a holiday at the same time.

- Category: 1 – Big data analytics
- Area of application: Marketing, sales and travel planning (improving preparation for visitors and forecasting demand, visitor behaviour and visitor flow)
- Phase of the customer journey: Before the trip (influencing the travel decision)
- Primary segments: Travel agents / B2C application
- Positive impact potentials: Improved visitor guidance; strengthening sustainable alternatives
- Negative impact potentials: Touristification of hitherto relatively unknown places

- State of development: Adoption in tourism (C)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 9/BD-9
- Source: http://signup.whimsy.travel via www.trendexplorer.com of TrendOne GmbH

B.1.10 Smart billboards displaying specific advertising

In cooperation with BBDO, Uber has promoted its services using digital billboards in Russia and addressed its target group with the help of geo-targeting. The billboards were used in Novosibirsk and Ekaterinburg. Data from mobile phone companies was used here to identify people who often use taxis and to reach them via a patented solution for programmatic advertising. The billboards recognised people by their smartphones and automatically displayed Uber advertising.

- Category: 1 – Big data analytics
- Area of application: Marketing, sales and travel planning (improved positioning and promotion of brands through targeted, personalised marketing activities)
- Phase of the customer journey: In general for all phases
- Primary segments: Transport / B2C application
- Positive impact potentials: Targeted advertising of sustainable offers; communication of sustainability trends
- Negative impact potentials: Energy consumption of the billboards; loss of parts of the natural environment because of billboard erection (mobile advertising on the internet would be better)
- State of development: First pilot projects (B)
- Development perspective: Average potential (B)
- Sequential number and code: 10/BD-11
- Source: https://www.uber.com via www.trendexplorer.com of TrendOne GmbH

B.1.11 PredictHQ start-up in New Zealand: How global events affect business

The PredictHQ start-up in New Zealand uses large amounts of data on local and global events to determine how they are likely to impact the businesses of its customers. The platform collects information on public holidays, small events, major events and environmental disasters. Based on additional information about individual companies, this information is categorised and appropriate conclusions are drawn. In addition to gaining an outlook into the future, customers also learn what consequences past events may have had on the development of their company.

- Category: 1 – Big data analytics
- Area of application: Marketing, sales and travel planning (identifying mistakes / possible improvements; capacity and resource planning; increased efficiency; cost savings)
- Phase of the customer journey: In general for all phases
- Primary segments: Destination/Accommodation/Transport/B2B application
- Positive impact potentials: Better planning / Minimising resource use
- Negative impact potentials: Excessive environmental impact as a result of greater tourist numbers at certain times
- State of development: First applications (B)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 11/BD-21
- Source: https://www.predicthq.com via www.trendexplorer.com of TrendOne GmbH

B.1.12 Boosting Peru's tourism industry with big data

Promperú is a specialist agency that promotes the country in the areas of export, image and tourism. With the help of the LUCA Tourism technology, mobile data records of the provider Movistar are analysed and evaluated. The results contain detailed information on demographics, length of stay, where tourists come from and popular tourist attractions. This knowledge allows the destination to significantly improve its own position on the market.

- Category: 1 – Big data analytics
- Area of application: Market research (collection and analysis of information via customer profiles (e. g. expenditure analysis); basis for customer satisfaction analyses (e. g. sentiment analysis) and competitive analyses)
- Phase of the customer journey: Before and during the trip
- Primary segments: Destination / B2B application
- Positive impact potentials: Identifying customer environmental awareness and adjusting offer in line with this; sustainable alternatives improve a region's eco-friendliness
- Negative impact potentials: Greater total volume of tourists as a result of offers optimally adapted to suit interests
- State of development: Adoption in tourism (C)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 12/BD-16
- Source: https://data-speaks.luca-d3.com/2017/10/peru-tourism-Big Data.html?m=1

B.1.13 Patterns of use: New research with big data reveals popularity of federal lands for overnight trips

Nature parks are a very popular travel destination in the US. Strategic planning on the part of the park management is necessary so that they can continue to be used sustainably. Stacy Supac from NC State University analysed an enormous set of data from the www.recreation.gov website, which has been collecting user data since 1999. It was the first time that the data was used for analysis purposes and Stacy was able to present interesting results. Above all, it was able to show when and where managers can expect high tourism demand. He also showed how far in advance a trip is booked, how far the tourists travel, and to which regions they travel the most. The findings can now be used for the sustainable development of the parks.

- Category: 1 – Big data analytics
- Area of application: Market research (collection and analysis of information via customer profiles (e. g. expenditure analysis); basis for customer satisfaction analyses (e. g. sentiment analysis) and competitive analyses)
- Phase of the customer journey: In general for all phases
- Primary segments: Destination / B2B application
- Positive impact potentials: The development of sustainable offers
- Negative impact potentials:
- State of development: Adoption in tourism (C)
- Development perspective: Average potential (B)
- Sequential number and code: 13/BD-17
- Source: https://cnr.ncsu.edu/geospatial/news/2016/10/20/Big Data-reveals-popularity-of-federal-lands/

B.1.14 Big data and tourism: How this Girona Festival became data-driven

Every year in May, Catalonia hosts the 10-day "Temps de Flors" flower festival. For two years now, LUCA's technology (Smart Steps) has been used to analyse and evaluate data from mobile networks. What was previously only possible with the help of very complex face-to-face surveys has now become much simpler and more precise thanks to big data and the new analysis method. The analysis provides detailed information about the number, origin, age, gender and other characteristics of the festival-goers.

- Category: 1 – Big data analytics
- Area of application: Market research (collection and analysis of information via customer profiles (e. g. expenditure analysis); basis for customer satisfaction analyses (e. g. sentiment analysis) and competitive analyses)
- Phase of the customer journey: In general for all phases
- Primary segments: Destination / B2B application
- Positive impact potentials: Identifying customer environmental awareness and adjusting offer in line with this; sustainable alternatives improve a region's eco-friendliness
- Negative impact potentials: Greater total volume of visitors
- State of development: Adoption in tourism (C)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 14/BD-18
- Source: https://data-speaks.luca-d3.com/2016/12/Big Data-and-tourism-how-this-girona.html

B.1.15 BBVA bank shows how big data can boost tourism in Mexico

For a study on tourism activity in Mexico, experts were commissioned by the Mexican tourism ministry to analyse payment data of the BBVA bank. The study came to the following conclusions. among others: International tourists spend 35% of their total expenses and national tourists 27% of their total expenses in Playa del Carmen. National tourists spend 25% of their expenses in Cancun. In both places, people spend most of the money on Fridays and Saturdays. The largest revenues are generated by tourists from the USA, followed by tourists from Argentina. These and other findings can now be used to further improve and promote tourism destinations in the country. In addition, the analyses can detect trends at an early phase, which means the appropriate measures can be taken.

- Category: 1 – Big data analytics
- Area of application: Market research (collection and analysis of information via customer profiles (e. g. expenditure analysis); basis for customer satisfaction analyses (e. g. sentiment analysis) and competitive analyses)
- Phase of the customer journey: In general for all phases
- Primary segments: Destination / B2B application
- Positive impact potentials: Identifying customer environmental awareness and adjusting offer in line with this; sustainable alternatives improve a region's eco-friendliness
- Negative impact potentials: Increased total volume of tourists, because offers adapted to their environmental awareness = attractive region
- State of development: Adoption in tourism (C)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 15/BD-20
- Source: https://www.bbva.com/en/bbva-shows-Big Data-can-boost-tourism-mexico/

B.1.16 Smart destination management system in Buenos Aires

In 2017, the city of Buenos Aires set up its first intelligent management system (based on big data) specifically for tourism. The project originated in an agreement between the Buenos Aires tourism authority, Spain's state-run company for the management of innovation and tourism technologies (SEGITTUR) and Argentina's National Ministry of Tourism. The platform is interactive and includes many different variables and indicators to facilitate decision-making for both the public and private sectors. Unlike the similar national initiative in Portugal (TravelBI Portugal), the Buenos Aires platform is not yet publicly accessible and is currently primarily used for internal decision making in destination management.

- Category: 1 – Big data analytics
- Area of application: Market research, product design (improving the performance of service providers and offers within a destination)
- Phase of the customer journey: In general for all phases
- Primary segments: Destination / B2B, B2C application
- Positive impact potentials: Improved, more sustainable performance of service providers/offers
- Negative impact potentials: Increased total volume of tourists (marketing arouses/strengthens interest of many tourists)
- State of development: First attempts (A+B)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 16/BD-5
- Source: http://cf.cdn.unwto.org/sites/all/files/docpdf/segitturpresentation.pdf

B.1.17 Analysis of visitor behaviour in Madrid

The first pilot project set up to obtain better information on tourist behaviour in Madrid and Barcelona through big data was carried out in 2014 by Telefónica and the BBVA bank (see also B.1.15), and over the past few years has been expanded to include further partners and other destinations around the world. Using the telephone and payment information provided, the following information can be extracted from big data analysis to give local stakeholders a better basis for decision-making: Main country of origin of visitors, country of origin of tourists who choose Madrid and those who choose Barcelona; length of stay by country of origin; travel between the two destinations Barcelona and Madrid; days and areas where foreign visitors wish to stay; average daily expenditure and expenditure throughout the stay.

- Category: 1 – Big data analytics
- Area of application: Market research, product design, quality management (collection and analysis of information via customer profiles (e. g. expenditure analysis); basis for customer satisfaction analyses (e. g. sentiment analysis) and basis for competitive analyses)
- Phase of the customer journey: During the trip
- Primary segments: Destination/Accommodation/B2B application
- Positive impact potentials: Identifying customer environmental awareness and adjusting offer in line with this; sustainable alternatives improve a region's eco-friendliness
- Negative impact potentials: Increased total volume of tourists, because offers adapted to their environmental awareness = attractive region.
- State of development: First applications (B+C)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 17/BD-6
- Source: https://www.bbvadata.com/urbandiscovery/

B.1.18 Winter Olympics 2018, South Korea: Analysis of the correlation between visitor flow, temperature and day of the week

The analysis of data throughout the winter (January to March 2018) showed that the temperature had an impact on the decision to take a walk on the Seoullo bridge. The results showed that people's behaviour differed between weekends and weekdays, and additional factors such as work and leisure were taking into account for decision-making. In addition, warmer temperatures seemed to attract people to the Seoullo bridge, increasing the average number of visitors by 50% (55% on weekends, 45% on weekdays).

Based on these results, forecasts can be made to provide tourism companies such as festival organisers with detailed weather/crowd forecasts.

- Category: 1 – Big data analytics
- Area of application: Market research, product design, quality management (collection and analysis of information via customer profiles (e. g. expenditure analysis); basis for customer satisfaction analyses (e. g. sentiment analysis) and competitive analyses)
- Phase of the customer journey: Before and during the trip
- Primary segments: Destination / B2B application
- Positive impact potentials: Improved forecasting of visitor flow; possibility of designing alternative offers to reduce environmental impact by distributing visitors (based on weather conditions)
- Negative impact potentials: Interventions in nature / loss of nature through measures to distribute visitors on good and bad days (further attractions, putting a roof over the bridge for rainy days)
- State of development: Adoption in tourism (C)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 18/BD-7
- Source: http://www.dfrc.com.sg/Big Data-weather-tourist-destinations/

B.1.19 Analysis of customer satisfaction in NH Hotels

The hotel chain "NH Hotels" has around 400 hotels worldwide. To better track and understand customer satisfaction in real time, the company has developed its own online tracking tool for ratings. This big data-based tool locates every mention of the hotels and compares it with five competitors in order to know in real time what is said, which services are most appreciated (customer service, facilities, location, cleaning, restoration, ...), which offers are considered, what guests are not satisfied with and which details they appreciate. The company adds traditional NH satisfaction surveys sent to customers to the online reputation measurement, it integrates financial metrics to prioritise hotel resources, it assesses the impact of investments and measures their ROI. The key to success here lies in the speed with which possible problems can be identified and solved in the shortest possible time, as they are transmitted by the customer.

- Category: 1 – Big data analytics
- Area of application: Market research, product design, quality management (collection and analysis of information via customer profiles (e. g. expenditure analysis); basis for customer satisfaction analyses (e. g. sentiment analysis) and competitive analyses)
- Phase of the customer journey: In general for all phases
- Primary segments: Accommodation / B2B application
- Positive impact potentials: Identification of customer environmental awareness; preparing a sustainable offer / sustainable facilities
- Negative impact potentials: Offers are adapted to environmental awareness = customer satisfaction = demand increases = expansion requires areas of nature, which will be lost

- State of development: High prevalence (D)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 19/BD-8
- Source: http://www.thinktur.org/media/Big Data.-Retos-y-oportunidades-para-el-turismo.pdf

B.1.20 FiveThirtyEight website: finding the best airport and the quickest flights

A new tool on ESPN's "FiveThirtyEight" website shows airlines and airports in the USA and provides users with information about delays and waiting times. Six million flights were evaluated to determine which airlines are on average delayed by how much or how fast they usually fly on certain routes. Customers can also compare different airports on the website. For example, they can see the average waiting time before or after the flight.

- Category: 1 – Big data analytics
- Area of application: Market research, product management, quality management (collection and analysis of information via customer profiles (e. g. expenditure analysis); basis for customer satisfaction analyses (e. g. sentiment analysis) and competitive analyses)
- Phase of the customer journey: Before the trip (influencing the travel decision)
- Primary segments: Transport/Travel agents/B2C application
- Positive impact potentials: Strengthening or referral to more sustainable airports/airlines
- Negative impact potentials: Only supports aviation, no other sustainable transport alternatives
- State of development: Adoption in tourism (C)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 20/BD-10
- Source: http://fivethirtyeight.com via www.trendexplorer.com of TrendOne GmbH

B.1.21 Software creates objects from plastic bottles

Researchers at the Hasso Plattner Institute developed the "TrussFab" software, which uses algorithms to create arrangements of plastic bottles from digital 3D models. The software is used to design digital 3D models of various objects such as furniture, buildings or boats. Using algorithms, it then automatically converts these 3D models into designs that can be assembled from plastic bottles. With TrussFab, 3D printing can also be used to produce connecting parts that quickly and securely connect several plastic bottles together.

- Category: 1 – Big data analytics
- Area of application: Company-internal process optimisation, quality management (identifying mistakes / possible improvements; resource planning and reduction; increased efficiency)
- Phase of the customer journey: In general for all phases
- Primary segments: Destination/Transport/Accommodation/B2B application
- Positive impact potentials: Eco-friendly because plastic gets recycled
- Negative impact potentials: Continuous or new production of plastic bottles, as they cannot be reused when utilised for other purposes
- State of development: First pilot projects (B)
- Development perspective: Average potential (B)
- Sequential number and code: 21/BD-13
- Source: https://hpi.de via www.trendexplorer.com of TrendOne GmbH

B.2 Internet of Things and geo-intelligence

B.2.1 Disney MagicBand

After several years of planning, Disney introduced its MagicBand in 2017. The wristband allows park visitors to digitally store various items such as park tickets, credit card information and room keys. It contains an RFID chip and a radio with a range of 40 feet in each direction and is read by wristband readers in various locations in the park, particularly at park entrances and rides. Disney sends the MagicBands to visitors before their trip shortly after they have purchased their tickets online and have created a travel itinerary. The wristbands are currently only used in the park in Orlando, with the intention of eventually extending their use to cover the other Disney parks.

- Category: 2 – Internet of Things and geo-intelligence
- Area of application: Visitor management (distribution of information; (real-time) identification of tourist movement patterns and behaviour)
- Phase of the customer journey: Before and during the trip
- Primary segments: Destination / B2C application
- Positive impact potentials: Real-time identification of highly frequented places
- Negative impact potentials: Wristband readers consume energy; making the wristbands uses resources
- State of development: Adoption in tourism (C)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 22/IoT-2
- Source: https://innovationatwork.ieee.org/disney-internet-of-things-magicband/

B.2.2 Aloft Santa Clara Hotel: Intelligent hotel rooms with voice control systems

The Aloft Santa Clara Hotel in San Jose encourages guests to book voice-activated rooms equipped with an iPad that gives guests a whole new way of interacting with their room. Guests can use Siri to get the device to change the lighting to purple or blue, to play a music video on YouTube or a series on Netflix, or to set the room temperature – whatever makes the guest happy.

- Category: 2 – Internet of Things and geo-intelligence
- Area of application: Customer service (+ smart home), (intelligent buildings and attractions)
- Phase of the customer journey: During the trip
- Primary segments: Accommodation / B2C application
- Positive impact potentials: Communication of sustainable offers using existing devices (iPad, etc.); influencing guests towards sustainability, e. g., with information on devices about sustainable behaviour (water and electricity consumption, resource consumption in general)
- Negative impact potentials: Devices use energy
- State of development: First applications (B)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 23/IoT-1
- Source: https://www.telegraph.co.uk/travel/destinations/north-america/united-states/articles/aloft-launches-the-worlds-first-voice-activated-hotel-room/

B.2.3 Hotel room adapts to guest needs

The US hotel chain Marriott is working with Samsung to develop the hotel room of the future that uses Internet of Things systems combined with voice control. To this end, concepts under which guests can create their own personal feel-good atmosphere and use the room according to their needs are tested in the IoT Guestroom Lab. For example, guests can be woken up by a virtual assistant, start a yoga session with instructions in front of a large mirror and request room service. All this can be ordered by voice command or via an app.

- Category: 2 – Internet of Things and geo-intelligence
- Area of application: Customer service (+ smart home), (intelligent, more efficient buildings and attractions (e. g. hotels, airports, public facilities, …); increased efficiency: saving of costs and resources)
- Phase of the customer journey: During the trip
- Primary segments: Accommodation / B2C application
- Positive impact potentials: Communication/Promotion of sustainable offers/activities in the direct environment (regional); raising guest awareness of sustainability; communicating sustainable handling of resources (reduction of water and energy consumption); adjustment to customer wishes in order to increase satisfaction
- Negative impact potentials: Increased energy consumption by the devices
- State of development: First applications (B)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 24/IoT-9
- Source: http://news.marriott.com via www.trendexplorer.com of TrendOne GmbH

B.2.4 Smart shower reduces water consumption

The start-up company Livin Life has created the "Livin Shower", a smart and easy-to-install shower system. You first use the system's app to create different shower profiles with the preferred shower temperature. If a user intends to take a shower, the water in the shower heats up to the set temperature, so that they can start showering straight away without using unnecessary water. The shower system can also be controlled by voice and connect to music streaming services via Bluetooth so that the user can listen to music while showering.

- Category: 2 – Internet of Things and geo-intelligence
- Area of application: Customer service (+ smart home), (intelligent, more efficient buildings and attractions (e. g. hotels, airports, public facilities, …); increased efficiency: saving of costs and resources)
- Phase of the customer journey: During the trip
- Primary segments: Accommodation / B2C application
- Positive impact potentials: Reduction of water consumption; influencing consumption to make it more sustainable; adaptation to customer wishes in order to increase satisfaction
- Negative impact potentials: Energy consumption (using apps, playing music, etc.)
- State of development: First applications (B)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 25/IoT-10
- Source: https://www.livinshower.com via www.trendexplorer.com of TrendOne GmbH

B.2.5 Vertically starting taxi

The Munich-based company Lilium has developed a fully electric aircraft that takes off and lands vertically. The two-seater is powered by 36 engines, some of which can be pivoted for vertical take-off. Once the plane is in the air, it moves into forward flight and uses the natural lift of the wings. The vehicle, designed to pass through city traffic quickly, is 90 percent more energy-efficient than comparable quadcopter drones while being just as manoeuvrable. And it is cheaper than a taxi ride.

- Category: 2 – Internet of Things and geo-intelligence
- Area of application: Destination management, transport, traffic (intelligent vehicles)
- Phase of the customer journey: During the trip
- Primary segments: Transport / B2C application
- Positive impact potentials: Reducing city road traffic; improving air quality through fewer cars; increased efficiency
- Negative impact potentials: Interferes with wildlife (birds)
- State of development: First attempts (A)
- Development perspective: Low potential (A)
- Sequential number and code: 26/IoT-14
- Source: https://lilium.com via www.trendexplorer.com of TrendOne GmbH

B.2.6 RFID tags become sensors

Researchers at the Auto-ID Lab at MIT have developed RFID stickers that act as sensors and detect dangerous gases in their environment, among other things. The stickers use chips that can switch between a passive, energy-based mode and a local, energy-supported mode. The chips are integrated into RFID tags with a conventional radio frequency antenna, and a simple circuit was built around the memory chips, which only activates the energy-supported mode when a stimulus is detected in the environment. In this mode, the chip transmits a new protocol code that can be read out.

- Category: 2 – Internet of Things and geo-intelligence
- Area of application: Crisis management (observation of environmental conditions to identify need for action)
- Phase of the customer journey: During the trip
- Primary segments: Destination / B2B application
- Positive impact potentials: Analysis of environmental impacts; eco-friendliness
- Negative impact potentials: Sensors disrupt the ecosystem (attached to trees??)
- State of development: First attempts (A+B)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 27/IoT- 17
- Source: http://news.mit.edu via www.trendexplorer.com of TrendOne GmbH

B.2.7 Taxi billboard displays information based on location

Australian telecommunications company Telstra and the start-up company Cab Digital Media have jointly launched TaxiLive, an interconnected billboard for taxis. "TaxiLive" is installed at the back of the vehicle where it displays location-based information. The IoT solution uses Telstra's mobile network and delivers traffic information, weather warnings and advertising messages via GPS based on the time of day and the vehicle's location. 300 taxis in Sydney will initially be fitted with the billboards and thus also provide data for smart city applications.

- Category: 2 – Internet of Things and geo-intelligence
- Area of application: Crisis management (+ customer service) (intelligent vehicles:)
- Phase of the customer journey: During the trip
- Primary segments: Destination/Transport/B2C application
- Positive impact potentials: Communication of sustainability topics; information about environmental conditions (weather, dangers, crises, etc.)
- Negative impact potentials: Increased resource consumption (fuel or energy consumption for the boards); boards can distract and therefore endanger road users
- State of development: First applications (B)
- Development perspective: Low potential (A)
- Sequential number and code: 28/IoT-13
- Source: https://www.telstra.com.au via www.trendexplorer.com of TrendOne GmbH

B.2.8 Forest fire detection and alarm system

The Edith Cowan University (ECU) Centre for Communications and Electronics Research (CCER) has built sensors to detect forest fires and then inform the relevant stakeholders (including in tourism) over WiFi. The sensors use solar panel batteries and the network is self-healing. Similar systems, for example, were built by the University of California; their system supports players with state-of-the-art sensors and analysis software to minimise false alarms.

- Category: 2 – Internet of Things and geo-intelligence
- Area of application: Crisis management (+ visitor management) (distribution of information; (real-time) identification of tourist movement patterns and behaviour)
- Phase of the customer journey: During the trip
- Primary segments: Destination / B2C application
- Positive impact potentials: Improving safety in vulnerable regions
- Negative impact potentials: Sensors disrupt the ecosystem; radiation (WiFi); how does WiFi get into the forest?
- State of development: Adoption in tourism (C)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 29/IoT-12
- Source: https://researchspace.csir.co.za/dspace/bitstream/handle/10204/8674/Gcaba_2016.pdf?sequence=1&isAllowed=y

B.2.9 Port of Rotterdam becomes a smart IoT port

The port of Rotterdam has announced a digitisation initiative in cooperation with IBM. The aim of the cooperation is to fit the port with IoT technologies and a connection to the cloud in order to prepare it for the handling of interconnected vessels. With the help of smart quay walls and buoys fitted with sensors, water, weather and berth data will be collected in real time and analysed by IBM's IoT platform. The prepared data will then be made available for operational use in dashboard applications.

- Category: 2 – Internet of Things and geo-intelligence
- Area of application: Logistics (intelligent, more efficient equipment/services to increase efficiency: saving of costs and resources)
- Phase of the customer journey: In general for all phases
- Primary segments: Transport / B2B application
- Positive impact potentials: Analysis of water conditions
- Negative impact potentials: Environmental impact due to increased shipping traffic
- State of development: First applications (B)

- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 30/IoT-6
- Source: https://www.portofrotterdam.com via www.trendexplorer.com of TrendOne GmbH

B.2.10 Electronic luggage label

The Dutch start-up Bagtag has developed an electronic label that travellers can use to check in their luggage online. The device replaces conventional paper labels at airports and thus saves travellers long waiting times at the airport check-in desk. It is attached to the suitcase and connects to a smartphone via Bluetooth. Travellers can then check in their luggage using the Lufthansa app, for example. The electronic label then shows the luggage information on an energy-saving e-paper display.

- Category: 2 – Internet of Things and geo-intelligence
- Area of application: Logistics (intelligent, more efficient equipment/services to increase efficiency: saving of costs and resources)
- Phase of the customer journey: During the trip
- Primary segments: Transport / B2B application
- Positive impact potentials: Reduction of resource consumption (no need for paper labels); no waiting times
- Negative impact potentials: Energy consumption of the labels
- State of development: First attempts (A)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 31/IoT-11
- Source: https://bagtag.com via www.trendexplorer.com of TrendOne GmbH

B.2.11 Intelligent bus stop

The mechanical engineering group ST Engineering built an intelligent bus stop in Singapore that identifies suspicious behaviour and improves air quality. The stop is fitted with an air cleaning system that sucks in warm air and cools it down to 24 degrees without using much energy. People waiting at the bus stop benefit from fresh air drawn in from nozzles in the ceiling. Sensors and a computer system identify suspicious activities and the flow of traffic is kept track of. In addition, interactive screens provide real-time environmental information.

- Category: 2 – Internet of Things and geo-intelligence
- Area of application: Market research (intelligent, more efficient buildings and attractions (e. g. hotels, airports, public facilities, …); increased efficiency: saving of costs and resources)
- Phase of the customer journey: During the trip
- Primary segments: Transport/Destination/B2B application
- Positive impact potentials: Improving air quality in conurbations with high traffic volumes
- Negative impact potentials: Energy consumption
- State of development: First applications (B)
- Development perspective: Average potential (B)
- Sequential number and code: 32/IoT-5
- Source: https://www.stengg.com via www.trendexplorer.com of TrendOne GmbH

B.2.12 Benches generate environmental data and electricity

At the Cortina Fashion Weekend in Cortina d'Ampezzo, Audi Italy together with Point Architects presented the "Digital Points" project. They showcased special benches with integrated sensors which collected and displayed environmental data in real time. Each bench monitored the climate, noise pollution and solar activity. With the help of integrated solar panels, the benches generated their own electricity and a light sticks installation displayed the collected energy. The light sticks changed colour depending on the amount of energy generated.

- Category: 2 – Internet of Things and geo-intelligence
- Area of application: Market research (intelligent, more efficient buildings and attractions (e. g. hotels, airports, public facilities, …); increased efficiency: saving of costs and resources)
- Phase of the customer journey: During the trip
- Primary segments: Transport / B2B application
- Positive impact potentials: Monitoring environmental conditions and deriving sustainable possible actions for a healthier environment
- Negative impact potentials: Disruption of the ecosystem by the light sticks
- State of development: First applications (B)
- Development perspective: Average potential (B)
- Sequential number and code: 33/IoT-7
- Source: http://www.pointarchitects.it via www.trendexplorer.com of TrendOne GmbH

B.2.13 Sensors testing environmental impact of tourism

Libelium's Internet of Things sensor platform helps the Spanish island of Mallorca to analyse the environmental impact on the port of Palma and thus become a sustainable destination. The platform is primarily about air pollution and noise caused by the many ships that dock in the island's port. A total of 27 wireless sensors are to be installed in the port area to measure the impact. The analysis of the measurement results will help make decisions that contribute to improving the living conditions on the island.

- Category: 2 – Internet of Things and geo-intelligence
- Area of application: Market research (more knowledge about relevant developments; identification of need for action; planning of capacities and resources)
- Phase of the customer journey: During the trip
- Primary segments: Destination / B2B application
- Positive impact potentials: Improving environmental compatibility; environmental protection (bodies of water)
- Negative impact potentials: Energy consumption of the sensors
- State of development: Adoption in tourism (C)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 34/IoT-15
- Source: http://www.libelium.com via www.trendexplorer.com of TrendOne GmbH

B.2.14 Smart umbrella follows the sun

The US start-up ShadeCraft developed the smart parasol "Sunflower", which automatically rotates to align with the sun. Integrated solar cells store energy to power three electric motors, a loudspeaker, a 360-degree camera, a lamp, a microphone, a Bluetooth module and a WiFi module. Furthermore, the product has a USB port for charging smartphones and other devices. The

built-in sensors measure wind speed, air quality and temperature. Users can access this data remotely via the SmartShade app.

- Category: 2 – Internet of Things and geo-intelligence
- Area of application: Market research, product design (intelligent, more efficient attractions; increased efficiency: saving of costs and resources through solar, for example)
- Phase of the customer journey: During the trip
- Primary segments: Destination / B2B, B2C application
- Positive impact potentials: Observation of environmental conditions to derive needs for action; communication of sustainable topics and recommendations via loudspeakers
- Negative impact potentials: Energy consumption
- State of development: First applications (B)
- Development perspective: Average potential (B)
- Sequential number and code: 35/IoT-8
- Source: http://shadecraft.com via www.trendexplorer.com of TrendOne GmbH

B.2.15 Hotel chain launches pop-up innovation lab

The hotel company Marriott International has opened the first pop-up hotel innovation lab, creating an interactive hotel experience in the city centre of Los Angeles that obtains real-time feedback from visitors. Industry experts, hotel guests, employees and the public are invited to the laboratory to see, feel, taste and hear the developments that are considered for the future of the Aloft and Element brands. By providing real time feedback, visitors can rate the developments and help shape their future hotel experiences.

- Category: 2 – Internet of Things and geo-intelligence
- Area of application: Market research, product management (collecting customer feedback to adapt products/services to customer wishes; increasing customer satisfaction)
- Phase of the customer journey: During the trip
- Primary segments: Accommodation / B2C application
- Positive impact potentials: Raising awareness of sustainable facilities
- Negative impact potentials:
- State of development: First applications (B)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 36/IoT-4
- Source: http://news.marriott.com via www.trendexplorer.com of TrendOne GmbH

B.2.16 Mobility service with payment and localisation technologies

Mastercard and HERE Technologies are jointly expanding their digital payment and location technologies to offer interconnected vehicle services. The mobility-as-a-service concept for consumers will use the data analysis capabilities of the two companies, including HERE's open-location platform, to provide customers with location-based, personalised information and offers that are most relevant at the time. Mobility and logistics providers, cities and tourism authorities, trademarks and financial institutions will also make data available.

- Category: 2 – Internet of Things and geo-intelligence
- Area of application: Market research, product management (intelligent, more efficient services to increase efficiency: saving of costs and resources)
- Phase of the customer journey: In general for all phases
- Primary segments: Destination/Transport/B2C application

- Positive impact potentials: Increased efficiency; avoidance of waiting times and traffic jams; improved visitor guidance in conurbations
- Negative impact potentials: Increased traffic through simplification
- State of development: First applications (B)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 37/IoT-16
- Source: https://www.here.com via www.trendexplorer.com of TrendOne GmbH

B.2.17 Measuring the movements of people in buildings

Researchers at the Rensselaer Polytechnic Institute and the University of New Mexico are working with industry partner ABB to develop cost-effective sensor technology that monitors people in commercial buildings. This is designed to prevent large amounts of energy being wasted on heating and cooling empty buildings. The technology supports building automation and uses infrared LEDs and photodiodes to measure the light field emanating from a scene. This makes indoor activity visible without violating privacy.

- Category: 2 – Internet of Things and geo-intelligence
- Area of application: Smart home (intelligent, more efficient buildings and attractions (e. g. hotels, airports, public facilities, …); increased efficiency: saving of costs and resources)
- Phase of the customer journey: During the trip
- Primary segments: Accommodation/Destination/B2B application
- Positive impact potentials: Lowering of energy consumption by switching off appliances when people are absent; efficiency increase and environmental friendliness (not customer-oriented)
- Negative impact potentials: Energy consumption of building monitoring
- State of development: First attempts (A)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 38/IoT-3
- Source: https://lesa.rpi.edu via www.trendexplorer.com of TrendOne GmbH

B.3 Artificial intelligence

B.3.1 Cleaning robot removes rubbish on the beach

The Italian start-up Dronyx developed the Solarino Beach Cleaner, which removes washed up rubbish from beaches. The robot is supplied with power by the integrated batteries, and the solar cells, which are also integrated, can extend the battery life if required. The robot is relatively quiet and cleans up to 3,000 square metres per hour. It can also be used to pull ships from the sea to the beach. As more and more rubbish is washed up from the sea, autonomous cleaning robots could soon be used more frequently.

- Category: 3 – Artificial intelligence
- Area of application: Autonomous vehicles (observation of environmental conditions; identification of need for action; planning of capacities and resources
- Better information for tourists and to increase customer satisfaction)
- Phase of the customer journey: During the trip
- Primary segments: Destination / B2B application
- Positive impact potentials: Better environmental friendliness; cleanliness; communicating (to tourists/locals) a more sustainable approach to the environment as something self-evident

- Negative impact potentials: Disruption of the ecosystem; can robots distinguish between living creatures and waste?; energy consumption of the robot; greater total volume of tourists in the regions who use the robot (at first the robot is exceptional, new and interesting)
- State of development: First attempts / Prototype (A)
- Development perspective: High potential C
- Sequential number and code: 39/KI-13
- Source: http://www.dronyx.com via www.trendexplorer.com of TrendOne GmbH

B.3.2 AI in public transport – Stockholm as an example

In Europe, many cities are experimenting with autonomous public transport vehicles. A recent example of a large city administration experimenting with autonomous public transport is the Swedish capital of Stockholm. The project, which is a partnership of the bus company Nobina, the telecommunications company Ericsson, and the Stockholm Public Transport Company, the Swedish Royal Institute of Technology (KTH), Klövern, Urban ICT Arena and Stockholm City, started in January 2018 with two autonomous shuttle buses that cover 24 km of pedestrian zones, cycle paths and roads. The Connected Urban Transport (CUT) platform by Ericsson is at the centre of the project. CUT is a virtual bus driver for the shuttle vehicles in Stockholm. It communicates with sensor-intensive intelligent bus stops, traffic lights and road infrastructures and connects everything and everyone on and off the road. The cloud-based solution thus forms an intelligent ecosystem in which all interconnected stakeholders can use and monetise their data and improve their end-user services.

- Category: 3 – Artificial intelligence
- Area of application: Autonomous vehicles and mobility (intelligent/autonomous vehicles; intelligent traffic planning/infrastructure; seamless travel routes; intermodality; resource management)
- Phase of the customer journey: During the trip
- Primary segments: Transport/DestinationB2C application
- Positive impact potentials: Increasing environmental friendliness and safety
- Negative impact potentials:
- State of development: First applications (B)
- Development perspective: High potential C
- Sequential number and code: 40/KI-6
- Source: https://www.forbes.com/sites/heatherfarmbrough/2018/01/31/ugly-but-useful-stockholm-introduces-driverless-busses/#3443ae0060f4

B.3.3 Railway launches shuttle service

In Wittlich in Rhineland-Palatinate, Deutsche Bahn has integrated the driver-based "ioki" shuttle service (two buses) into the local public transport. In the future, e-shuttles with driver, autonomous electric buses and three-wheeled e-tuk-tuks will be used. The aim is to make public transport, city logistics and railway stations more comfortable and environmentally friendly with the help of new technologies and innovative ideas.

- Category: 3 – Artificial intelligence
- Area of application: Autonomous vehicles and mobility (intelligent/autonomous vehicles; intelligent traffic planning/infrastructure; seamless travel routes; intermodality; resource management)
- Phase of the customer journey: During the trip
- Primary segments: Transport/Destination/B2C application

- Positive impact potentials: More sustainable transport alternative; increased efficiency; reducing resource consumption; comfort
- Negative impact potentials: Greater energy consumption for passenger transport (people are lazy and will increasingly use such means of transport in the future instead of walking or cycling); short distances in railway stations, which means comfort is no greater
- State of development: First applications (B)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 41/KI-15
- Source: http://www.ioki.com via www.trendexplorer.com of TrendOne GmbH

B.3.4 Autonomous vehicle adapts to its purpose

Toyota, Amazon, Pizza Hut and Uber have announced the joint development of the "e-Pallet" concept car, which can be adapted modularly depending on purpose, making it suitable for on-demand car pools, small transports or deliveries. Since there are no permanently installed pillars or structural barriers and the size can be adapted to the purpose, the vehicle could even be turned into a mobile hotel room or a pop-up shop. The plan is for the autonomous e-vehicle to be used for the first time at the 2020 Olympic Games in Tokyo.

- Category: 3 – Artificial intelligence
- Area of application: Autonomous vehicles and mobility (intelligent/autonomous vehicles; intelligent traffic planning/infrastructure; seamless travel routes; intermodality; resource management)
- Phase of the customer journey: During the trip
- Primary segments: Transport/Destination/Accommodation/B2B application
- Positive impact potentials: Increasing environmental friendliness and safety; increased efficiency
- Negative impact potentials: Loss of important space in conurbations due to increased use of vehicles as hotel rooms
- State of development: First attempts / Prototype (A)
- Development perspective: Low potential or difficult to assess (A-C)
- Sequential number and code: 42/KI-16
- Source: http://corporatenews.pressroom.toyota.com via www.trendexplorer.com of TrendOne GmbH

B.3.5 Autonomous boat crosses the Atlantic

The engineers Christopher Sam Soon and Isaac Penny are preparing a solar-powered autonomous boat to cross the Atlantic Ocean starting from the US. The boat named Solar Voyager has two solar panels that generate 240 watts of energy. The energy is stored in batteries so that the boat can also be operated at night. Using satellite constellations, the boat navigates from one pre-programmed stop to the next. It moves at a speed of five kilometres per hour and is expected to reach its destination, France or Spain, within four months.

- Category: 3 – Artificial intelligence
- Area of application: Autonomous vehicles and mobility (intelligent/autonomous vehicles; intelligent traffic planning/infrastructure; ensures seamless travel routes; intermodality; resource management)
- Phase of the customer journey: During the trip
- Primary segments: Transport / B2B, B2C application
- Positive impact potentials: Eco-friendly alternative to overseas transport
- Negative impact potentials: Low efficiency, long duration (larger solar cells and battery will make it very viable in the future)

- State of development: First attempts (A+B)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 43/KI-19
- Source: http://www.solar-voyager.com via www.trendexplorer.com of TrendOne GmbH

B.3.6 Autonomous ferry to be ordered at the push of a button

Engineers from the Norwegian University of Technology and Natural Sciences have developed an autonomous electric ferry that transports people and bicycles across the Trondheim canal between Ravnkloa and Vestre Kanalhavn. The ferry can be requested at the push of a button and bypasses river traffic with the help of sensors, lidar and cameras. A ride on the "Autoferry" currently takes just one minute and saves up to twelve people a 15-minute walk. In the long term, the "Autoferry" is designed to supplant expensive bridges and manned ferries.

- Category: 3 – Artificial intelligence
- Area of application: Autonomous vehicles and mobility (intelligent/autonomous vehicles; intelligent traffic planning/infrastructure; ensures seamless travel routes; intermodality; resource management)
- Phase of the customer journey: During the trip
- Primary segments: Transport/Destination/B2C application
- Positive impact potentials: More environmentally friendly alternative to bridges and manned ferries
- Negative impact potentials: Energy consumption for transport (instead of a 15-minute walk for reasons of convenience); disruption of the water ecosystem
- State of development: Adoption in tourism (C)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 44/KI-20
- Source: https://www.ntnu.edu via www.trendexplorer.com of TrendOne GmbH

B.3.7 AI dustbin rewards proper recycling

The British company Cambridge Consultants has developed a smart bin recycling system that uses artificial intelligence to show users which rubbish can be recycled and what bin it goes into. Users place the item of rubbish on a surface, where it is scanned by a camera with image recognition A green light then indicates the correct bin. The system creates opportunities for brands to interact with their customers: One option would be for customers to use an app that awards points for each correctly disposed of item, which can be redeemed in shops.

- Category: 3 – Artificial intelligence
- Area of application: Visitor management, visitor guidance (observation of environmental conditions; identification of need for action; planning of capacities and resources
- Better information for tourists and to increase customer satisfaction)
- Phase of the customer journey: In general for all phases
- Primary segments: Destination / B2C application
- Positive impact potentials: Increasing environmental friendliness; cleanliness; unusualness and competition (collecting points) is attractive for tourists, increases utilisation and therefore disposal of rubbish
- Negative impact potentials: Energy consumption; increased generation of waste through a sense of competition (increased purchase of products that generate as much waste as possible in order to collect as many points as possible); environmental friendliness is lost (even if environment appears clean)

- State of development: First applications (B)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 45/KI-11
- Source: https://www.cambridgeconsultants.com via www.trendexplorer.com of TrendOne GmbH

B.3.8 Artificial intelligence improves traffic

Researchers at Carnegie Mellon University have developed "Surtrac", a system based on artificial intelligence that adjusts traffic lights at junctions in real time. The system is already being used successfully in Pittsburgh, where cameras and radar systems monitor traffic and create a real-time schedule that allows cars to cross the junction as quickly as possible. The data is then forwarded to other traffic junctions. Gradually, all junctions will be fitted with DSRC radios, which will communicate with radios in connected vehicles to share navigation information with them. DSRC (Dedicated Short Range Communication) is a technology which allows communication between traffic lights and vehicles.

- Category: 3 – Artificial intelligence
- Area of application: Visitor management, visitor guidance (intelligent/autonomous vehicles; intelligent traffic planning/infrastructure; seamless travel routes; intermodality; resource management)
- Phase of the customer journey: Before and during the trip
- Primary segments: Destination/Transport/B2C application
- Positive impact potentials: Avoidance of traffic jams; increased efficiency
- Negative impact potentials: Promotes car traffic instead of sustainable alternatives such as the development of cycle paths
- State of development: First applications (B)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 46/KI-21
- Source: https://rapidflowtech.com via www.trendexplorer.com of TrendOne GmbH

B.3.9 Skyscanner Facebook Messenger bot

Since 2016, the Skyscanner Facebook Messenger bot has been helping people find flights. With an average of 50 million travellers looking for flights on Skyscanner every month, Skyscanner was the first travel search engine to officially launch a Facebook Messenger bot. Customers can send a message to Skyscanner via Facebook Messenger and have the bot help them look for a flight. They can enter a destination, departure airport and other information needed to look for flights, and the bot gives them information about the cheapest destinations from the nearest airport. The bot is talkative and reacts very quickly.

- Category: 3 – Artificial intelligence
- Area of application: Customer service ((direct) interaction with the customer; customer advice and support by direct messaging; personal assistants/chatbots/robots)
- Phase of the customer journey: Before the trip (influencing the travel decision)
- Primary segments: Travel agents / B2C application
- Positive impact potentials: Advice on and sale of sustainable offers/products
- Negative impact potentials: Simplification and convenience generate more flight bookings
- State of development: High prevalence (D)
- Development perspective: High potential C
- Sequential number and code: 47/KI-1

- Source: https://www.skyscanner.net/news/tools/skyscanner-facebook-messenger-bot

B.3.10 AI supports KLM's customer service

In May 2016, KLM, in partnership with the San Francisco-based technology company Digital-Genius, launched an AI platform that converts customer questions into suggestions that are displayed on the customer service representative's work screen. KLM employs around 250 social media service agents who conduct around 30,000 customer conversations a week via Twitter, WhatsApp and Facebook Messenger. The platform, the first of its kind in the aviation industry, currently supports more than 50% of all KLM customer service requests.

- Category: 3 – Artificial intelligence
- Area of application: Customer service ((direct) interaction with the customer; customer advice and support by direct messaging; personal assistants/chatbots/robots)
- Phase of the customer journey: In general for all phases
- Primary segments: Transport / B2C application
- Positive impact potentials: More information / Communication of sustainable offers
- Negative impact potentials: Simplification, convenience and customer satisfaction with the service leads to more flight bookings
- State of development: High prevalence (D)
- Development perspective: High potential C
- Sequential number and code: 48/KI-2
- Source: https://www.travelweekly.com/Travel-News/Airline-News/Artificial-intelligence-driving-KLM-Social Media-strategy

B.3.11 AI supports KLM's customer service

KLM is developing increasingly more offers that involve artificial intelligence simplifying travel and travel planning for customers. Example: KLM's service bot (which is called: Blue Bot) – in 2017, KLM launched its own intelligent, interactive, voice-operated pack assistant on Google Home, which helps KLM passengers pack their bags via the recently launched service bot called BB. Based on their KLM destination, the duration of their trip and the local weather, this bot offers passengers personal advice on what to pack.

- Category: 3 – Artificial intelligence
- Area of application: Customer service ((direct) interaction with the customer; customer advice and support by direct messaging; personal assistants/chatbots/robots)
- Phase of the customer journey: Before the trip (influencing the travel decision)
- Primary segments: Transport / B2C application
- Positive impact potentials: You take less luggage because the bot only lists things you really need
- Negative impact potentials: Recommendations create purchase obligation (customers feel obliged to buy products on the pack list = increased consumption, more production)
- State of development: Adoption in tourism (C)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 49/KI-3
- Source: https://news.klm.com/klm-helps-you-packing-with-voice-driven-assistant-on-google-home

B.3.12 Connie – Hilton and IBM's world first Watson-enabled hotel concierge robot

Connie, the robot that provides help and information to hotel guests during their stay, was introduced in 2016 as the partners' first pilot robot. Connie uses the knowledge of Watson and WayBlazer to inform guests about local tourist attractions, restaurant recommendations, hotel facilities and services.

- Category: 3 – Artificial intelligence
- Area of application: Customer service ((direct) interaction with the customer; customer advice and support by direct messaging; personal assistants/chatbots/robots)
- Phase of the customer journey: During the trip
- Primary segments: Accommodation / B2C application
- Positive impact potentials: Information and advice on sustainable offers in the immediate vicinity
- Negative impact potentials: Energy consumption of the robot
- State of development: First applications (B+C)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 50/KI-4
- Source: http://www.hoteliermiddleeast.com/33274-ibm-launches-watson-assistant-for-hospitality-to-enhance-guest-engagement/

B.3.13 Mariott International: Check-in with face recognition

In the summer of 2018, Alibaba Group and Marriott International announced that they would work with Fliggy, Alibaba's travel services platform, to advance Marriott International's facial recognition check-in test. Initially, the pilot project will be tested in the Chinese market with the aim of expanding it internationally in all Marriott hotels. To use the service, guests simply scan their ID, take a photo and enter their contact information into a self-service device. The intelligent device issues room key cards once the person's identity and booking information have been verified.

- Category: 3 – Artificial intelligence
- Area of application: Customer service ((direct) interaction with the customer; customer advice and support by direct messaging; personal assistants/chatbots/robots)
- Phase of the customer journey: During the trip
- Primary segments: Accommodation / B2C application
- Positive impact potentials: Automation of check-in processes; increased efficiency
- Negative impact potentials: Energy consumption
- State of development: Adoption in tourism (C)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 51/KI-5
- Source: http://news.marriott.com/2018/07/joint-venture-of-alibaba-group-and-marriott-international-trials-facial-recognition-check-in-technology/

B.3.14 Intelligent service robot for hotel and restaurant industry

Alibaba A.I. Labs, responsible at Alibaba for artificial intelligence in consumer products, has developed a service robot for the hotel and restaurant industry. The robot delivers food or laundry to hotel rooms. Guests can communicate directly with the machine using voice commands, touch or gestures. The robot is about one metre tall and moves at a speed of up to one metre per second. It is also fitted, among other things, with an autonomous navigation system and a system for controlling lifts.

- Category: 3 – Artificial intelligence
- Area of application: Customer service ((direct) interaction with the customer; customer advice and support by direct messaging; personal assistants/chatbots/robots)
- Phase of the customer journey: During the trip
- Primary segments: Accommodation / B2C application
- Positive impact potentials: Increased efficiency; automation of processes
- Negative impact potentials: Energy consumption
- State of development: First applications (B)
- Development perspective: Average potential (B)
- Sequential number and code: 52/KI-7
- Source: https://www.alizila.com via www.trendexplorer.com of TrendOne GmbH

B.3.15 Hotel chain Clarion: Chatbot as hotel porter

In its hotel Amaranten in Stockholm, the Swedish hotel chain Clarion is testing a porter service that uses voice-activated chatbots. The system was developed in cooperation with the software developer EdgeDNA and is based on Alexa, Amazon's digital assistant. Guests at the Amaranth can use the chatbot as a wake-up service, to order a taxi, play music and obtain information about things like the weather. In future, they will be able to use the service to control every aspect of their hotel room, including lighting.

- Category: 3 – Artificial intelligence
- Area of application: Customer service ((direct) interaction with the customer; customer advice and support by direct messaging; personal assistants/chatbots/robots)
- Phase of the customer journey: During the trip
- Primary segments: Accommodation / B2C application
- Positive impact potentials: Advice about sustainable offers; increased efficiency
- Negative impact potentials: Energy consumption of the chatbot
- State of development: Adoption in tourism (C)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 53/KI-9
- Source: https://edgedna.com via www.trendexplorer.com of TrendOne GmbH

B.3.16 WeBeam smartphone application: personal assistant for events

The smartphone application WeBeam by the Canadian start-up of the same name serves as an intelligent personal assistant at events. It shows people in the surrounding area together with their job and interests and marks in colour those who share commonalities with the user. This allows users to identify like-minded people and start conversations more easily. Users can exchange contact information by Bluetooth by simply holding devices together while both access each other's profiles.

- Category: 3 – Artificial intelligence
- Area of application: Customer service (intelligent motion and behaviour pattern analysis)
- Phase of the customer journey: During the trip
- Primary segments: Destination / B2C application
- Positive impact potentials: Finding people with similar interests, such as with regard to sustainability; visitor satisfaction
- Negative impact potentials: Energy consumption of the app
- State of development: Adoption in tourism (C)
- Development perspective: Average potential (B)
- Sequential number and code: 54/KI-10

- Source: http://webeam.com via www.trendexplorer.com of TrendOne GmbH

B.3.17 NASA's "Smart Path" illuminates visitors

NASA has fit the Kennedy Space Center with piezoelectric tiles that light up when visitors walk over them and send information to visitors' smartphones. The "Smart Path" consists of 1,000 tiles spread over 3,700 square metres. They are equipped with circuit boards, solar collectors, a battery, LEDs, a Bluetooth and a WiFi transmitter as well as a microcontroller and a piezoelectric element that uses visitor steps to generate energy. The tiles together form mosaic images of Earth, the Moon, Mars and the International Space Station.

- Category: 3 – Artificial intelligence
- Area of application: Destination management (observation of environmental conditions; identification of need for action; planning of capacities and resources
- Better information for tourists and to increase customer satisfaction)
- Phase of the customer journey: During the trip
- Primary segments: Destination / B2C application
- Positive impact potentials: Communicating the relevance of the sustainable handling of our environment; pointing out the impacts on Earth or the whole universe
- Negative impact potentials: Loss of natural conditions / area from laying the tiles (3,700 sqm)
- State of development: First applications (B)
- Development perspective: Average potential (B)
- Sequential number and code: 55/KI-18
- Source: http://www.news.gatech.edu via www.trendexplorer.com of TrendOne GmbH

B.3.18 Start-up predicts flood risk

The Jupiter start-up offers a "FloodScore" analysis for developers, insurance companies, city officials and urban planners dealing with coastal cities that predicts the risk of flooding in a district or at a specific address. Jupiter's platform uses machine learning to analyse data on sea-level rise, erosion and the effects of flood-proof paving, as well as data from satellites and various sensors. The system can also assess how stored hazardous industrial waste can affect health during a flood.

- Category: 3 – Artificial intelligence
- Area of application: Crisis management (observation of environmental conditions; identification of need for action; planning of capacities and resources
- Better information for tourists and to increase customer satisfaction)
- Phase of the customer journey: During the trip
- Primary segments: Destination / B2B application
- Positive impact potentials: Increasing safety in coastal regions; possibility of mitigating major damage caused by floods
- Negative impact potentials:
- State of development: First applications (B)
- Development perspective: High potential C
- Sequential number and code: 56/KI-12
- Source: https://jupiterintel.com via www.trendexplorer.com of TrendOne GmbH

B.3.19 Browser based on artificial intelligence

San Francisco-based start-up Biggerpan has launched Ulli, the first smartphone browser based on artificial intelligence. When a user accesses web pages, it recommends possible next steps via the "Magic Wand Button" feature. As the user reads an article about a current film at the cinema it can note down the next screening in the calendar, call a taxi or find a nearby restaurant among other things. The company does not save the user's browser history and a privacy mode can be activated on request.

- Category: 3 – Artificial intelligence
- Area of application: Marketing, sales and travel planning ((direct) interaction with the customer; customer advice and support by direct messaging; personal assistants/chatbots/robots)
- Phase of the customer journey: Before and during the trip
- Primary segments: Destination / B2C application
- Positive impact potentials: Influencing customers by offering sustainable alternatives
- Negative impact potentials: Greater total volume of tourists because of simplified and automated product mixes
- State of development: High prevalence (D)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 57/KI-8
- Source: https://biggerpan.com via www.trendexplorer.com of TrendOne GmbH

B.3.20 Travel planning with the help of the crowd

The German start-up Mapify has developed an app of the same name that combines the visual appeal of Instagram with the benefits of a travel search engine. Users upload holiday photos onto the app and add extra information such as travel routes and short descriptions. Based on this data, the app generates travel recommendations for other users using artificial intelligence. Depending on the selected destination, Mapify automatically suggests the cheapest flight connections and accommodation via interfaces to Skyscanner or Airbnb, thus eliminating the time-consuming search for such information.

- Category: 3 – Artificial intelligence
- Area of application: Marketing, sales and travel planning (intelligent/optimised promotion; better understanding of customer/guest needs and satisfaction; automated news and product pooling; automated, personalised marketing activities and competitor analyses)
- Phase of the customer journey: Before the trip (influencing the travel decision)
- Primary segments: Travel agents / B2C application
- Positive impact potentials: Influencing users towards sustainability; offers of sustainable alternatives
- Negative impact potentials: Touristification of hitherto relatively unknown places; greater total volume of tourists (triggering of emotions through pictures and personal opinions = decision to travel)
- State of development: Adoption in tourism (C)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 58/KI-14
- Source: https://mapify.travel via www.trendexplorer.com of TrendOne GmbH

B.3.21 IBM: Big data for an agile supply chain

With "Watson Supply Chain", IBM has launched a powerful analysis tool for supply chain management. Since the acquisition of the Weather Company, IBM has had access to large amounts of weather and location data. This data is supplemented with information from news services and social media as well as information on the current traffic situation and fed into the IBM cloud. Based on this data, the artificial intelligence Watson can derive implications for global supply chains and identify potential supply chain bottlenecks in advance.

- Category: 3 – Artificial intelligence
- Area of application: Company-internal process optimisation (+ logistics) (automation of business processes through automated analyses and predictions; automated error detection and maintenance; automated capacity planning; increased efficiency and cost savings)
- Phase of the customer journey: In general for all phases
- Primary segments: Transport / B2B application
- Positive impact potentials: Application of sustainable alternatives for transport; avoidance of traffic jams and waiting times; increased efficiency
- Negative impact potentials:
- State of development: First applications (B)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 59/KI-17
- Source: https://www.ibm.com via www.trendexplorer.com of TrendOne GmbH

B.4 Smart mobile devices and digital payment

B.4.1 App connects people at the airport

The Berlin-based start-up WaitList has developed an app of the same name that gives airport visitors the opportunity to meet interesting new people. The app shows users who is currently at the airport and has time for spontaneous interaction. The app also displays short business cards with the skills and interests of each waiting person, allowing users to easily identify potentially valuable conversation partners. If a match is made, the app suggests an airport café for a personal meeting.

- Category: 4 – Smart mobile devices and digital payment
- Area of application: Visitor management (observation and analysis of visitor flow; better travel experience increases customer satisfaction)
- Phase of the customer journey: During the trip
- Primary segments: Transport / B2C application
- Positive impact potentials: Finding people with similar interests with regard to sustainability topics (exchange of ideas)
- Negative impact potentials: App uses energy
- State of development: First applications (B)
- Development perspective: Average potential (B)
- Sequential number and code: 60/MD-15
- Source: http://www.waitlist.tech via www.trendexplorer.com of TrendOne GmbH

B.4.2 Social network for families

The Hamburg-based start-up Familonet has developed a smartphone application of the same name that allows users to keep an eye on the whereabouts of friends and family members. To do this, they organise their networks in the app. Users decide if and when they can be located and which of their locations are displayed to other users. Parents can use the app to check if their child has arrived at school, and students can see if other members of their study group are in the library. The app also allows private chats among members as well as sending a call for help.

- Category: 4 – Smart mobile devices and digital payment
- Area of application: Visitor management (observation of visitor flow by locating users; improved and simplified travel experiences increase customer satisfaction)
- Phase of the customer journey: During the trip
- Primary segments: Destination / B2C application
- Positive impact potentials: Display of sustainable offers in the immediate vicinity
- Negative impact potentials: Greater total volume of tourists as a result of recommendations and direct tracking; long distances can be travelled alone because of chat with call for help + direct tracking no longer a problem
- State of development: Adoption in tourism (C)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 61/MD-8
- Source: https://www.familo.net via www.trendexplorer.com of TrendOne GmbH

B.4.3 Identification of customer requirements on board

As part of the "Telekom Fashion Fusion & Lufthansa FlyingLab" competition, Lufthansa and Deutsche Telekom have selected finalist teams who are working on improving on board customer experience. The "Feel.Flight" team is developing a WhatsApp and Messenger chatbot, among other things, to determine the needs of travellers and prioritise them for the crew. The "Smart Chair" team is working on providing passengers with better entertainment and maximum comfort at their seats, while the "Lyra" team is developing smart glasses and apps that forward requests to flight attendants and reduce waiting times.

- Category: 4 – Smart mobile devices and digital payment
- Area of application: Customer service (simpler travel planning and positive experiences; better travel experiences improve customer satisfaction)
- Phase of the customer journey: Before and during the trip
- Primary segments: Transport / B2B application
- Positive impact potentials: Promotion of sustainable offers in the destination region; information about sustainable behaviour (in the destination region); awareness raising
- Negative impact potentials: Greater total volume of tourists as a result of maximum comfort
- State of development: First applications (B)
- Development perspective: Average potential (B)
- Sequential number and code: 62/MD-7
- Source: https://www.flyinglab.aero via www.trendexplorer.com of TrendOne GmbH

B.4.4 Machine prints out short story at the airport

The Akron-Canton Airport in Ohio, USA, in partnership with the Akron-Summit County Public Library and the Knight Foundation, is offering travellers free short stories on recycled receipt paper to reduce their waiting time. Stories from different genres and for different reading ages

were compiled for the machines and printed on recycled paper. With the short stories, travellers can now bridge the waiting time at the airport without a mobile device in their hands.

- Category: 4 – Smart mobile devices and digital payment
- Area of application: Customer service (positive experiences during the trip)
- Phase of the customer journey: During the trip
- Primary segments: Transport / B2C application
- Positive impact potentials: Reduction of energy consumption (no mobile devices)
- Negative impact potentials: Printing the short stories consumes resources
- State of development: First applications (B)
- Development perspective: Average potential (B)
- Sequential number and code: 63/MD-9
- Source: https://www.akroncantonairport.com via www.trendexplorer.com of TrendOne GmbH

B.4.5 Beacon – technology for banks and airlines

The Berlin-based start-up Hotel Beacons with its "Conichiwa" solution that uses the beacon technology offers an on-demand service for different industries. "Conichiwa" can be used by banks, for example, to offer a better service. With "Conichiwa", customers can interact remotely with branches and make appointments, use personalised banking services and make location-based payments. Airlines can use Conichiwa to provide audio, video and interactive games during the flight.

- Category: 4 – Smart mobile devices and digital payment
- Area of application: Customer service (positive experiences during the trip)
- Phase of the customer journey: During the trip
- Primary segments: Transport / B2B application
- Positive impact potentials: Increased efficiency; communication of sustainable topics
- Negative impact potentials:
- State of development: First applications (A)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 64/MD-10
- Source: https://conichiwa.com via www.trendexplorer.com of TrendOne GmbH

B.4.6 Checking in luggage via smartphone

The luggage manufacturer Rimowa has developed the "Electronic Tag" for luggage, which digitally displays travel information, thus simplifying and speeding up the check-in process. Travellers hand in their luggage at an automated check-in counter and send their digital boarding pass from their smartphone via Bluetooth to their luggage, which is fit with a digital data module. The module displays all relevant travel information. The Electronic Tag not only enables faster check-in, it could also mean that lost luggage is a thing of the past.

- Category: 4 – Smart mobile devices and digital payment
- Area of application: Customer service (simpler travel planning and positive experiences; better travel experiences improve customer satisfaction)
- Phase of the customer journey: Before and during the trip
- Primary segments: Transport / B2C application
- Positive impact potentials: Conservation of resources with digital boarding pass and labels; avoiding waiting times; increased efficiency
- Negative impact potentials: Energy consumption of the labels

- State of development: First applications (B)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 65/MD-11
- Source: http://www.rimowa.com via www.trendexplorer.com of TrendOne GmbH

B.4.7 Validating ticket with hand implant

Customers of the state-owned railway company SJ in Sweden will soon be able to show their tickets using a hand implant. This is made possible by a chip the size of a rice grain from the cooperation partner Biohack, which is injected into the upper or lower edge of the hand. Passengers can then use a train app to buy a ticket and have their travel authorisation transferred from the smartphone to the chip in their hand using special chip technology.

- Category: 4 – Smart mobile devices and digital payment
- Area of application: Customer service (direct bookings through in-app purchases simplify travel planning and ensure increasing customer satisfaction)
- Phase of the customer journey: Before and during the trip
- Primary segments: Transport / B2C application
- Positive impact potentials: Reduction of resource consumption
- Negative impact potentials:
- State of development: First attempts (A)
- Development perspective: Low potential or difficult to assess (A)
- Sequential number and code: 66/MD-13
- Source: http://biohacking.se via www.trendexplorer.com of TrendOne GmbH

B.4.8 Google Translate & co. – mobile translation apps

Apps installed on the mobile phone such as Google Translate, WayGo, Microsoft Translator, iTranslate Voice and many others have made extremely rapid progress in recent years and have made it easier for many travellers to communicate at a foreign destination thanks to the easy-to-use mobile phone apps. While translations were mainly text-based a few years ago, real-time language translations are getting better and better. 2017 saw the presentation of the Google Earbuds, for example, which translates conversations in real time based on Google Assistant and Google Translate. Given the speed with which language and translation technologies have evolved in recent years (Siri, Cortana, Alexa and other language assistants in mobile devices have already learned to understand what people say and execute commands in one language), we can assume that there will be more exciting progress in the coming years than what Google Buds offer today.

- Category: 4 – Smart mobile devices and digital payment
- Area of application: Customer service (immediate help with problems (foreign language communication problems); simplification of travel planning and positive experiences)
- Phase of the customer journey: Before and during the trip
- Primary segments: All segments / B2B, B2C application
- Positive impact potentials: Communication of sustainable offers in different languages (addressing all potential customers); communication between guest and provider without language barriers
- Negative impact potentials: Energy consumption instead of using a dictionary
- State of development: High prevalence (D)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 67/MD-16

- Source: https://www.orange-business.com/en/blogs/language-translation-boosted-by-ai
- https://skift.com/2017/11/16/google-earbuds-with-real-time-translation-arent-much-more-than-a-gimmick/
- https://www.telegraph.co.uk/technology/2017/10/04/googles-new-headphones-c

B.4.9 Opening your front door remotely

The Nello intercom system by Locumi Labs gives you keyless access to your home. Your front door can be activated via voice commands, the associated app or by setting specific time windows. This makes Nello especially useful for granting access to external service staff when the residents themselves are out. Amazon Echo users can add the Nello function to the language assistant and enable the system to open the door after the doorbell rings. The associated digital key can be controlled via an activity protocol and is tamper-proof.

- Category: 4 – Smart mobile devices and digital payment
- Area of application: Customer service (making travel planning easier, generate more positive experiences)
- Phase of the customer journey: During the trip
- Primary segments: Accommodation / B2C application
- Positive impact potentials:
- Negative impact potentials: Energy consumption
- State of development: Adoption in tourism (C)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 68/MD-14
- Source: https://www.nello.io via www.trendexplorer.com of TrendOne GmbH

B.4.10 HotelTonight

HotelTonight is a mobile hotel booking application that allows users to find and book hotel rooms on the day using their smartphone. It offers some of the best last-minute hotel deals, which can be booked up to 7 days in advance. As the smartphone is particularly suitable for last-minute hotel reservations, HotelTonight benefits from many spontaneous and short-term mobile travel bookings. The service presents new business opportunities for hotel bookings via smartphones and gives hotels a channel through which to sell those rooms that would otherwise remain vacant. Founded in 2010, HotelTonight was the first hotel booking app specifically developed for the smartphone.

- Category: 4 – Smart mobile devices and digital payment
- Area of application: Customer service, sales, reputation management (simplifying travel planning through direct bookings and in-app purchases; immediate support in case of problems ensures better customer service quality and thus increases customer satisfaction; direct linking of supply and demand)
- Phase of the customer journey: Before the trip (influencing the travel decision)
- Primary segments: Accommodation / B2B, B2C application
- Positive impact potentials: Availability of alternative offers
- Negative impact potentials: Greater total volume of tourists (especially as a result of spontaneous bookings)
- State of development: Adoption in tourism (C)
- Development perspective: Average potential (B)
- Sequential number and code: 69/MD-2

- Source: https://www.businessinsider.com/the-mobile-tourist-how-smartphones-are-shaking-up-the-travel-market-2013-2?IR=T
- https://www.crunchbase.com/organization/hoteltonight#section-overview

B.4.11 Travel app for women

Tourlina, an app developed by Michael Klumpp, allows women to find a female travel companion within a safe network. The user is checked and verified by Tourlina when she registers. She then enters the country she is looking to visit and the time of travel to find travel companions wishing to travel to the same country during the same period. By swiping right or left, she can select a travel companion. If the selected user had the same idea, the two users can chat and plan their journey.

- Category: 4 – Smart mobile devices and digital payment
- Area of application: Customer service, sales, reputation management (immediate help with problems (searching for a travel companion); simplification of travel planning and positive experiences)
- Phase of the customer journey: Before the trip (influencing the travel decision)
- Primary segments: Travel agents / B2C application
- Positive impact potentials: Promotion of sustainable travel opportunities
- Negative impact potentials: Negative environmental impact from world trips for example (travel companions are generally wanted for longer trips and more far-away destinations)
- State of development: Adoption in tourism (C)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 70/MD-6
- Source: http://tourlina.com via www.trendexplorer.com of TrendOne GmbH

B.4.12 WeChat

WeChat, the popular Chinese messaging app owned by technology group Tencent, launched its payment service, WeChat Pay, in Europe in 2017. WeChat is a giant social media service with 938 million monthly active users. The connected mobile service 'WeChat Pay' has 600 million active users. WeChat will come up against Alipay, the payments service run by Alibaba affiliate Ant Financial, which launched in Europe in 2015. As Chinese tourists are the highest spending market worldwide, the move is specifically aimed at Chinese tourists coming to Europe and is not necessarily a challenger to the likes of Apple Pay and Samsung Pay, both of which operate in parts of Europe. Travellers using the service can open their WeChat wallet feature, show the barcode on their smartphone to the retailer, and the shop assistant will scan the code to activate the payment process.

- Category: 4 – Smart mobile devices and digital payment
- Area of application: Digital payment (instant shopping / digital payment; simplified payment processes and travel planning (cashless travel) generate an increase in sales volume / turnover; collection of information on transactions / payment behaviour of travellers)
- Phase of the customer journey: Before and during the trip
- Primary segments: All segments / B2C application
- Positive impact potentials: Conservation of resources (no need for banknotes)
- Negative impact potentials: Energy consumption; more consumption as a result of simpler payment processes (consumption of more resources)
- State of development: First applications (B)

- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 71/MD-3
- Source: https://www.cnbc.com/2017/07/10/wechat-pay-europe-launch-tencent-to-challenge-alipay.html
- https://www.wirecard.com/newsroom/press-releases/newsdetail/wirecard-brings-wechat-pay-to-europe/

B.4.13 Venmo

Venmo is a PayPal-operated peer-to-peer payment app created in 2009 by two former college residents who were looking for a better way to pay each other. What began as a simple SMS platform to send and receive money has evolved into a social payment app that allows you to share bills, pay one another and shop with approved merchants. Venmo has become increasingly popular with younger generations in recent years because of its simple social network-inspired design and lower fee structure. This has made it attractive for PayPal, who use it to gain market share with a different target group. The app includes a social network-style news feed that displays transactions between a user and their Facebook friends. No dollar amounts are displayed, but Venmo users can mark transactions with a playful tag when making a payment.

- Category: 4 – Smart mobile devices and digital payment
- Area of application: Digital payment (instant shopping / digital payment; simplified payment processes and travel planning (cashless travel) generate an increase in sales volume / turnover; collection of information on transactions / payment behaviour of travellers)
- Phase of the customer journey: Before and during the trip
- Primary segments: All segments / B2C application
- Positive impact potentials: Conservation of resources (no need for banknotes)
- Negative impact potentials: Energy consumption; more consumption as a result of simpler payment processes (consumption of more resources)
- State of development: First applications (B)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 72/MD-5
- Source: https://www.businessinsider.com/this-week-in-bi-intelligence-ebays-payment-app-is-blowing-up-on-college-campuses-2014-5?IR=T

B.4.14 Buying locally using an app

As part of the "Digital Villages" project, the Fraunhofer Institute for Experimental Software Engineering tested a smartphone application in the towns of Betzdorf and Eisenberg; the app allows residents to have goods from local retailers delivered to their homes. The approximately 270 registered users have mainly used the app to order regional food, medicines and books from the local library. They received personal advice via video chat from the shop assistants. Volunteers then delivered the ordered goods directly to the customer's home.

- Category: 4 – Smart mobile devices and digital payment
- Area of application: Logistics (simplifying travel planning through direct bookings and in-app purchases; immediate support in case of problems ensures better customer service quality and thus increases customer satisfaction; direct linking of supply and demand)
- Phase of the customer journey: Before and during the trip
- Primary segments: Destination / B2C application

- Positive impact potentials: Promotion of sustainable, local offers/products; support of the regional economy
- Negative impact potentials: Energy consumption through use of the app (especially advice via video chat)
- State of development: First applications (B)
- Development perspective: Average potential (B)
- Sequential number and code: 73/MD-4
- Source: http://www.digitale-doerfer.de via www.trendexplorer.com of TrendOne GmbH

B.4.15 On-demand electric bus shuttle

The VW subsidiary Moia has presented its first demand-based shuttle service. At the beginning of 2019, the first virtual stops will be installed in Hamburg; initially, around 200 of the electric vehicles specially designed for the pooling service will operate in the city. The six-seater vehicle will have a range of 300 kilometres and can be charged to 80 percent within half an hour. The seats are equipped with WiFi, a reading lamp and a USB port. The shuttle can be requested via an app, and the exact routes will depend on demand.

- Category: 4 – Smart mobile devices and digital payment
- Area of application: Logistics (direct bookings through in-app purchases simplify travel planning and ensure increasing customer satisfaction)
- Phase of the customer journey: Before the trip (influencing the travel decision)
- Primary segments: Transport / B2C application
- Positive impact potentials: More sustainable transport alternative; increased efficiency; reducing resource consumption; comfort
- Negative impact potentials: Energy consumption
- State of development: First attempts (A)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 74/MD-12
- Source: https://www.moia.io via www.trendexplorer.com of TrendOne GmbH

B.5 Extended reality (AR, VR, MR)

B.5.1 Augmented reality game: Pokémon Go for crisis management at destinations

The augmented reality game Pokémon Go was released in July 2016 and downloaded more than 500 million times within a few months.

Destinations also quickly realised the potential of attracting visitors to their areas, as the app uses GPS to determine players' locations, allowing 250 Pokémon characters to be hunted at specific destinations. While many destinations have since only used the game for marketing purposes (for example to have their own Pokéstop, the small Norwegian town of Vindenes built the world's first Pokémon Go statue), Thailand also used the game to bring visitors back to certain places after the bombing in Bangkok.

- Category: 5 – Extended reality (AR, VR, MR)
- Area of application: Visitor management, visitor guidance (improving the attractiveness and name recognition of certain locations/attractions (at the destination) generates more sales)
- Phase of the customer journey: During the trip
- Primary segments: Destination / B2B, B2C application

- Positive impact potentials: Promotion of sustainable offers possible; influencing consumption in the direction of sustainability; new attractiveness of locations (that may have becoming insignificant); data generates customer understanding = simplified guidance
- Negative impact potentials: Negative impact on the environment as a result of greater total volume of tourists (more people, more rubbish, more traffic, etc.)
- State of development: High prevalence (D)
- Development perspective: Average potential (B)
- Sequential number and code: 75/AR-1
- Source: https://www.lonelyplanet.com/news/2016/08/18/tourism-pokemon-go/ , https://destinationthink.com/destinations-using-pokemon-go/

B.5.2 Wikitude AR travel guide

The Salzburg-based company Mobilizy, founded in 2009, positions itself as a provider in the area of augmented reality. The Wikitude World Browser is a mobile travel guide for Android and iPhone and is based on location-specific information on currently around 400,000 points of interest worldwide (sights, restaurants, insider tips, ...), which can be found by address or coordinates. At the location, the details are displayed as a map or satellite view as well as in the form of user-friendly augmented reality (AR). Visitors move through the real world with their mobile phone cameras running and interesting facts about the surrounding real world are displayed on their smartphone. Wikitude uses the compass, GPS and motion sensor of the mobile phone to work out which locations are currently displayed on the screen. The possibility of presenting location-specific information in this way is popular with users as well as business customers. For businesses, Wikitude opens up new options of communicating product information and advertising to potential customers at the point of sale. Next steps in the development of Wikitude: embedding it into social platforms such as Facebook and projects with business customers (e. g. travel book publishers).

- Category: 5 – Extended reality (AR, VR, MR)
- Area of application: Visitor management, visitor guidance (providing better information on specific topics such as environmental protection, the impact of tourism, etc., can lead to consumers changing their behaviour (raising awareness))
- Phase of the customer journey: During the trip
- Primary segments: Destination / B2C application
- Positive impact potentials: Raising awareness of environmental topics and sustainability; promotion of sustainable offers (influencing); presentation of future prospects at the location: sustainable actions vs. non-sustainable actions (emotions increase awareness)
- Negative impact potentials: Greater total volume of tourists, wanting to use the new development; greater energy consumption from using the mobile phone / the use of AR travel guides
- State of development: Adoption in tourism (C)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 76/AR-9
- Source: https://www.lifewire.com/Virtual Reality-tourism-4129394
- https://www.aws.at/service/cases/gefoerderte-projekte-auswahl/kreativwirtschaft/wikitude-ar-travel-guide/
- https://www.wikitude.com/

B.5.3 Virtual reality has added a new dimension to theme park rides

The roller coasters and attractions in the famous theme parks of the world have become bigger, higher and faster. But it seems as if the parks have slowly reached their limits and are less willing to make new investments. Many of them now focus on virtual reality. During the ride, the user wears VR glasses that simulate a completely different environment. For example, you can sit on a dragon while on the ride, fly through fictitious worlds and be attacked by creatures. With VR, the Free Fall Tower suddenly turns into a spectacular helicopter crash. The technology is still in its infancy, but who knows – maybe we will soon be able to save ourselves the journey and dive into the world of Disneyland from the comfort of our sofa.

- Category: 5 – Extended reality (AR, VR, MR)
- Area of application: Visitor management, visitor guidance (improving the attractiveness and name recognition of certain locations/attractions (at the destination) generates more sales)
- Phase of the customer journey: During the trip
- Primary segments: Destination / B2C application
- Positive impact potentials: No new attractions necessary, because old rides are given new appeal
- Negative impact potentials: Energy consumption
- State of development: First applications (A)
- Development perspective: Average potential (B)
- Sequential number and code: 77/AR-11
- Source: http://theconversation.com/Virtual Reality-has-added-a-new-dimension-to-theme-park-rides-so-whats-next-for-thrill-seekers-89222

B.5.4 Mixed reality for cultural heritage

The Tokyo-based AsukaLab Inc. has been using mixed reality applications since 2015 to digitally reconstruct ruins and offer more realistic and interactive tours to stimulate tourism at historic sites. From the ruins around Asuka in the Nara Prefecture (the cultural centre during the Asuka period (592-710)) to the long-lost Donjon of Edo Castle in Tokyo today, the company offers travel agencies and communities mixed reality business solutions. By using sensors to track head movements, people can move around the image and look around the ancient surroundings. Among other places, AsukaLab has developed mixed reality content for the main tower of Sunpu Castle in the Shizuoka Prefecture and Sannai Maruyama Prefecture, as well as for historical excavation sites in the Aomori Prefecture.

- Category: 5 – Extended reality (AR, VR, MR)
- Area of application: Visitor management, visitor guidance (medial creation of travel destinations and offers; detailed (visual) information about destinations, accommodation, attractions before the trip increase name recognition, sales figures / turnover as well as customer satisfaction)
- Phase of the customer journey: Before the trip (influencing the travel decision)
- Primary segments: Travel agents / B2B application
- Positive impact potentials: Possibility of promotion of sustainable offers; influencing potential customer consumption in the direction of sustainability; enhancement and new attractiveness of tourist destinations
- Negative impact potentials: Greater total volume of tourists at the destinations (emotions generated by images and deeper insights make destinations attractive = higher number of visitors); VR glasses consume energy
- State of development: High prevalence (D)
- Development perspective: Absolutely transformative (D)

- Sequential number and code: 78/AR-13
- Source: https://www.japantimes.co.jp/news/2015/03/08/national/virtual-technology-resurrects-ancient-sites/#.W6DAu877SUk
- https://www.youtube.com/watch?v=wuYL61FPklw

B.5.5 3D – printed coral reefs in the Caribbean

Fabien Cousteau's Ocean Learning Center and the Harbour Village Beach Club on the Caribbean island of Bonaire have launched an initiative to preserve and revitalise endangered coral reefs. The shape, texture and chemical composition of the endangered coral reefs are reproduced using 3D printing. The aim is for baby coral polyps as well as algae, fish and octopus to settle there again. The initiative also aims to raise awareness of the issue among visitors and tourists.

- Category: 5 – Extended reality (AR, VR, MR)
- Area of application: Education, research (providing better information on specific topics such as environmental protection, the impact of tourism, etc., can lead to consumers changing their behaviour (raising awareness))
- Phase of the customer journey: In general for all phases
- Primary segments: Destination / B2B application
- Positive impact potentials: Raising awareness among tourists and encouraging them to treat the environment in a more sustainable way, environmental protection and preservation of the coral reefs
- Negative impact potentials: "Reconstruction" or recovery of coral reefs attracts more tourists (e. g. divers) = greater overall number of tourists; 3D reproduction intervenes with nature
- State of development: First attempts (A+B)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 79/AR-5
- Source: http://www.harbourvillage.com via www.trendexplorer.com of TrendOne GmbH

B.5.6 JFK Airport's big push for affordable virtual reality

JFK Airport has recognised the great potential of virtual reality and opened a VR experience centre in one of its terminals. Passengers can immerse themselves in various virtual worlds while they wait. There are five different possible experiences: "First Time", "Experience", "Create", "Play" and "Social Cause". From diving with whales and insights into the world of quantum physics to games like Fruit Ninja, there is something for everyone. It remains to be seen whether further airports and companies will expand their offer to include VR. So far, companies have been cautious, because many customers still shy away from this new technology.

- Category: 5 – Extended reality (AR, VR, MR)
- Area of application: Customer service (positive experiences during the trip)
- Phase of the customer journey: During the trip
- Primary segments: Transport / B2C application
- Positive impact potentials: Communication of sustainable topics
- Negative impact potentials: Energy consumption
- State of development: First applications (B)
- Development perspective: Average potential (B)
- Sequential number and code: 80/AR-12
- Source: https://www.airport-technology.com/comment/jfk-airports-big-push-affordable-Virtual Reality/

B.5.7 Exploring homes in advance with VR and AR Airbnb

Airbnb has announced that it will integrate virtual and augmented reality into its platform. The aim is to enable potential customers to virtually explore and get to know homes and neighbourhoods they are interested in before they set off on their journey. It will also enable providers to introduce themselves virtually and to present objects in the home along with digital information such as functional descriptions or personal stories. This additional information can be accessed on a mobile device to make living in the home easier for future tenants.

- Category: 5 – Extended reality (AR, VR, MR)
- Area of application: Marketing, sales and travel planning (medial creation of potential travel destinations and offers; detailed (visual) information about destinations, accommodation, events, attractions before the trip increase name recognition, sales figures / turnover as well as customer satisfaction)
- Phase of the customer journey: Before the trip (influencing the travel decision)
- Primary segments: Accommodation / B2C application
- Positive impact potentials: Sustainably designed homes (passive houses, energy-saving methods, etc.); new tourism accommodation need not be built
- Negative impact potentials: Greater total volume of tourists as a result of additional information in the form of images (= emotions, familiarity)
- State of development: Adoption in tourism (C)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 81/AR-3
- Source: https://press.atairbnb.com via www.trendexplorer.com of TrendOne GmbH

B.5.8 Virtual reality supports travel booking

The travel search engine Kayak introduced the feature "Kayak VR", which allows users to visit destinations in virtual reality before making a booking. The Kayak VR application is part of the Google Daydream platform and combines 360-degree views with an audio guide. To help users choose their destination, Kayak VR provides them with suggestions for local activities and insights into hotels. Compared to ordinary photos, virtual reality views give you a better sense of proportions and the surroundings.

- Category: 5 – Extended reality (AR, VR, MR)
- Area of application: Marketing, sales and travel planning (medial creation of potential travel destinations and offers; detailed (visual) information about destinations, accommodation, events, attractions before the trip increase name recognition, sales figures / turnover as well as customer satisfaction)
- Phase of the customer journey: Before the trip (influencing the travel decision)
- Primary segments: Destination / B2C application
- Positive impact potentials: Promotion of sustainable travel opportunities
- Negative impact potentials: Greater total volume of tourists as a result of additional information in the form of images (= emotions, familiarity)
- State of development: First applications (B)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 82/AR-4
- Source: https://www.kayak.com via www.trendexplorer.com of TrendOne GmbH

B.5.9 Inspecting the aircraft cabin in VR

The airline Emirates has introduced a feature on its website that allows visitors to explore their seat in virtual reality. The 360-degree view includes Economy, Business and First Class as well as Lounge and Spa areas. With the help of a virtual reality headset users can move freely through the cabin and select their seat. Additional videos demonstrate the equipment and unique components of the Emirates fleet to new customers.

- Category: 5 – Extended reality (AR, VR, MR)
- Area of application: Marketing, sales and travel planning (medial creation of potential travel destinations and offers; detailed (visual) information about destinations, accommodation, events, attractions before the trip increase name recognition, sales figures / turnover as well as customer satisfaction)
- Phase of the customer journey: Before the trip (influencing the travel decision)
- Primary segments: Transport / B2C application
- Positive impact potentials: Promotion of sustainable offers/fittings; influencing the mindset of potential customers (to pay more attention to sustainability in aviation)
- Negative impact potentials: Passengers feel very well prepared for the journey after using VR to inspect the cabin and know what to expect = greater volume of tourists (including anxious passengers)
- State of development: Adoption in tourism (C)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 83/AR-6
- Source: https://www.emirates.com via www.trendexplorer.com of TrendOne GmbH

B.5.10 Winning travel vouchers with heavenly illusions

The American hotel group Marriott International was the first company to use the "Echo" projection technology of the Lightvert start-up for its advertising. This technology uses the Phi effect to create optical illusions in the form of projections in the sky. Marriott used Echo for its Travel Brilliantly campaign near London's South Bank, where images of the Eiffel Tower and the Roman Colosseum appeared in the sky for three days. Passers-by who shared photos of this on social media had the chance to win travel vouchers.

- Category: 5 – Extended reality (AR, VR, MR)
- Area of application: Marketing, sales and travel planning (medial creation of potential travel destinations and offers; detailed (visual) information about destinations, accommodation, events, attractions before the trip increase name recognition, sales figures / turnover as well as customer satisfaction)
- Phase of the customer journey: Before the trip (influencing the travel decision)
- Primary segments: Accommodation/Destination/B2B application
- Positive impact potentials: Awareness raising in the direction of sustainable travel
- Negative impact potentials: Greater total volume of tourists at the marketed destinations due to the unusual advertising (eye-catching, images generate emotions)
- State of development: First applications (B)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 84/AR-10
- Source: https://lightvert.com via www.trendexplorer.com of TrendOne GmbH

B.5.11 Interactive travel compass for long-distance travel

The airline Lufthansa has launched the interactive "Reisekompass" poster, whose 360-degree view takes passers-by in Berlin and Hamburg to far-away countries during the winter months.

Such a revolving poster is installed in the Alstertal shopping centre in Hamburg as well as in the Sony Centre in Berlin; the user turns the poster to select a destination. Once the destination has been selected, the 360-degree journey begins, taking the user to New York, Miami, Tokyo or Hong Kong. The digital poster is designed to offer a source of inspiration and allows the user to virtually explore their next destination.

- Category: 5 – Extended reality (AR, VR, MR)
- Area of application: Marketing, sales and travel planning (medial creation of potential travel destinations and offers; detailed (visual) information about destinations, accommodation, events, attractions before the trip increase name recognition, sales figures / turnover as well as customer satisfaction)
- Phase of the customer journey: Before the trip (influencing the travel decision)
- Primary segments: Destination / B2C application
- Positive impact potentials: Promotion of sustainable offers / travel opportunities; influencing potential customers with beautiful images of destinations in the direction of sustainability (this is how beautiful sustainable can be)
- Negative impact potentials: Type of advertising triggers wanderlust and highlights the destinations' attractiveness = greater travel volume = higher consumption of resources negatively effects the environment (especially the consumption of jet fuel by Lufthansa aircraft)
- State of development: First applications (B)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 85/AR-2
- Source: http://socialhub.lufthansa.com via www.trendexplorer.com of TrendOne GmbH

B.5.12 Everest VR

Everest VR was created in 2016 by the Icelandic company Sólfar Studios in collaboration with Visual Effects House RVX, a Reykjavik-based visual effects and animation company. Everest VR is an immersive experience that allows people to explore Mount Everest, including the famous base camps, the Khumbu Icefall, Camp Four, the Hillary Step, the Lhotse Face, and the mountain summit. An important part of the Everest VR project is interactivity. To enhance interaction and immersion, handset controls (Oculus touch controllers) are used as the key to the VR experience. The team members are told, for example, that they have to hold on to a rope, climb up a ladder or look over the edge. Unlike other VR experiences that offer simple 360-degree videos and photos of far-away places, people can climb Everest with the Oculus touch controllers. More than 300,000 high-resolution photos of Mount Everest were used to create a realistic 3D model of the mountain.

- Category: 5 – Extended reality (AR, VR, MR)
- Area of application: Virtual travel (virtual access to places (e. g. protected or destroyed); better information on specific topics such as wheelchair accessibility, environmental protection, impact of tourism, etc., through educational offers can lead to behavioural changes)
- Phase of the customer journey: Before the trip
- Primary segments: Destination / B2C application
- Positive impact potentials: Raising awareness of nature, cultural heritage and environmental issues; promotion of sustainable services; changing consumption patterns; experience that users may not be able to have on a real journey
- Negative impact potentials: Greater total volume of tourists (insights can encourage people to explore the region in real life / recommend it to friends and family) OR reduction of number of tourists because region loses in attractiveness because already experienced virtually

- State of development: Adoption in tourism (C)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 86/AR-7
- Source: https://mashable.com/2017/02/14/mount-everest-Virtual Reality/?europe=true#Wvjphz6r0qqh

B.5.13 Visit Wales virtual reality project – Dolphin Dive

In 2017, Visit Wales announced that it would support six VR projects worth £290,000 through its Tourism Innovation Fund. The Wildlife Trust of South and West Wales was awarded £30,000 to create two VR videos – one of which was "Dolphin Dive" off the coast of Pembrokeshire. This 360-degree virtual reality experience lets people swim with dolphins. The South and West Wales Wildlife Trust used six cameras attached to the front of a boat and took 360° shots of a flock of dolphins to create the virtual reality experience. The photos were initially used as research material by scientists before a decision was made to turn them into a virtual reality experience that the public could enjoy.

- Category: 5 – Extended reality (AR, VR, MR)
- Area of application: Virtual travel (virtual access to places (e. g. protected or destroyed); better information on specific topics such as environmental protection, impact of tourism, etc., through educational offers can lead to behavioural changes among consumers (B))
- Phase of the customer journey: Before the trip
- Primary segments: Destination / B2C application
- Positive impact potentials: Raising awareness of nature and animal protection as well as other environmental issues; triggering emotions through apparent proximity to dolphins; increasing awareness of sustainable action; promotion of sustainable offers
- Negative impact potentials: Greater total volume of tourists coming to the coast to swim (the video doesn't give them direct contact but attracts them) OR reduction of number of tourists because of a loss of attractiveness because people already had a virtual experience
- State of development: Adoption in tourism (C)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 87/AR-8
- Source: https://www.bbc.com/news/uk-wales-41635746
- http://www.itv.com/news/wales/2017-04-12/360-Virtual Reality-experience-lets-people-swim-with-dolphins-off-the-pembrokeshire-coast/

B.6 Security, data protection and blockchain

B.6.1 Aruba – blockchain for distribution

A partnership with two major airlines (Lufthansa and Air New Zealand) and travel technology specialist Winding Tree has made Aruba the first country to officially use Blockchain in a tourism distribution platform. The platform connects Aruba's numerous small hotels with their potential customers and is due to be launched in early 2018. Based on the Ethereum protocol, the platform offers the use of a public, decentralised blockchain including intelligent contracts. These intelligent contracts provide a more efficient, customisable and secure interface between customers and suppliers. This step is part of Aruba's general plan to implement a "Smart Island Strategy" aimed at making the country 100% renewable by 2020.

- Category: 6 - Security, data protection and blockchain
- Area of application: Visitor management, visitor guidance (+digital payment) (intelligent contracts; increasing customer control over their data; no need for agents / third parties creates better links between guests and providers; easier management of visitor flow due to "direct contact")
- Phase of the customer journey: Before and during the trip
- Primary segments: All segments / B2B application
- Positive impact potentials: Offer of sustainable alternatives; increased efficiency
- Negative impact potentials: Energy consumption
- State of development: First applications (B)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 88/BC-1
- Source: https://medium.com/@otncoin/tourism-the-next-sector-to-benefit-big-from-blockchain-solutions-2f3ff633b0f3

B.6.2 E-bikes generate cryptocurrency

In London, the e-bike supplier 50Cycles, in cooperation with LoyalCoin, introduced electric bikes called Toba, which generate LoyalCoins cryptocurrency during a ride. Users can track how many LoyalCoins they have collected using an app. For 1,000 miles users receive LoyalCoins worth GBP 20. The app also contains a private key that serves as proof of ownership. Users can trade the collected cryptocurrency and use it to pay for various 50Cycles products.

- Category: 6 - Security, data protection and blockchain
- Area of application: Visitor management, visitor guidance (+digital payment) (payments are made on decentralised platforms as an alternative and secure payment method; improved data security / secure payment transactions; earning a so-called cryptocurrency promotes sustainability)
- Phase of the customer journey: During the trip
- Primary segments: Transport / B2C application
- Positive impact potentials: Conserving resources by reducing public transport; reducing air pollution in conurbations; influencing consumption towards sustainability; raising awareness among tourists of sustainable transport
- Negative impact potentials: Environmental awareness is not based on conviction but rather on financial incentive
- State of development: First applications (B)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 89/BC-5
- Source: https://www.50cycles.com via www.trendexplorer.com of TrendOne GmbH

B.6.3 Cyber security – campaign monitors webcams

The French internet security company Uppersafe has launched a campaign to secretly monitor 20 webcams for a week, the images of which could be seen on publicly accessible websites. During this time, all the habits of unsuspecting users were recorded and their IP addresses were identified to find out where they lived. Each person under surveillance was sent a parcel containing, for example, a glass to replace a recently broken one. The parcel also contained a phone number which the recipients could call to find out who was behind the campaign.

- Category: 6 - Security, data protection and blockchain
- Area of application: Visitor management, visitor guidance (+digital payment) (increasing customer control over their data/behaviour)
- Phase of the customer journey: During and after the trip

- Primary segments: All segments / B2B, B2C application
- Positive impact potentials: Possibility of sustainable control of resource consumption (sustainable production, etc.)
- Negative impact potentials: Monitoring uses energy; invasion of privacy
- State of development: First applications (B)
- Development perspective: Low potential (A)
- Sequential number and code: 90/BC- 12
- Source: https://web.uppersafe.com via www.trendexplorer.com of TrendOne GmbH

B.6.4 Biometric admission system in the subway

The American company Cubic Transportation Systems is working on a biometric ticket system that uses object tracking, face recognition and a hand-held vein scanner to identify subway passengers. The system's aim is to reduce waiting times at the entrance to the subway during rush hour. To use the system, subway passengers have their hand veins or face scanned once and link it to their payment account. According to Cubic, the system will initially be tested in an underground station in England.

- Category: 6 - Security, data protection and blockchain
- Area of application: Visitor management, visitor guidance (+digital payment) (increasing customer control over their data/behaviour; easier management of visitor flow (e. g. in certain areas))
- Phase of the customer journey: During the trip
- Primary segments: Transport / B2B application
- Positive impact potentials: No printed tickets means reduced waiting times and resource consumption
- Negative impact potentials: Checks consume energy
- State of development: First attempts (A)
- Development perspective: Average potential (B)
- Sequential number and code: 91/BC- 13
- Source: https://www.cubic.com via www.trendexplorer.com of TrendOne GmbH

B.6.5 Ticketing with inaudible audio signals

Ticketmaster is working with LISNR, the provider of data-via-audio solutions, to introduce the "Presence" ticket system. The ticketing technology is based on the transmission of "Smart Tones" via smartphones. The tones range from 18.7 to 19.5 kilohertz and are barely audible to humans. They transfer data between compatible devices and are intended to be used to authenticate ticket holders. The system is designed to give visitors quick admission to an event and event organisers can use it to identify participants and help them prevent fraud.

- Category: 6 - Security, data protection and blockchain
- Area of application: Visitor management, visitor guidance (+digital payment) (increasing customer control over their data/behaviour; easier management of visitor flow (e. g. in certain areas))
- Phase of the customer journey: During the trip
- Primary segments: Destination / B2B application
- Positive impact potentials: Shorter waiting times at point of entry as well as lower resource consumption (no need for printed tickets)
- Negative impact potentials: All devices consume energy; signals disrupt other organisms that are able to hear these sounds
- State of development: First attempts (A)
- Development perspective: Average potential (B)

- Sequential number and code: 92/BC- 14
- Source: http://lisnr.com via www.trendexplorer.com of TrendOne GmbH

B.6.6 IATA's Travacoin

The International Air Transport Association (IATA) is currently testing a new blockchain-based cryptocurrency to compensate passengers for flight delays. The new cryptocurrency Travacoin was presented at the SITA IT Summit in Brussels in 2017. The Travacoin start-up developed the currency specifically for airlines and travel agencies as a payment system that compensates passengers for long delays, cancellations and if they were denied boarding. In the event of delays or cancellations, passengers are automatically compensated in Travacoins. In addition, passengers can use Travacoins to purchase tickets from another airline and other services such as hotel accommodation. This should also increase customer satisfaction.

- Category: 6 - Security, data protection and blockchain
- Area of application: Digital payment (payments are made on decentralised platforms as an alternative and secure payment method; improved data security / secure payment transactions; cryptocurrency as compensation)
- Phase of the customer journey: Before and during the trip
- Primary segments: Transport/Travel agents/B2B, B2C application
- Positive impact potentials:
- Negative impact potentials: Improved air traffic processes (promotion)
- State of development: First applications (B)
- Development perspective: Average potential (B)
- Sequential number and code: 93/BC-2
- Source: https://coinidol.com/travacoin-used-as-compensation-for-flight-delays/
- http://www.travacoin.com/

B.6.7 Axa Travel Insurance

In 2017, Axa was the first major insurer to launch an insurance product based on the Ethereum cryptocurrency. With Fizzy passengers can insure themselves against delays; it is a parametric insurance, which means the product settles automatically. The parametric insurance Fizzy does not pay out in the event of a loss, but rather when a parameter or a certain figure exceeds a limit value governed by the policy, in this case if the flight is delayed by more than two hours. It was as recently as March that Axa announced the set up of a Global Parametrics department.

According to the company, the purchase of a delay policy is stored in the Ethereum blockchain, and the smart contract network also has a direct link to a worldwide air traffic database. Fizzy identifies the loss without a loss report or any human intervention; customers will have the money in their account within seven days, and the algorithm even handles rating: Insurance from the blockchain machine.

- Category: 6 - Security, data protection and blockchain
- Area of application: Digital payment (payments are made on decentralised platforms as an alternative and secure payment method; improved data security / secure payment transactions)
- Phase of the customer journey: During the trip
- Primary segments: Transport (expansion to include all tourism stakeholders conceivable) / B2C application
- Positive impact potentials:

- Negative impact potentials:
- State of development: First applications (B)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 94/BC-4
- Source: https://be.invalue.de/d/publikationen/vwheute/2017/09/14/axa-gewinnt-blockchain-rennen.html

B.6.8 Certifying documents by blockchain

Stampery is a start-up company from Madrid that uses the blockchain of the virtual currency Bitcoin to certify any document. To do this, users simply email the document via their Stampery account, integrate the service into their product via a programming interface or link it to their Dropbox account. This way, users can certify the existence, their ownership of and the completeness of contracts, wills or intellectual property. Once a document has been protected, anyone can check it for completeness and authenticity free of charge.

- Category: 6 - Security, data protection and blockchain
- Area of application: Digital identification and data protection (increasing customer control over their data transparency)
- Phase of the customer journey: In general for all phases
- Primary segments: All segments / B2B application
- Positive impact potentials: Conservation of resources (paper); increased efficiency
- Negative impact potentials: Using the service consumes energy
- State of development: First applications (B)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 95/BC-10
- Soure: https://stampery.com via www.trendexplorer.com of TrendOne GmbH

B.6.9 City offers electronic ID based on blockchain technology

The Swiss city of Zug will be the first municipality in the world to offer its residents a digital identity based on blockchain technology. Residents use an app to register and transmit personal information. Then all they have to do is visit the residents' registration office in person. There, the digital identity created in the app is authenticated before it is secured using blockchain technology and linked to a crypto address.

- Category: 6 - Security, data protection and blockchain
- Area of application: Digital identification and data protection (improved data security)
- Phase of the customer journey: Before and during the trip
- Primary segments: All segments / B2C application
- Positive impact potentials: Conservation of resources (paper); increased efficiency
- Negative impact potentials: Using the service consumes energy
- State of development: First applications (B)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 96/BC-11
- Source: http://www.stadtzug.ch via www.trendexplorer.com of TrendOne GmbH

B.6.10 IT security solutions for interconnected vehicles

The start-up Argus Cyber Security provides IT security solutions for infotainment and telematics systems, vehicle networks, individual electronic control units and after-market devices to pro-

tect networked vehicles from cyber attacks. DPI algorithms (which are registered for patent approval) identify attacks. In addition, Argus solutions are seamlessly updated with secure Argus cloud servers to quickly respond to new threats. An architectural change is not necessary; the security solutions can be easily integrated into existing systems.

- Category: 6 - Security, data protection and blockchain
- Area of application: Digital identification and data protection (improved data security)
- Phase of the customer journey: In general for all phases
- Primary segments: Transport / B2B application
- Positive impact potentials: Safety for vehicles with artificial intelligence (resource conservation, eco-friendliness)
- Negative impact potentials: Energy consumption
- State of development: First attempts (A)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 97/BC- 15
- Source: https://argus-sec.com via www.trendexplorer.com of TrendOne GmbH

B.6.11 Virtual concealment of IP addresses against cyber attacks

Researchers from the US Army Research Laboratory, the New Zealand University of Canterbury and the Gwangju Institute of Science and Technology have developed the Flexible Random Virtual IP Multiplexing defence system that protects computer systems from cyber attacks. The international research team has combined the specially developed Moving Target Defense technology with software-defined networking. This allows computers to keep their IP addresses while disguising themselves with a virtual IP address that changes frequently. This is designed to make it more difficult for hackers to identify a target.

- Category: 6 - Security, data protection and blockchain
- Area of application: Digital identification and data protection (improved data security)
- Phase of the customer journey: In general for all phases
- Primary segments: All segments / B2C application
- Positive impact potentials:
- Negative impact potentials:
- State of development: First attempts (A)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 98/BC-16
- Source: www.trendexplorer.com of TrendOne GmbH

B.6.12 Identifying customer identity by voice

The software developer Nuance has equipped the customer service department of the Czech Česká spořitelna bank with a security feature that verifies the identity of customers by their voice. It works in the background and replaces passwords and security questions. First, the biometric voiceprint of the person is taken, which is later compared with the voice on the phone. People's unique characteristics can be recognised by the smallest unit of sound, the phoneme. The input is converted by time-frequency transformation into a frequency spectrum whose data volume is sufficient for verification.

- Category: 6 - Security, data protection and blockchain
- Area of application: Digital identification and data protection (user voice analysis for better data security)

- Phase of the customer journey: During the trip
- Primary segments: Accommodation (room door?) / B2B, B2C application
- Positive impact potentials:
- Negative impact potentials: Service / Voice analysis consumes energy
- State of development: First attempts (A)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 99/BC- 17
- Source: https://www.nuance.com via www.trendexplorer.com of TrendOne GmbH

B.6.13 Suitcase tracking

More than 20 million suitcases and bags are lost each year in global air traffic, which costs the airlines around USD 2.4 billion. Safer and more transparent delivery processes that increase efficiency and thus reduce costs are still urgently required. New blockchain technology will make it possible for all involved parties – passengers, airlines, airports and ground traders – to track every suitcase in real time. This allows passengers to make sure that their luggage is on the right plane even on longer transit flights. The technology will be launched in 2018; it will then be possible to track the location of a suitcase like a parcel.

- Category: 6 - Security, data protection and blockchain
- Area of application: Logistics (greater transparency by tracking goods along their delivery route in real time; automated processes)
- Phase of the customer journey: During the trip
- Primary segments: Transport / B2B, B2C application
- Positive impact potentials: Tracking means fewer errors and therefore less resource consumption
- Negative impact potentials: Energy consumption and customers getting used to the service
- State of development: First attempts (A)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 100/BC-3
- Source: https://www.materna.de/SharedDocs/Downloads/EN/Referenzen/Frankfurt-Airport-Blockchain-based-baggage-tracking.pdf?__blob=publicationFile
- https://www.huffingtonpost.de/entry/zukunft-des-flughafens-koffer-tracking-mit-blockchain_de_5b531d9ce4b0eb29100e58db

B.6.14 Blockchain-based logbook for private flights

The start-up company Aerotrips from Cyprus has developed the Aeron Pilot app, which uses blockchain technology to digitally store logbook data and thus contribute to the prevention of aircraft accidents. The app is designed to replace the traditional logbook, and it records and confirms the qualification of each pilot. A decentralised database and an online system provide data from aircraft and flight schools as well as information about pilots from all over the world. Since it is almost impossible to recover a lost or damaged logbook, the digital solution is designed to provide more security for passengers and pilots.

- Category: 6 - Security, data protection and blockchain
- Area of application: Logistics (greater transparency by observing aircraft along their route in real time; automation of processes)
- Phase of the customer journey: During the trip
- Primary segments: Transport / B2B application

- Positive impact potentials: Prevention of serious accidents which may also harm the environment
- Negative impact potentials: Tool/App consumes energy
- State of development: First attempts (A)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 101/BC- 18
- Source: https://aeron.aero via www.trendexplorer.com of TrendOne GmbH

B.6.15 Hotel booking platform that does not charge commission

The hotel booking platform GOeureka uses the Ethereum blockchain technology to allow users to book a hotel room without charging commission; it also awards loyalty rewards and discounts without hidden costs. The use of smart contracts allows the development of autonomous agents that can be implemented across the entire GOeureka platform to automate many processes and eliminate the need for intermediaries. The latter generally lead to slower processing, higher transaction fees and thus higher prices.

- Category: 6 - Security, data protection and blockchain
- Area of application: Marketing, sales and travel planning (intelligent contracts; increasing customer control over their data; no need for agents / third parties creates better links between guests and providers)
- Phase of the customer journey: Before the trip (influencing the travel decision)
- Primary segments: Accommodation / B2B, B2C application
- Positive impact potentials: Sustainable travel options (accommodation)
- Negative impact potentials: Greater total volume of tourists as a result of lower prices
- State of development: First attempts (A+B)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 102/BC-7
- Source: https://goeureka.io via www.trendexplorer.com of TrendOne GmbH

B.6.16 Self-sufficient and sustainable living in a high-tech suburb

In a suburb of Amsterdam a car-free eco-settlement is being built that combines almost entirely self-sufficient living with modern technologies. In the 50-hectare ReGen Village, vertical farms, orchards and fields will secure the food supply, with natural leftover recycling benefiting the regional animals and aquacultures. The energy will be obtained from renewable sources, stored and managed by a network system that uses artificial intelligence. There is also a blockchain-based time bank that rewards residents who are active in the community.

- Category: 6 - Security, data protection and blockchain
- Area of application: Marketing, sales and travel planning (+ digital payment) (capacity planning and saving of resources through division of labour)
- Phase of the customer journey: In general for all phases
- Primary segments: Destination / B2B application
- Positive impact potentials: Possibility to create sustainable experiences (travel offers)
- Negative impact potentials:
- State of development: First applications (B)
- Development perspective: Average potential (B)
- Sequential number and code: 103/BC-6
- Source: http://www.regenvillages.com via www.trendexplorer.com of TrendOne GmbH

B.6.17 Frequent flyer programme with blockchain wallet

Singapore Airlines offers KrisPay, a digital wallet based on blockchain technology that allows KrisFlyer customers to convert their miles into digital currency. To do this they have to install the KrisPay app, log in with their customer number and use a tap to convert the KrisFlyer miles into KrisPay miles. When they have earned 15 miles, the equivalent of USD 0.10, they can use them to pay for purchases from the airline's partner companies. According to Singapore Airlines, KrisPay is integrated into customers' everyday lives.

- Category: 6 - Security, data protection and blockchain
- Area of application: Marketing, sales and travel planning (+digital payment) (payments are made on decentralised platforms as an alternative and secure payment method; improved data security / secure payment transactions)
- Phase of the customer journey: Especially during the trip
- Primary segments: Transport / B2C application
- Positive impact potentials:
- Negative impact potentials: Encourages the purchase of many flights = increased consumption of resources, environmental pollution
- State of development: First applications (B)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 104/BC-9
- Source: https://www.singaporeair.com via www.trendexplorer.com of TrendOne GmbH

B.7 Digital accessibility and open data

B.7.1 Fast internet in EU airspace

In cooperation with Deutsche Telekom, Inmarsat, a provider of satellite technologies, will set up a satellite system that makes high-speed internet access on planes the standard. By the end of the year, a system will be developed that delivers constant and fast internet access on planes throughout the airspace of the EU, Switzerland and Norway. The system combines satellite connections with 300 LTE ground stations. The first customers will be Deutsche Lufthansa and the International Airlines Group.

- Category: 7 – Digital accessibility and open data
- Area of application: Product management (development of completely new or modified products/services, greater attractiveness of certain attractions and thus customer satisfaction)
- Phase of the customer journey: During the trip
- Primary segments: Transport / B2B application
- Positive impact potentials: Communication of sustainable offers in the destination region
- Negative impact potentials: Using the internet consumes energy; greater total volume of passengers on short-haul routes such as business travellers who need an internet connection to work while travelling (may switch from rail to air)
- State of development: First applications (B)
- Development perspective: High potential (C)
- Sequential number and code: 105/DA-2
- Source: https://www.inmarsat.com via www.trendexplorer.com of TrendOne GmbH

B.7.2 Offsetting your carbon footprint with Google Maps

Google has developed the Environmental Insights Explorer tool that allows towns to work out their carbon footprint$_2$. The tool uses data from Google Maps in combination with other data to estimate how much energy a building consumes and its approximate emissions release. This is based on a building's size and what it is used for. Towns can also find out how much CO_2 is emitted by the town traffic. The tool is intended to help towns reduce their carbon footprint in keeping with the Paris Climate Agreement.

- Category: 7 – Digital accessibility and open data
- Area of application: Smart destination management ()
- Phase of the customer journey: In general for all phases
- Primary segments: All segments / B2B, B2C application
- Positive impact potentials: Reducing energy consumption by raising awareness among users; influencing consumption in the direction of sustainability
- Negative impact potentials: Tool consumes energy
- State of development: First attempts (A+B)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 106/DA-1
- Source: https://insights.sustainability.google via www.trendexplorer.com of TrendOne GmbH

B.7.3 Map shows environmental performance of brand suppliers

The American Natural Resources Defense Council and the Chinese Institute of Public and Environmental Affairs have created a map showing the environmental footprint of Chinese manufacturers working for global companies. The map visualises the supply chain of the participating brands and thus makes it transparent. The Chinese suppliers are listed together with freely available environmental data on air emissions and waste water disposal. This allows suppliers to prove their compliance with environmental regulations and win new customers.

- Category: 7 – Digital accessibility and open data
- Area of application: Company-internal process optimisation (identifying errors / opportunities for improvement; improved capacity and resource planning to increase efficiency and save costs)
- Phase of the customer journey: In general for all phases
- Primary segments: All segments / B2B application
- Positive impact potentials: Change in production patterns and reducing resource consumption; eco-friendliness means customer satisfaction which in turn generates higher turnover
- Negative impact potentials:
- State of development: First applications (B)
- Development perspective: Transformative (C+D)
- Sequential number and code: 107/DA-3
- Source: https://www.nrdc.org via www.trendexplorer.com of TrendOne GmbH

B.8 Cloud computing

B.8.1 SCTH adopts private cloud to streamline IT service delivery

The Saudi Commission for Tourism and National Heritage (SCTH) employs over 1,300 people in 33 locations and is responsible for the country's tourism development. The commission is forward-looking, has a strong demand for IT and is looking to develop its online presence. So far, it has been operating 200 servers and a further 30 have been applied for. The commission now wants to move to HPE Cloud Service Automation (CSA), a cloud system that manages all IT and administrative processes. Automation can reduce the time required for these processes by approx. 88%.

- Category: 8 – Cloud computing
- Area of application: Data management (more efficient work processes, secure back-ups and no geographical limitations (via possible remote access to services and information) means efficient IT systems; expansion of capacities as required)
- Phase of the customer journey: In general for all phases
- Primary segments: Destination / B2B application
- Positive impact potentials: Reduction of resource consumption by storing data in the cloud; increased efficiency
- Negative impact potentials: Energy consumption
- State of development: Mostly still being developed (A)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 108/CC-5
- Source: https://www.esensesoftware.com/docs/default-source/case-studies-pdf/esense-scth-hpe.pdf?sfvrsn=c642e9a0_0

B.8.2 Smart destination platforms

Many of the initiatives that contribute to better, evidence-based decision making at destinations, such as the destination management platforms of Buenos Aires or Portugal, are now all based on a cloud model, which enables the complexity and agility of the platforms in the first place. The two destinations Buenos Aires and Portugal opted for Microsoft's Business Intelligence (BI) solution and based their data systems on it.

- Category: 8 – Cloud computing
- Area of application: Data management (more efficient work processes, secure back-ups and no geographical limitations (via possible remote access to services and information) means efficient IT systems; expansion of capacities as required)
- Phase of the customer journey: In general for all phases
- Primary segments: Destination / B2B application
- Positive impact potentials: Increased efficiency; reduction of resource consumption
- Negative impact potentials:
- State of development: Adoption in tourism (C)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 109/CC-6
- Source: http://www.thinktur.org/media/Libro-Blanco-Destinos-Tursticos-Inteligentes-construyendo-el-futuro.pdf https://powerbi.microsoft.com/en-us/landing/signin/

B.8.3 Travelport mobile agent

With more flexible technology, cloud computing enables all stakeholders in the travel industry to simplify and improve their business processes. Travel agencies or accommodation establishments, for example, can gain easy access to relevant data, which increases efficiency and productivity and lowers costs. One company that offers cloud solutions specifically for the tourism sector is Travel Technology & Solutions. A cloud solution developed by the company is called Travelport Mobile Solution; it allows travel agencies to access their reservations, change bookings and issue tickets from anywhere in the world provided they have access to the internet.

- Category: 8 – Cloud computing
- Area of application: Marketing, sales and travel planning (more efficient work processes, secure back-ups and no geographical limitations (via possible remote access to services and information) means efficient IT systems; expansion of capacities as required)
- Phase of the customer journey: In general for all phases
- Primary segments: Travel agents/Accommodation/B2B application
- Positive impact potentials: Increased efficiency; reduction of resource consumption
- Negative impact potentials:
- State of development: High prevalence (D)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 110/CC-1
- Source: http://www.tts.com/blog/cloud-computing-becomes-crucial-for-travel-agencies/

B.8.4 TravelAp

TravelAps is a cloud system solution by ERS (Electronic Reservation Systems), which enables travel agencies or hotels to open an online travel portal within seconds. Founded in 2013, the company's TravelAps cloud solution helps travel companies that provide a variety of travel services to dynamically integrate their services with other external services and sell them as a dynamic package. Because the service is cloud-based and many services such as payment gateways are already integrated and provided by the company in advance, travel companies benefit from more efficient and easier processes.

- Category: 8 – Cloud computing
- Area of application: Marketing, sales and travel planning (more efficient work processes, secure back-ups and no geographical limitations (via possible remote access to services and information) means efficient IT systems; expansion of capacities as required)
- Phase of the customer journey: Before the trip
- Primary segments: Travel agents/Accommodation/B2B application
- Positive impact potentials: Increased efficiency; reduction of resource consumption
- Negative impact potentials:
- State of development: Adoption in tourism (C)
- Development perspective: High customer benefit and potential for C
- Sequential number and code: 111/CC-3
- Source: https://www.insightssuccess.com/travelaps-employing-cloud-solutions-for-better-travel-and-tourism-industry/

B.8.5 Cloud computing becomes crucial for travel agencies

As travel planning and preparation continues to move online, tourism service providers must adapt to new circumstances and upgrade and adapt their technology. Cloud computing is a

helpful tool here, which the stakeholders in the tourism sector can use in a variety of ways. An advantage that Lufthansa makes use of is that the cloud is online at all times of the day, anywhere in the world, so that a booking can be made at any time. What is more, providers that offer very seasonal services can adjust their online capacity as needed. The data on the cloud platforms is usually also better protected than on the company's own servers.

- Category: 8 – Cloud computing
- Area of application: Marketing, sales and travel planning (more efficient work processes, secure back-ups and no geographical limitations (via possible remote access to services and information) means efficient IT systems; expansion of capacities as required)
- Phase of the customer journey: Before and during the trip
- Primary segments: Transport/Travel agents/B2B application
- Positive impact potentials: Reduction of resource consumption by storing data in the cloud; increased efficiency
- Negative impact potentials:
- State of development: Adoption in tourism (C)
- Development perspective: High customer benefit and potential for C and possibly D
- Sequential number and code: 112/CC-4
- Source: http://www.tts.com/blog/cloud-computing-becomes-crucial-for-travel-agencies/

B.8.6 Public power socket monitors use

On behalf of the automobile manufacturer Toyota, the creative agency Dentsu has developed the intelligent Smile Lock socket, which monitors power consumption and makes it easier for owners of compact electric cars to access energy. The Smile Lock is installed at existing sockets in cities and communicates with a smartphone app. The information about usage periods and the customer is transmitted to a cloud service. Users are then invoiced for the amount of energy they use. The Smile Lock allows owners of public power sources to monetise them.

- Category: 8 – Cloud computing
- Area of application: Off-topic (more efficient work processes, secure back-ups and no geographical limitations (via possible remote access to services and information) means efficient IT systems; expansion of capacities as required)
- Phase of the customer journey: In general for all phases
- Primary segments: All segments / B2B, B2C application
- Positive impact potentials: Reducing energy consumption by raising awareness about consumption
- Negative impact potentials:
- State of development: First applications (B)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 113/CC-2

B.9 Digital platforms, sharing economy and social networks

B.9.1 Airbnb opens Office of Healthy Tourism

Airbnb has set up the Office of Healthy Tourism to counter the high volume of tourists in major cities around the world and help travellers find new destinations. The initiative aims to harness the economic benefits of tourism for locals and small businesses off the beaten track and at the same time take pressure off popular tourist hotspots. The office builds on the work of previous

programmes, which for example promoted 40 villages in Italy, and will continue to focus on rural regeneration.

- Category: 9 – Digital platforms, sharing economy and social networks
- Area of application: Visitor management, visitor guidance (changing consumption and production patterns through expansion of offers)
- Phase of the customer journey: Before and during the trip
- Primary segments: Destination/Accommodation/B2B, B2C application
- Positive impact potentials: Change in consumption patterns towards sustainability; improved visitor guidance in conurbations; strengthening of the regional economy
- Negative impact potentials: Touristification of unknown places (on the one hand this is a goal, but it can soon lead to too much tourism in small city districts and towns, etc.)
- State of development: Adoption in tourism (C)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 114/DP-7
- Source: https://press.atairbnb.com via www.trendexplorer.com of TrendOne GmbH

B.9.2 Exploring the origin of fruit

Australian jam manufacturer Goulburn Valley Fruit has added GPS data to its labelling system, allowing users to explore the origin of the jam on an online platform. The labels designed by the advertising agency Leo Burnett show the exact GPS coordinates of where the fruit was picked. Customers can enter the coordinates online to see where the fruit from their jam comes from. They can also explore the entire plantation and its surroundings with 360-degree videos. The tours can even be downloaded and used to plan a trip.

- Category: 9 – Digital platforms, sharing economy and social networks
- Area of application: Marketing, sales and travel planning (multi-channel strategies improve market coverage and thus increase sales volume; 24/7 availability and interaction with the digital traveller/customer; more information generates more customer satisfaction)
- Phase of the customer journey: Before and during the trip
- Primary segments: Travel agents / B2C application
- Positive impact potentials: Support for local agriculture, which in turn can lead to fair treatment of the environment
- Negative impact potentials: Touristification of small towns/farms
- State of development: First applications (B)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 115/DP-11
- Source: https://www.leoburnett.com.au via www.trendexplorer.com of TrendOne GmbH

B.9.3 Advertising marketplace for services

The Pinnwand.io marketplace of the Berlin start-up Vida Ventures can be used to make inquiries; for example, users can search for a nutritionist, personal coach or wedding photographer. The start-up forwards the request to suitable service providers in its portfolio, who have 24 hours to make the user an offer. If they are happy with the offer, a transaction will be concluded. Pinnwand.io is particularly popular when it comes to sports lessons. Their service is similar to that of American service providers such as TaskRabbit, which are not yet globally active.

- Category: 9 – Digital platforms, sharing economy and social networks

- Area of application: Marketing, sales and travel planning (multi-channel strategies improve market coverage and thus increase sales volume; 24/7 availability and interaction with the digital traveller/customer; more information generates more customer satisfaction)
- Phase of the customer journey: Before the trip (influencing the travel decision)
- Primary segments: All segments / B2B, B2C, C2C application
- Positive impact potentials: Promotion/Offer of sustainable alternatives
- Negative impact potentials:
- State of development: Adoption in tourism (C)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 116/DP-12
- Source: http://pinnwand.io via www.trendexplorer.com of TrendOne GmbH

B.9.4 TripAdvisor

TripAdvisor was founded in 2000 when its founders identified a gap in the market for easily accessible, unbiased travel information. Today it is one of the best known platform companies in the world, with a mission to help people plan and book the perfect trip. TripAdvisor achieves its goal by providing users with a platform that aggregates user-generated ratings and opinions about accommodation, destinations, activities and restaurants worldwide and connects users with accommodation establishments and travel service providers to book every aspect of their trip. TripAdvisor is a classic example of an indirect network effect business. The network typically involves three stakeholders: the user, TripAdvisor – the platform/interface, as well as the advertiser (e. g. OTAs, hotels and other service providers). As more users use TripAdvisor and add online reviews, more businesses advertise their services, which in turn attracts more users. With over 200 million reviews, TripAdvisor has successfully expanded its business to include indirect network effects and continues to integrate its services to become the first end-to-end travel platform – which is also the goal of its competitors such as Google Trips.

- Category: 9 – Digital platforms, sharing economy and social networks
- Area of application: Marketing, sales and travel planning (+reputation management) (performance monitoring and customer ratings; ever greater quantity and quality of online customer ratings (reviews); easier to make a decision through user-generated content (UGC); live support with problems and questions/requests)
- Phase of the customer journey: In general for all phases
- Primary segments: Destination/Accommodation/Transport/B2B, B2C application
- Positive impact potentials: Promotion/Communication of sustainable offers; influencing customer consumption towards sustainability
- Negative impact potentials: Touristification of small, unknown places / residential districts
- State of development: High prevalence (D)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 117/DP-1
- Source: https://www.tripadvisor.com/
- https://digit.hbs.org/submission/tripadvisor-book-the-perfect-trip/
- https://www.innovationtactics.com/tripadvisor-business-model-canvas/

B.9.5 Booking.com

Booking.com was founded in Amsterdam in 1996 and has developed from a small Dutch start-up into one of the largest travel e-commerce companies in the world. The company is part of the Priceline Group. The booking platform connects travellers with the world's largest range of

accommodation, including apartments, holiday homes, family-run bed & breakfasts, 5-star luxury resorts, tree houses and even igloos. Booking.com's website and mobile apps are available in over 40 languages, offering a total of 28,943,869 entries which cover 141,132 destinations in 230 countries and territories worldwide. As a customer-driven company, Booking.com employs more than 2,000 technology experts who work on product development and use artificial intelligence and machine learning to extract data to develop sophisticated services for travellers. With its Booking Booster Programme in 2017, the company was the first of its kind to specifically support start-up companies that focus on promoting sustainable tourism development.

- Category: 9 – Digital platforms, sharing economy and social networks
- Area of application: Marketing, sales and travel planning (+reputation management) (multi-channel strategies improve market coverage and thus increase sales volume; 24/7 availability and interaction with the digital traveller/customer; more information generates more customer satisfaction)
- Phase of the customer journey: Before the trip (influencing the travel decision)
- Primary segments: Accommodation / B2B, B2C application
- Positive impact potentials: Promotion/Communication of sustainable offers; influencing customer consumption towards sustainability
- Negative impact potentials: Greater total volume of tourists
- State of development: High prevalence (D)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 118/DP-2
- Source: www.booking.com
- https://www.independent.co.uk/news/business/analysis-and-features/a-view-from-the-top-gillian-tans-ceo-booking-com-travel-priceline-group-a7802661.html

B.9.6 Facebook

Facebook is the most popular social network with 1.55 billion monthly users and more than 450 million daily users. Given its large and very active global community of users who share opinions, recommendations and comments across the platform, Facebook has become an important tool for the travel industry – especially for decision-making, creating marketing campaigns and communicating with customers. Facebook has grown in relevance over the years as an advertising and retargeting platform for travel brands and has become much more than just a social network. It is constantly expanding its reach with Instagram, Facebook Messenger, WhatsApp, Oculus and other integrated widgets and apps such as shopping, review and mapping features. Messaging features and chatbots, for example, are valuable tools for being in touch with consumers before the booking, during the trip, at the destination and for marketing purposes after the trip.

- Category: 9 – Digital platforms, sharing economy and social networks
- Area of application: Marketing, sales and travel planning (+reputation management) (performance monitoring (e. g. of events) and customer ratings; ever greater quantity and quality of online customer ratings (reviews); easier to make a decision through user-generated content (UGC); live support with problems)
- Phase of the customer journey: In general for all phases
- Primary segments: Destination/Transport/Accommodation/Travel agents/B2B, B2C application
- Positive impact potentials: Strengthening of sustainable, local services by bringing them in line with the sustainability mindset of the users; influencing users in the direction of sustainability through targeted marketing (reciprocal control); increased efficiency
- Negative impact potentials:

- State of development: High prevalence (D)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 119/DP-14
- Source: https://skift.com/2017/02/28/new-skift-research-report-a-deep-dive-into-facebooks-impact-on-travel/

B.9.7 Instagram

Instagram is a social networking photo and video sharing service owned by Facebook. Since its launch in October 2010, Instagram has made great strides in the world of social media and now has over 1 billion users worldwide. The platform enables users to upload content and share photos and videos about their lives with the world in real time. Due to its enormous visual power, Instagram has become one of the most popular tools for tourism companies and destinations. The result: with more than 150 million photos with hashtag #travel and millions of photos tagged with different destinations (#Berlin, #Roma, #Gijón), tourism has become one of the most important contents on this social network.

- Category: 9 – Digital platforms, sharing economy and social networks
- Area of application: Marketing, sales and travel planning (+reputation management) (performance monitoring (e. g. of events) and customer ratings; ever greater quantity and quality of online customer ratings (reviews); easier to make a decision through user-generated content (UGC); live support with problems)
- Phase of the customer journey: In general for all phases
- Primary segments: Destination/Transport/Accommodation/Travel agents/B2B, B2C application
- Positive impact potentials: Strengthening of sustainable, local services; influencing users in the direction of sustainability through targeted marketing and conveying emotions; increased efficiency
- Negative impact potentials: Touristification of unknown places (triggering emotions through images)
- State of development: High prevalence (D)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 120/DP-15
- Source: https://www.nationalgeographic.com/travel/travel-interests/arts-and-culture/how-instagram-is-changing-travel/
- https://dilsecreativo.com/instagram-y-turismo/

B.9.8 Twitter

Since Twitter (the online news and social networking service) was founded in 2006, it has developed into one of the most important communication channels in the world. While Twitter messages (tweets) used to be limited to 140 characters, this number was doubled in 2017. Registered users can post tweets or share, like and comment on other people's tweets. Twitter offers many opportunities to tourism companies for direct communication with customers, marketing, performance assessment and many other activities. The speed with which information moves through the network, Millennials abandoning Facebook in ever-increasing numbers, and the power of group conversations identified by hashtags make Twitter a special network with qualities that are also highly valued in tourism.

- Category: 9 – Digital platforms, sharing economy and social networks
- Area of application: Marketing, sales and travel planning (+reputation management) (performance monitoring and customer ratings; ever greater quantity and quality of

online customer ratings (reviews); easier to make a decision through user-generated content (UGC); live support with problems and questions/requests)
- Phase of the customer journey: In general for all phases
- Primary segments: Destination/Transport/Accommodation/Travel agents/B2C application
- Positive impact potentials: Communication of sustainable offers in order to influence customers' consumption (towards sustainability)
- Negative impact potentials:
- State of development: High prevalence (D)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 121/DP-16
- Source: https://about.twitter.com/en_us
- https://www.forbes.com/sites/christianwolan/2011/04/14/the-real-story-of-twitter/#15c0f41b66af

B.9.9 Eatwith

Eatwith (formerly: VizEat – founded in Paris in 2014) is the world's largest social eating platform, connecting travellers with local hosts through authentic culinary experiences. The platform is also called the Airbnb of dining. Visitors can use the platform to find dining with locals, cooking courses and food tours. What is more, hosts do not have to be professional chefs, guests do not have to be visitors but can also be locals who want to meet new people and/or learn new recipes. Over the years, the company has acquired several of its competitors and has partnered with leading food, travel and technology companies, including TripAdvisor, Ctrip and Huawei.

- Category: 9 – Digital platforms, sharing economy and social networks
- Area of application: Sharing models (sharing economy model: education and changing consumption and production patterns through expansion of offers)
- Phase of the customer journey: Before the trip (influencing the travel decision)
- Primary segments: Destination / B2B, B2C application
- Positive impact potentials: Promotion/Communication of sustainable offers; influencing customer consumption towards sustainability
- Negative impact potentials:
- State of development: Adoption in tourism (C)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 122/DP-3
- Source: https://www.eatwith.com/
- https://www.wysetc.org/2018/01/dining-platform-vizeat-rebrands-to-newly-acquired-eatwith/
- http://www.elmundo.es/f5/descubre/2017/01/04/586b97bc268e3e10208b45f1.html

B.9.10 Private car sharing at airports

With travellers as its target group, the American platform Flightcar competes with private car sharing services. Holidaymakers travelling by plane can rent out their car for the duration of their holiday using Flightcar. The business model takes account of the fact that parking fees at airports can quickly become more expensive than the holiday itself. Travellers can even earn a little extra by renting out their car via Flightcar. And passengers arriving at airports can enjoy lower rental prices compared to the established providers.

- Category: 9 – Digital platforms, sharing economy and social networks
- Area of application: Sharing models (sharing economy model: education and changing consumption and production patterns through expansion of offers)

- Phase of the customer journey: During the trip
- Primary segments: Transport / B2C application
- Positive impact potentials: Changing consumption patterns in the direction of sustainability; reducing resource consumption (less need for rental cars)
- Negative impact potentials: More private transport at the destinations because renting a car is inexpensive for tourists
- State of development: First applications (B)
- Development perspective: Average potential (B)
- Sequential number and code: 123/DP-4
- Source: http://flightcar.com via www.trendexplorer.com of TrendOne GmbH

B.9.11 Locals lend their property to tourists

The AsapNinja marketplace connects locals and tourists with the aim of allowing travellers to rent items for the duration of their stay. The start-up company in particular has bulky items such as prams or sports equipment in mind, which are expensive to transport. To rent out an item, you list it on AsapNinja together with your terms. Travellers can search for specific items and contact the lender. A positive side effect is that people from different countries, but with the same interests, come into contact with each other.

- Category: 9 – Digital platforms, sharing economy and social networks
- Area of application: Sharing models (sharing economy model: education and changing consumption and production patterns through expansion of offers)
- Phase of the customer journey: During the trip
- Primary segments: Destination / B2C application
- Positive impact potentials: Changing consumption patterns in the direction of sustainability; reducing resource consumption (e. g. fuel because tourists do not bring bulky items with them)
- Negative impact potentials:
- State of development: First applications (B)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 124/DP-6
- Source: http://www.asapninja.com via www.trendexplorer.com of TrendOne GmbH

B.9.12 Finding home-made food at destination

AirBites is looking to transfer the principle of Airbnb to food and connects travellers with people who cook for them in their home. Users can find information about hosts, location and the food they offer via a search form, contact their favourites and dine there for a fee. After the meal, guest and host can rate each other. The concept was developed by students of the Miami Ad School in Berlin; however, they are not looking to implement the idea themselves. Instead, they are offering their ideas to entrepreneurs for further development and implementation.

- Category: 9 – Digital platforms, sharing economy and social networks
- Area of application: Sharing models (sharing economy model: education and changing consumption and production patterns through expansion of offers)
- Phase of the customer journey: During the trip
- Primary segments: Destination / B2C application
- Positive impact potentials: Changing consumption patterns, reducing resource consumption (the locals will cook for themselves anyway, all they have to do is cook more); cultural exchange
- Negative impact potentials:
- State of development: First attempts (A+B)

- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 125/DP-8
- Source: https://www.facebook.com via www.trendexplorer.com of TrendOne GmbH

B.9.13 The harmonisation of private transport

Toyota together with Toyota City's city council and public transport companies has developed the Ha:mo transport system designed to promote the intelligent linking of private and public transport systems. The Harmonious Mobility Network consists of Ha:mo Navi, a personalised route guidance system that includes various means of transport such as bus, rail and car. Ha:mo Ride is also a car sharing system that allows users to book and hire electric cars at railway stations using their smartphones.

- Category: 9 – Digital platforms, sharing economy and social networks
- Area of application: Sharing models (sharing economy model: education and changing consumption and production patterns through expansion of offers)
- Phase of the customer journey: During the trip
- Primary segments: Transport / B2C application
- Positive impact potentials: Changing consumption patterns to make them more sustainable (car sharing, public transport) = reducing resource consumption; raising awareness; better visitor guidance in conurbations; avoiding waiting times and traffic jams
- Negative impact potentials: Energy consumption for transport instead of choosing more sustainable alternatives (cycle paths in the city)
- State of development: Adoption in tourism (C)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 126/DP-9
- Source: http://www.toyota.co.jp via www.trendexplorer.com of TrendOne GmbH

B.9.14 Social network for activities

BlindAd is the name of a new social network founded by Nicolas and Dominic Amann from Freiburg; the network allows strangers to meet up for leisure activities. It thus opposes the consequence of other social networks, namely of social contacts only taking place via the internet. The network is organised based on so-called "adventures" that users take part in, such as sports, going out or partying. The "adventures" are entered by the users together with their age and number of participants.

- Category: 9 – Digital platforms, sharing economy and social networks
- Area of application: Sharing models (sharing economy model: education and changing consumption and production patterns through expansion of offers)
- Phase of the customer journey: Before and during the trip
- Primary segments: Travel agents / B2C application
- Positive impact potentials: Promotion of sustainable leisure activities; raising awareness among users
- Negative impact potentials: Greater total volume of tourists, because they meet up for more activities
- State of development: Adoption in tourism (C)
- Development perspective: High customer benefit and potential for C and D
- Sequential number and code: 127/DP-10
- Source: http://www.blindad.de via www.trendexplorer.com of TrendOne GmbH

B.9.15 Airbnb

Airbnb was founded in 2008 and came about based on the personal experience of its founders, who had begun to let people sleep on their air mattresses in San Francisco. Today, Airbnb gives millions of people access to local accommodation in more than 191 countries, from apartments and villas to castles, tree houses and B&Bs, and it has become the world's most successful sharing platform. Over the years the service has expanded and today offers not only accommodation, but also activities such as excursions or meeting rooms. Due to the enormous growth of the company, which has changed the way people move around at destinations, Airbnb is seen as one of the main reasons for the phenomenon of overtourism that is currently affecting the tourism sector.

- Category: 9 – Digital platforms, sharing economy and social networks
- Area of application: Sharing models (sharing economy model: education and changing consumption and production patterns through expansion of offers)
- Phase of the customer journey: Before the trip (influencing the travel decision)
- Primary segments: Accommodation / B2B, B2C application
- Positive impact potentials: Promotion/Communication of sustainable offers; influencing customer consumption towards sustainability
- Negative impact potentials: Greater total volume of tourists; touristification of small districts / residential areas
- State of development: High prevalence (D)
- Development perspective: Absolutely transformative (D)
- Sequential number and code: 128/DP-13
- Source: https://press.airbnb.com/about-us/
- https://www.welt.de/wirtschaft/article121384897/Alles-begann-mit-Luftmatratze-und-Fruehstueck.html
- https://skift.com/2018/09/17/skift-global-forum-preview-airbnbs-greg-greeley-on-building-a-travel-superbrand/

B.9.16 Integration of content in trip journal

The app by esplor.io allows users to track routes in an energy-saving way and then share them. This results in a trip journal. But it is also possible to integrate existing content from other social networks (Facebook, Twitter, Foursquare, Tripcase, TripIt, Instagram).

- Category: 9 – Digital platforms, sharing economy and social networks
- Area of application: Sharing models (sharing economy model: education and changing consumption and production patterns through expansion of offers)
- Phase of the customer journey: After the trip
- Primary segments: Travel experiences / B2C application
- Positive impact potentials: Influencing users towards sustainability; offers of sustainable alternatives
- Negative impact potentials: Touristification of hitherto relatively unknown places; greater total volume of tourists (triggering of emotions through pictures and personal opinions = decision to travel)
- State of development: Adoption in tourism (C)
- Development perspective: Low potential (A)
- Sequential number and code: 129/DP-17
- Source: https://esplor.io via Köhn/UBA (expert meeting on 16 January 19)