e-shape

EuroGEOSS Showcases: Applications Powered by Europe

D5.16 – Second socio-economic value of EO in selected sectors report

The e-shape project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 820852

DOCUMENT TYPE	Deliverable
DOCUMENT NAME:	e-shape-WP5-D5.16-Second socio-economic value of EO in selected sectors report
VERSION:	V2.0
DATE:	04/05/22
STATUS:	Second Draft
DISSEMINATION LEVEL:	Public

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REVIEW APPROVAL:				
REMARKS / IMPROVEMENTS:				

VERSION HISTORY (PRELIMINARY)			
VERSION:	DATE:	COMMENTS, CHANGES, STATUS:	PERSON(S) / ORGANISATION SHORT NAME:
v1.0	14/03/22	First Draft	Daire Boyle (Evenflow), Ruuta Skujina (Evenflow), Lefteris Mamais (Evenflow)
v2.0	04/05/22	Second Draft – Clarifications and edits added after first review: • Clarifications on the use of SeBS cases as the basis of extrapolation • How and why sectors have been chosen for each report including table (section 2.5) • Links to SDGs and Sendai Framework	Daire Boyle (Evenflow)
vFINAL	17/05/2022	Ready for submission	PMT

VERSION NUMBERING	
v0.1	Draft before peer-review approval
v1.0	After the first review
v2.0	After the second review
Vfinal	Deliverable ready to be submitted

STATUS / DISSEMINATION LEVEL			
STATUS		DISSEMINATION LEVEL	
S0	Approved/Released/Ready to be submitted	**PU**	Public
S1	Reviewed	**CO**	Confidential, restricted under conditions set out in the Grant Agreement
S2	Pending for review		
S3	Draft for comments	**CI**	Classified, information as referred to in Commission Decision 2001/844/EC.
S4	Under preparation		

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1 INTRODUCTION

The services and products developed by the different e-shape pilots have the potential to deliver significant benefits to their engaged users but also to additional stakeholders in the associated value chains. Understanding and quantifying – where possible – these benefits can support both the development of solutions that are better fit-for-purpose, but also stimulate their wider uptake. This becomes more prevalent when considering the mission of e-shape with regards to upscaling the pilot outputs.

In view of this, e-shape will produce three reports on "**Socio-economic value of EO in selected sectors**". These shall function as a "marketing" support tool targeted at the different user communities and providing impetus to the policy making surrounding the uptake of Copernicus and the e-shape showcases.

Moreover, by extending the methodological framework developed within the Sentinel Benefits Study (SeBS), these reports provide a contribution to the body of knowledge of the European EO community when it comes to quantifying and presenting the benefits EO solutions enable. The SeBS cases are in-depth value chain analysis studies of well-established EO services which often have several paying customers. The use of concrete data points within these studies forms the basis of much of the extrapolation within this report. Specifics on our methodology are provided in the following chapter.

The expected output of this activity is three publications focussing on different sectors, delivered at M23, M32 and M40:

- The first publication focussed on the agricultural sector. The report combined inputs from previous work with a fresh look into the value chains served by the different pilots under the agriculture showcase, so that the potential benefits they yield were highlighted.
- The second publication (this report) will focus on public wellbeing, linking to pilots in various showcases within e-shape which provide services related to public health, safety, and quality of life.
- The final publication will focus on natural capital and the environment and will also draw from various showcases within e-shape to illustrate the plethora of associated benefits.

The work is being performed by Evenflow and EARSC.

2 METHODOLOGY

2.1 Understanding the impact of an EO-based service across a value chain

The use of EO-based services can significantly help actors in different domains and along the respective value chains to address the challenges that shape their own operational reality. To fully understand this value it is essential to identify the decisions and processes undertaken by the different actors in the value chain and pinpoint how the availability of EO data or derived services generates value. Thus, the starting point of our analysis is the identification of well-defined value chains and the evaluation of how EO benefits the involved companies, businesses, government stakeholders and, eventually, even society, the economy and the environment at large (i.e. increased efficiency, productivity, quality, etc.). A generic visualisation of a value chain is shown below.

The idea behind these reports within e-shape is to extrapolate the concrete data points and deeply understood socio-economic benefits of EO from the SeBS studies to build a picture of the value EO can bring to different sectors. In parallel to this, the aims of the relevant e-shape pilots are linked throughout the document to elucidate the value they will provide.

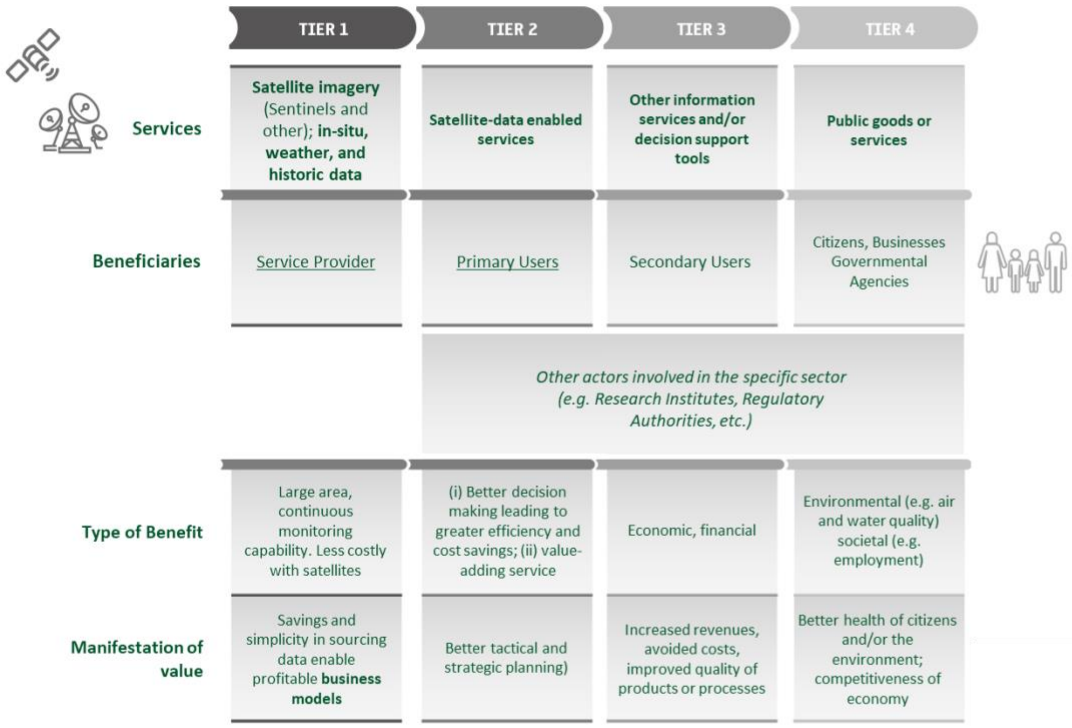

Figure 2-1: Visualisation of a "generic" value chain used to study the different cases

Studying each link of the value chain, we try to develop solid argumentation around the benefits the different actors experience thanks to the use of EO-based services, and where possible quantify these benefits.

Typically, each value chain consists of 4 "tiers". Short descriptions of what is generally dealt with in each tier are given below:

- **Tier 1**: **Service Provider** - In this tier the benefits experienced by the EO "service provider" are described. For example, a remote sensing company saving money by utilising free EO data as opposed to paying for EO data.
- **Tier 2: Primary User -** In this tier the benefits experienced by the primary user of the EO service are described. For example, a public body who use the EO service to help monitor farmers' compliance to CAP requirements in more efficient manner. **Note:** We are just using an example of a public body in this illustration. Tier 2 can also often describe private primary users.
- **Tier 3: Secondary Users -** In this tier the benefits experienced by the stakeholders downstream of the primary user are described. For example, farmers who get monitored and receive subsidy payments in a swifter and more transparent manner thanks to public body's efficient use of EO data.
- **Tier 4: Tertiary Users -** In this tier the benefits experienced by the stakeholders downstream of the tier 3 beneficiaries are described. Quite often tier 4 describes benefits experienced by citizens and society. For example, the benefits experienced by the general public who get to enjoy the rural landscapes maintained by the farmers in tier 3.

This **value-chain approach** has been developed by Geoff Sawyer and Marc de Vries (with 3 case studies analysed in 2015-2016), has been further honed through the SeBS study (reaching a current total of 19 cases with several more in the pipeline) and is strengthened through regular interactions with the GeoValue[1] community.

[1] See here https://geovalue.org/

This report builds on the outputs of these efforts and attempts, for the first time, a consistent “upscaling” of the application of the value-chain approach. In this regard, **we shall draw from the very well understood value chains within the SeBS case studies to illustrate how value can be experienced across sectors, ideally in direct reference to the services produced by the pilots.** The methodological framework developed in SeBS, and in particular the 6 dimensions of benefit (see 2.2 below) will form the basis for our analysis, which is extended through an extrapolation approach (see 2.3 below).

2.2 Documenting the value of a given EO-based service along 6 dimensions

For each application/pilot, the availability of EO-based data/products at the entry point of the value chain, enables actors in each different tier to access and act on different types of information, helping them to make informed decisions and proceed with targeted interventions. Whilst each case has its own characteristics, certain commonalities with regards to the types of experienced benefits have been observed. In practice, we can identify 6 dimensions of benefit: **(i)** economic, **(ii)** environmental, **(iii)** societal, **(iv)** regulatory, **(v)** innovation and entrepreneurship-related, and finally **(vi)** science and technology-related. The definitions for each of these dimensions are provided below.

Dimension	Definition
ECONOMIC	Impacts related to the production of goods or services, or impacts on monetary flow or volume, such as revenue, profit, capital and (indirectly, through turnover generation) employment.
ENVIRONMENTAL	Impacts related to the state and health of the environment, particularly as regards the ecosystem services on which human societies depend.
SOCIETAL	Impacts related to societal aspects such as increased trust in authorities, better public health or secured geostrategic position.
REGULATORY	Impacts linked to the development, enactment or enforcement of regulations, directives and other legal instruments by policymakers.
INNOVATION-ENTREPRENEURSHIP	Impacts linked to the development of new enterprise and/or the introduction of technological innovation into the market.
SCIENCE-TECHNOLOGY	Impacts linked to academic, scientific or technological research and development, the advancement of the state of knowledge in a particular domain.

Table 2-1: Definitions of the benefit dimensions

Each of these dimensions represents an area where the use of EO-based services can produce a significant impact. The benefits for some of these dimensions cannot always be quantified (let alone monetised) but that should not stop those providing, using or analysing such services to try and identify the specific contribution that EO has. Therefore, in our effort to extrapolate the value generated by EO, we shall consider both the quantifiable and non-quantifiable aspects. The specific approach we introduce in e-shape is described below.

2.3 Extrapolating this value by looking into geographic extension and market penetration aspects

Assessing the benefits generated by the use of EO in a given sector (here public wellbeing) presents us with an important challenge: how can we ensure that the argumentation we develop and the numbers we estimate are a good and representative fit to the reality of that sector? Traditionally, the "easy" answer to this has been a top-down, macro-economic approach combined with a few case studies to highlight the non-quantifiable benefits. Such approaches, used for instance in the Copernicus Market Report[2], whilst offering a nice panoramic view, often suffer from a lack of accuracy when it comes to the underlying structure. On the other side of the spectrum, bottom-up approaches such as the one deployed in SeBS, are by construction focussing on specific, very well studied cases and attempt only a qualitative analysis of how their results can be seen in a wider perspective.

Here, we aim to build on the well-studied bottom-up cases and construct a broader, well-justified picture. Please note: The extrapolation method described is primarily applied to economic benefits.

To do so we start with the assessment of specific value chains, which we then try to generalise and extrapolate so as to present benefits tracked back to EO-based services for whole sectors. The figure below is graphic representation of our approach. It distinguishes between a "bottom-up" type approach to estimating value and a "top-down" approach. A "bottom-up" approach gains a very good understanding of benefits and value manifested at the micro level i.e. in a single value chain with a relatively small number of stakeholders. This approach only gains a limited understanding of the overall value and benefits manifested at the macro level i.e. at a regional, national or supranational level. A "top-down" approach is the opposite, it gains a good understand of benefits and value manifested at a regional, national or supranational level, but only a limited understanding of the benefits and value manifested at the micro level. Our approach is somewhere in the middle, whereby we take well understood micro-level cases, link and group them by application and then build a picture of various market segments. Taking the market segments as "building blocks" of the overall market, we aim to illustrate the potential magnitude of the overall macro-level benefits.

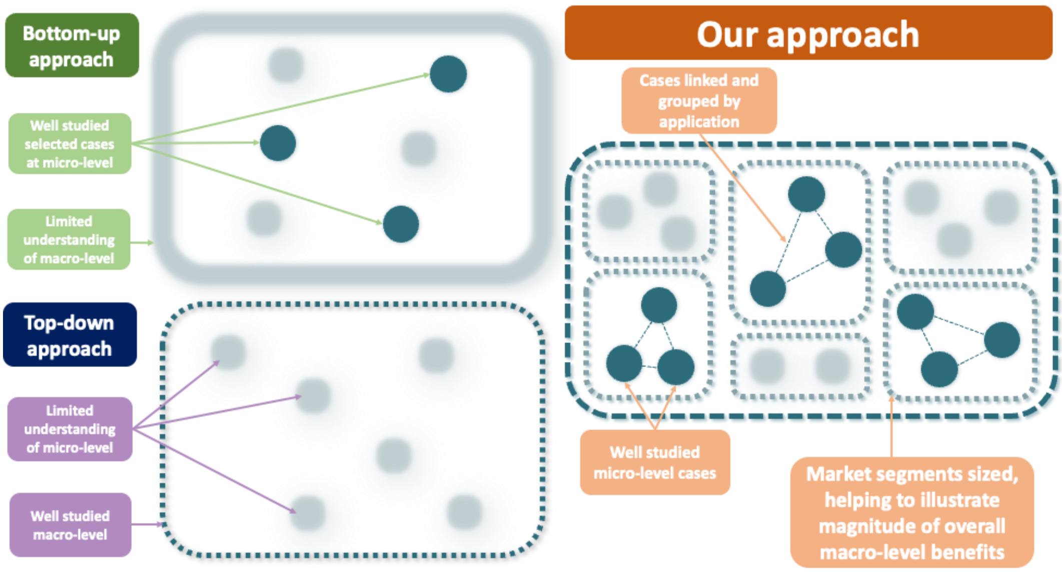

Figure 2-2: "Bottom-up", "top-down" and our approach to value estimation

[2] https://www.copernicus.eu/sites/default/files/PwC_Copernicus_Market_Report_2019.pdf

In our extrapolation we will be looking into two perspectives: (i) geographic extension, (ii) increased market penetration.

2.3.1 Geographic extension

The global coverage of Earth observations, i.e. their ability to capture every spot of the Earth, allows service providers to offer solutions that address customers across borders. Therefore, in principle, the findings of a given case can be extended beyond the geographic borders of the country in which the case is being carried out. In practice, however, this also depends on multiple other factors:

- is the EO service addressing a problem that is – to a large – extent similar in different countries?
- Is the climatology, geomorphology and other relevant environmental conditions comparable, to the extent that a given solution is transferrable?
- Is the regulatory or business framework equally conducive to the uptake of a given solution?

Depending on the answers to such questions, we are able to project the benefits of a given case in a wider geographical scale. In essence, this is a market sizing exercise, whereby the questions above act as filters that allow us to zoom in from the total addressable market (TAM), potentially at a global level, into the serviceable addressable (SAM) and eventually serviceable obtainable (SOM) markets. This process is applied for each individual case and, naturally, case-specific parameters are taken into account to define the extent to which this extrapolation can be justifiably done. Yet, despite such case-specific parameters, when we look at the full portfolio of cases that have been analysed, we can already note that the feasibility of a meaningful geographic extension is strongly justified.

In practice, within e-shape, we shall estimate the Service Obtainable Markets (SOM) for the applications/pilots that are considered in the analysis of EO value for a given sector, by addressing precisely geographic extension.

2.3.2 Market Penetration

The cases analysed in SeBS but also in other activities all share a common denominator: a very committed primary user who can appreciate the value they receive because it enables them to deliver increased value themselves (further down the chain). These primary users are the ones that typically offer an entry point to a specific market for the service provider. But how many more such clients could the service provider target? And what is a reasonable market share that either the specific cases or a bouquet of similar services can capture?

These are the questions that characterise the market penetration perspectives. In this regard it is important to observe that most of the EO-services are offered to their users through widely spread user interfaces (i.e. web services, smartphone apps, etc.). This, in itself, means that such services have wider market potential. What is more, the back end of these services relies on the processing of different sets of data (satellite observations, in situ, meteorological) which are typically provided at scale. In the specific case of Sentinels, the extra “handling costs” might not be negligible but they are certainly not restrictive for companies that want to serve multiple users simultaneously. Moreover, thanks to the proliferation of automated workflows, there is large growth potential. This may well be supported by the recent rise of services (such as Copernicus DIAS[3]) offering cloud computing services “next to the data”. These technological and service provision trends do not of course necessarily reduce the effort required by companies in business development and marketing of their solutions. They do however facilitate reaching out to a wider pool of potential users.

[3] See here: https://www.copernicus.eu/en/access-data/dias

In practice, within e-shape, we shall estimate the SOM for the applications/pilots that are considered in the analysis of EO value for a given sector, by addressing precisely this market penetration perspective.

2.4 Definition of "threads"

EO is adopted by so many users in such a large and varying number of applications that it is extremely difficult to estimate the true or total value it brings. As a result of its ever-increasing adoption and application, EO's benefits continue to branch across sectors and tiers in such a wide-reaching manner that to capture the almost fractal nature of its entire impact would be close to impossible. Instead, a different approach has been chosen.

As already described in our approach to extrapolation (see section 2.2 above) we are taking some already well-defined data points from SeBS as starting points for our analysis and will look at interesting "threads" of value. This will help to paint a picture of the value EO can bring to specific applications within the context of public wellbeing, without attempting to capture the entirety of the complex and continually evolving value it brings. This is precisely the compromise between the "bottom-up" and "top-down" value quantification described in section 2.2. We take well understood micro-level cases, link and group them by application and then build a picture of various market segments. We then take these market segments as contributing "building blocks" of the overall market and use them to illustrate the potential magnitude of the overall macro-level benefits. Some threads will quantitatively illustrate value while others will qualitatively describe how value is added. This "bottom-up" approach to the quantification of value (as opposed to a top-down, meta-level approach) draws from real-world, well understood value, builds a strong and rational extrapolation model and helps to convey the possibilities EO holds in a plausible and easily understandable way.

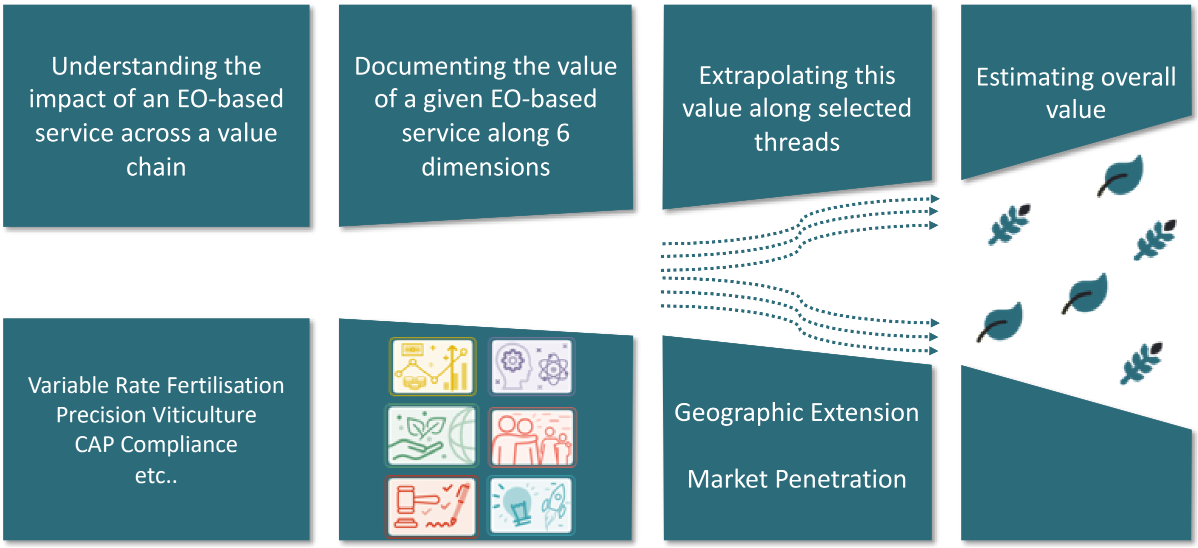

Figure 2-3: Graphical representation of the approach to evaluating socio-economic value in e-shape

For example, when using a thread to demonstrate economic benefits, we will begin with a specific service or benefit for which we already have robust data on regarding its economic impact in a given country or region. We will then extrapolate this thread across geographic regions using market penetration as a moderating factor to understand the potential value this particular application could bring to public wellbeing at a macro level.

When demonstrating the benefits associated with particular societal or environmental threads, we will draw from already well understood case studies to describe the potential value this thread could bring at a macro level.

2.5 Choice of sectors

The reasoning behind choosing broad "sectors" (i.e. public wellbeing) for each report is to link as many e-shape pilots back to the chosen sector as possible, thereby highlighting the work of all 37 e-shape pilots across the span of the three socio-economic reports. For each of the three reports we have chosen a "sector" or "theme" from which we can both extrapolate data from SeBS cases (to show the value EO has for the sector) and also weave in commentary which links back to each e-shape showcase/pilot. As can be seen in the table below, the plan is to cover each of the 7 e-shape showcases (and all pilots within) across all three reports.

Socio-economic report secotr or "theme"	SeBS case studies from which data will be extrapolated	Relevant e-shape showcases which can be linked throughout the report
1st report: "Agriculture"	MAKING WINE IN FRANCE GROWING POTATOES IN BELGIUM FARM MANAGEMENT SUPPORT IN POLAND FARM MANAGEMENT SUPPORT IN DENMARK GRASSLAND MONITORING IN ESTONIA	SC1 – Agriculture
2nd report: "Public wellbeing"	WATER QUALITY MANAGEMENT IN GERMANY GROUND MOTION MONITORING IN NORWAY FLOOD MANAGEMENT IN IRELAND AQUIFER MANAGEMENT IN SPAIN NAVIGATION THROUGH SEA-ICE OFF GREENLAND WINTER NAVIGATION IN THE BALTIC	SC2 – Health SC3 – Energy SC5 – Water SC6 – Disasters
3rd report: "Natural capital and the environment"	DEFORESTATION MONITORING FOR SUSTAINABLE PALM OIL PRODUCTION WATER QUALITY MANAGEMENT IN GERMANY GRASSLAND MONITORING IN ESTONIA AQUIFER MANAGEMENT IN SPAIN FORESTRY MANAGEMENT IN SWEDEN	SC4 – Ecosystem SC7 - Climate

Table 2-2: Choice of sectors across reports

As will be explained in the following section, the choice of "public wellbeing" also allows for strong parallels to be drawn between the aims of the e-shape pilots and the the UN's Sustainable Development Goals and Sendai Framework for Disaster Risk Reduction. The following section illustrates how EO can aid public wellbeing and describes some chosen threads of value across the already discussed 6 dimensions of benefit.

3 VALUE ADDED BY EO IN PUBLIC WELLBEING

3.1 How EO can aid public wellbeing

Within e-shape, we hope to develop effective solutions which can make peoples' lives safer, healthier, and easier. But what exactly are the types of societal and social challenges faced by people that can be addressed by EO?

Public health alerts on air quality, risks related to water-borne pollution, warnings of potential natural disasters and maintenance of critical infrastructures and amenities can all be monitored and informed by EO. In fact, EO can act as an important tool in our collective mission of achieving the UN's SDG3 - Good Health and Wellbeing, SDG6 – Clean Water and Sanitation as well as the UN's Sendai Framework for Disaster Risk Reduction.

3.1.1 Air Quality

According to the World Health Organization, air pollution is linked to 7 million deaths every year[4] and has serious effects on human health, including the development of respiratory issues, cardiovascular issues, lung cancer, and asthmatic attacks. Accurate early warnings of poor air quality are useful because they give people the option to reduce their risk of exposure to poor air by limiting outdoor activity at these times.

A plethora of different types of air pollutants such as aerosols, carbon monoxide, dust, nitrous oxide, ozone and sulphur dioxide can be measured using various types of remote sensing technologies and techniques.

Within e-shape, several pilots are developing solutions directly addressing, or partially addressing this dimension. Under the **Showcase 2 – Health**, these include:

- Pilot 2.1 – EO-based Surveillance of Mercury Pollution
- Pilot 2.2 – EO-based Surveillance of POPs Pollution
- Pilot 2.3 – EO based Pollution-health Risks Profiling in the Urban Environment
- Pilot 2.4 – EYWA – Early Warning System for Mosquito-Borne Diseases

3.1.2 Water Quality

Lakes, rivers, and coastal waters play a prominent role in our recreational activities and everyday life, therefore, having the tools and capability to predict and respond in advance to potential water quality risks can help avoid serious harm to public health. EO technology combined with modelling of highly complex, dynamic systems can provide monitoring and forecasting information of water quality. This information can guide actors concerned with the management of water quality in making quick and data-informed decisions to achieve regulatory compliance at low cost. In fact, safe access to clean (drinking) water and the sustainable management of water resources is recognised as the 6th goal of the UN Sustainable Development Goal recognising the significance of Clean Water and Sanitation.

Within e-shape, several pilots are developing solutions directly addressing, or partially addressing this dimension. Under **Showcase 5 - Water**, these include:

- Pilot 5.1 - Improved historical water availability and quality information service
- Pilot 5.3 - Dive - Diver Information on Visibility in Europe

[4] https://www.airscan.org/news/who2021#:~:text=In%202018%20WHO%20reported%20that,result%20in%20negative%20health%20impacts.

- Pilot 5.4 - Sargassum detection for seasonal planning
- Pilot 5.6 - EO based phytoplankton biomass for WFD

3.1.3 Natural Disasters & Crisis Response

Information is a critical resource in disaster response scenarios. Data regarding the geographic extent, severity, and socioeconomic impacts of a disaster event can help guide emergency responders and relief operations, particularly when delivered within hours of data acquisition. Information from remote observations provides a valuable tool for assessing conditions "on the ground" more quickly and efficiently. EO is foreseen to be particulary important to achieving the goals of the Sendai Framework for Disaster Risk Reduction, which aims to "*substantially reduce disaster risk and loss of lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries.*"

Within e-shape, several pilots are developing solutions directly addressing, or partially addressing this dimension. Under **Showcase 5 – Water**, and **Showcase 6 – Disasters**, these include:

- Pilot - 5.2 Satellite Earth Observation-derived water bodies and floodwater record over Europe
- Pilot 6.1 - EO4D ASH - EO Data for Detection, Discrimination and Distribution (4D) of Volcanic ash
- Pilot 6.2 - GEOSS for Disasters in Urban Environment
- Pilot 6.3 - Assessing Geo-hazard vulnerability of Cities and Critical Infrastructures
- Pilot 6.5 - FRIEND
- Pilot 6.6 - MountaiNow

3.1.4 Critical infrastructures and essential amenities

Critical infrastructure such as roads, ports, public buildings, along with essential amenities such as energy supply, transport services and food supply chains need to be monitored and maintained to ensure minimal disruption and risk of danger in peoples' lives. EO is an invaluable asset in the toolbox of construction companies, infrastructure managers, public authorities, and energy/utility operators when it comes to this. Thanks to its capacity to provide historical data on risk exposure and projections on the future impacts of climate change, EO supports the design of more resilient public infrastructures, the strategic planning of operations and the long-term monitoring of infrastructure health and environmental impact.

Within e-shape, several pilots are developing solutions directly addressing, or partially addressing this dimension. Under **Showcase 3 – Energy** and **Showcase 6 – Disasters,** these include:

- Pilot 3.1 - nextSENSE: solar energy nowcasting and short-term forecasting system
- Pilot 3.2 - High photovoltaic penetration at urban scale
- Pilot 3.3 - Merging offshore wind products
- Pilot 3.4 - WindSight - First class input data for wind energy models
- Pilot 6.3 - Assessing Geo-hazard vulnerability of Cities and Critical Infrastructures

3.2 Economic threads

When it comes to the impact of EO in public wellbeing, there is a plethora of varying case studies, impact assessments and scientific research regarding how EO data and EO based technologies can add value. As a result, conducting an all-encompassing, meta-analysis of the true value EO brings to the everyday lives of citizens and society is a very complex if at all attainable endeavour, and therefore goes beyond the scope of this publication. We can however try to shed light on some very important aspects of everyday life that are aided through the use of EO, thus capturing a proportion of the overall value that EO can deliver. To that end, we will take the approach of using the previously discussed "threads" of value to extrapolate some already well understood, real-world economic benefits from various SeBS case studies.

3.2.1 Understanding the impact of EO services across value chains

The table below is a summary of the SeBS cases which involve a strong public wellbeing dimension. "Extrapolatable" benefits from each case are listed and aggregated (where applicable) to provide data points regarding total value per year stemming from the case specific application of EO data in its respective region. By "extrapolatable" we mean that the benefit found in the particular case is generic enough as to allow one to reasonably assume that when applied in a different geographic location, a similar benefit would be achieved. Given that most cases have many situational nuances and uncertainties, both low and high estimates of value are provided, giving some parameters within which value was found to materialise.

Case study	Public wellbeing dimension	Specific benefit within the case	Lower findings of value	Upper findings of value
WATER QUALITY MANAGEMENT IN GERMANY[5]	**Water quality**	Better water quality in lakes for drinking water and leisure activities	€4 million/year	€7.8 million/year
GROUND MOTION MONITORING IN NORWAY[6]	**Critical Infrastructures and Essential Amenities**	Reduced public road closures - Maintenance of supply chains and transport links	€1.35 million/year	€3.78 million/year
FLOOD MANAGEMENT IN IRELAND[7]	**Natural Disasters and Crisis Response**	Better crisis response, avoided damages from flooding events	€5.8 million/year	€28.4 million/year
AQUIFER MANAGEMENT IN SPAIN[8]	**Natural Disasters and Crisis Response**	Avoided costs from aquifer associated damages to buildings	€29.4 million/year	€58.7 million/year
NAVIGATION THROUGH SEA-ICE OFF GREENLAND[9]	**Critical Infrastructures and Essential Amenities**	Maintenance of supply chains and transport links	€200,000/year	€1 million/year
WINTER NAVIGATION IN THE BALTIC[10]	**Critical Infrastructures and Essential Amenities**	Maintenance of supply chains and transport links	€3.5 million/year	€17.5 million/year

Table 3-1: Summary of extrapolatable benefits from SeBS cases

[5] https://earsc.org/sebs/all-cases/water-quality-management-in-germany/

[6] https://earsc.org/sebs/ground-motion-monitoring-in-norway/

[7] https://earsc.org/sebs/flood-management-in-ireland/

[8] https://earsc.org/sebs/aquifer-management-in-spain/

[9] https://earsc.org/sebs/navigation-through-sea-ice-off-greenland/

[10] https://earsc.org/sebs/winter-navigation-in-the-baltic/

3.2.2 Extrapolating the data

The next step is to set our extrapolation parameters, based on geographic extension. Clearly EO is almost uniquely positioned in its applicability to huge geographic extension, however, for the purposes of this document, geographic extrapolation is limited to the EU-27.

Given the specificities of each case, the geographic extension metrics must be based on different data sets in order to make sense. The value calculated at the national level of each of the selected SeBS cases will be extrapolated to other countries, based on relative magnitudes of metrics listed below:

- **Water Quality Management in Germany:** Lake surface area per country (km^2)
- **Ground Motion Monitoring in Norway:** Length of road network per country (km)
- **Flood Management in Ireland:** Reported flood phenomena per country (floods/10,000km^2)
- **Aquifer Management in Spain:** Fresh groundwater abstraction per country (million m^3)

Note: For the **Navigation Through Sea-Ice off Greenland** and **Winter Navigation in the Baltic,** the figures will remain as is and not extrapolated as these cases concern Greenland, Finland and Sweden, which are the countries primarily associated with winter sea-ice navigation issues in Europe and extrapolation across the EU27 does not make sense.

The following table shows the extrapolation data used in our calculations. **Please note:** Not all fresh groundwater data was available.

Country	Lake surface area (km^2)[11]	Length of road network (km)[12]	Average reported flood phenomena (floods/10,000km^2)[13]	Fresh groundwater (million m^3)[14]
Belgium	340	155210	15	-
Bulgaria	1271	19678	20	561.73
Czechia	978	130680	2	359.3
Denmark	596	74130	7	707.82
Germany	6140	230377	7	-
Estonia	2185	58787	2	229.09
Ireland	1480	96017	7	-
Greece	1731	117321	7	6228.35
Spain	5209	666145	15	-
France	6835	1071823	7	-
Croatia	470	26820	15	425.3
Italy	5382	256039	2	-
Cyprus	33	9765	7	135
Latvia	1960	70443	1	87.28
Lithuania	1657	72591	15	162.74
Luxembourg	15	2880	20	22.99
Hungary	1767	203310	2	606.88
Malta	4	2361	0	37.94
Netherlands	3758	138641	2	-

[11] https://ec.europa.eu/eurostat/databrowser/view/LAN_LCV_OVW__custom_2182909/default/table?lang=en

[12] https://erf.be/wp-content/uploads/2018/01/Road_statistics_2017.pdf

[13] https://www.eea.europa.eu/data-and-maps/figures/reported-flood-phenomena-per-country

[14] https://ec.europa.eu/eurostat/databrowser/view/ten00002/default/table?lang=en

Austria	1505	124114	7	-
Poland	5561	415122	15	2550.3
Portugal	1626	14310	2	-
Romania	3735	85531	2	705
Slovenia	108	38874	20	187.73
Slovakia	481	54806	7	338.7
Finland	36323	78093	1	-
Sweden	39798	216976	1	-

Table 3-2: Extrapolation parameters

Taking all data points and extrapolation parameters into account, the following table displays the results of our calculations for potential added value of EO in selected public wellbeing applications across the EU. It must be noted that due to the generalisations and assumptions made, the range of value is relatively large. However, due to the fact that all estimates of potential value are regarded as conservative, the values in the following table help to convey (by orders of magnitude) just how impactful EO could be for the wellbeing of Europe's citizens and society.

Crop type	Lower estimate of value	Upper estimate of value
Water quality	€ 66,113,811/year	€ 132,227,622/year
Critical Infrastructures and Essential Amenities	€ 67,080,266/year	€ 195,964,746/year
Natural Disasters and Crisis Response	€ 305,918,579/year	€ 1,111,037,157/year
TOTALS	**€ 439,112,656/year**	**€ 1,439,229,525/year**

Table 3-3: Potentials for threads of EO added value in public wellbeing applications

It is clear from the values presented above that EO holds huge promise in ensuring public wellbeing. Even the conservative lower estimate of €439 million per year is a significant benefit to the citizens and society of the EU. Within the context of this study, the €439 million per year added value is considered an absolute minimum, with real added value certainly higher in practice. As can be seen, the upper estimate of value is over €1.4 billion/year. This figure is quite staggering and stands as a testament to the efficacy and potential for EO in delivering both economic value and improving peoples' lives.

Again, the figures above represent only some "threads" of economic value that can be realised through the implementation of EO in public wellbeing applications. These threads represent only a portion of how EO can add value to public wellbeing, with there being many other parallel threads whose economic value are not captured within this report. For example, we have not included the economic benefits associated with the likes of improved air quality, improved urban planning, efficient use of clean energy, improved food quality etc. Rather than attempting to truly quantify the impact of EO in public wellbeing, by simply taking a small number of robust data points from well-established real-world applications, the narrative above gives an idea of just some of the efficacy and possibilities with regards to EO as well as conveying just how pervasive and impactful it can be.

3.3 Environmental threads

Public wellbeing and environmental concerns overlap to a great extent. Indeed, already in the definitions provided in the methodology section (chapter 2.2), we acknowledge this dependency of human societies on the health and state of the environment. EO services targeting, for instance, air or water quality, therefore address simultaneously aspects of public health and environmental sustainability. Similarly, any additional value brought by using EO data and technology in solutions targeting environmental challenges could also be directly considered as bringing value to society. To remain within the scope of this publication, this chapter on environmental threads will provide a detailed view on cases where public wellbeing applications also have environmental benefits.

3.3.1 Water and air quality

Asides from being crucial resources for the survival of living beings, water and air are "common goods". Therefore, often it is up to the governments to ensure the monitoring of their quality and address a variety of wellbeing concerns of inhabitants as well as the environmental issues at large. As discussed in the analyses of the relevant SeBS cases (i.e. Lake Water Quality Management in Germany and Aquifer Management in Spain), EO helps to increase and improve the monitoring of natural resources.

Satellite observations support the efforts of maintaining natural habitats and biodiversity through detection of environmental issues such as harmful algae blooms in water bodies. Due to their nature as common goods, EO based monitoring guides the likes of governments and responsible stakeholders in a more sustainable use of these resources. Specifically in cases where water risks becoming a scarce commodity, as in the Spanish Murcia region, EO-enabled monitoring helps authorities to act and reduce the impact on the surrounding ecosystems and the environment as caused by an overuse or a misuse of a resource.

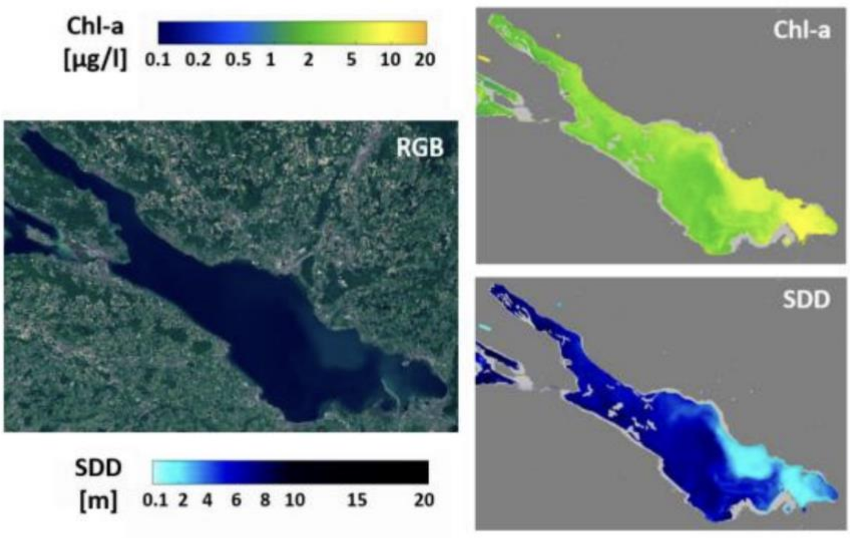

Figure 3-1: Sentinel-2 data for Lake Constance, Germany. RGB image left, Chlorophyll-a top right and Sechi depth bottom right[15]

Similarly, when it comes to air quality, EO-enabled applications targeting public health and wellbeing bring benefits to the application of environmental monitoring, therefore potentially allowing for the reduction of pollution. Copernicus Atmosphere Monitoring Service and commercial platforms such as

[15] https://earsc.org/sebs/wp-content/uploads/2021/06/Water-Quality-Management-in-Germany-final-1.pdf

AirQast are some examples of innovative ways in which we can monitor this crucial resource. Clearly, environmental benefits go hand-in-hand with regulations, which are discussed in the chapter **3.4 - Regulatory threads**.

Many e-shape pilots are related both to the public wellbeing and environment. For instance, Pilot 7.6 - super resolution air quality monitoring service aims to improve air quality monitoring at large. Grouped under the Health showcase, multiple pilots tackle air and water quality and their impact on human populations, which also brings value for the environment. A relevant example is the Pilot 2.3 on EO-based pollution-health risks profiling in the urban environment which aims to improve the monitoring and prediction of air quality and pollution in cities to help with urban planning and public health assessments. Similarly, pilot 2.1 EO-based surveillance of mercury pollution aims to model and monitor mercury pollution for humans and the environment, while pilot 2.2 EO-based surveillance of POPs pollution focuses on humans by addressing the Persistent Organic Pollutants in their environment.

3.3.2 Natural disasters and crisis response

Natural disasters often affect humans, human settlements and the surrounding environment in severe ways, therefore EO-based solutions often bring value to both public wellbeing and the environment. EO also informs a better and more efficient crisis response and recovery in the case of disasters. Furthermore, the role of EO in building disaster resilience is increasing as is the availability of the technology and data. By improving disaster resilience, EO has a role in achieving SDGs related to the environment, in particular SDG 11 on sustainable cities and communities and SDG 13 on climate action.

In the micro-level SeBS case concerning the Flood management in Ireland, some particular aspects of environmental value were highlighted. Direct environmental impacts of flooding can be both positive (biological productivity and diversity in the flood plain) and negative (well-being of wildlife, riverbank erosion, pollution). However, in either case, EO enables better environmental protection by minimising the environmental impacts of flood response. Furthermore, it helps assessment of damages and therefore informs the long-term recovery, including any works to be carried out.

3.3.3 Indirect environmental value

Indirect value for the environment can potentially come from multiple domains where EO technology is aiding public wellbeing. This can include more-energy efficient construction, or applications in urban planning, transport, etc. To illustrate particular indirect benefits, we'll look into a two similar SeBS cases concerning navigation (Winter Navigation in the Baltic and Navigation through sea-ice in Greenland). In the case of Finland, it has been noted that "*environmental agencies and researchers where even local offices around the Finnish coast benefit from the ice charts and comparison with the actual conditions*". While in the case of Greenland, the main environmental benefits cited are the reduced risk of accidents and potential oil spills. Moreover, as the traffic in the region is estimated to increase, these benefits are estimated to increase as well.

Among the e-shape pilots, a relevant case here involves Pilot 7.5 - Seasonal Preparedness. It aims to improve extended and long-range forecasted climate outlooks on onset and offset of seasons, which directly would benefit the transport and tourism industries, while indirectly provide information concerning the environment.

3.4 Regulatory threads

3.4.1 Water quality

Only a few countries in the EU have national monitoring programmes for the assessment of the chemical and physical water quality of lakes. Most countries, however, undertake monitoring of lakes at regional or local scale. During the last 10-15 years, some countries have conducted national lake inventories and collected data and elaborated reports on the general environmental state of lakes based on locally gathered information. In the Nordic countries, in which there are many natural lakes, monitoring programmes cover a vast number of lakes. Finland, for instance, has been monitoring a wide range of lakes since the early 1960s. During the 1980s Norway and Sweden have conducted lake surveys to assess the extent of acidification and eutrophication. Others, for example, the Netherlands and Portugal, do not have any specific lake monitoring programme, but include their lakes in river or inland water programmes.

Adopted in 2000, the **EU Water Framework Directive (WFD)**[16] has given a push to European countries to streamline their monitoring activities and improve the ecology of their waters and the water quality of lakes. This has led to increased environmental awareness and increasing demands to counteract the accelerating pollution of European lakes described above.

There are a number of objectives in protecting the quality of water[17,18]. The key ones at European level are general protection of the aquatic ecology, specific protection of unique and valuable habitats, protection of drinking water resources, and protection of bathing water. All these objectives must be integrated for each river basin. The last three - special habitats, drinking water areas and bathing water - apply only to specific bodies of water (those supporting special wetlands; those identified for drinking water abstraction; those generally used as bathing areas). In contrast, ecological protection should apply to all waters.

A major step forward for the WFD would be the **explicit encouragement to use satellite-based monitoring** to complement national and statutory monitoring and reporting, such as already exercised by a limited number of countries. Particularly useful satellite products would include those that enhance confidence in the classification of phytoplankton biomass (typically measured by chlorophyll-a). EO could vastly improving spatial and temporal coverage, as it is already mature and can support quality elements that have thus far been considered too costly to include using conventional methods, such as assessing the frequency and intensity of algal blooms in lakes and coastal waters.

Within e-shape, Pilot 5.6 - EO based phytoplankton biomass for WFD is aiming to generate recognition and support for EO-based products in the scope of the WFD at political, administrative and management levels. It also will be providing WFD ecological status products of phytoplankton biomass for management of selected water bodies, based on Chlorophyll-a concentrations derived from EO data.

3.4.2 Air quality

In Europe, the Ambient Air Quality and Cleaner Air for Europe (AAQ)[19] Directive is the primary regulation associated with air quality. When introduced in 2008, this directive merged most of pre-existing air quality legislation into a single directive with no change to the other existing objectives. The AAQ aims to protect human health and the environment from the harmful effects of air pollution and sets clear and binding objectives and defines specific responsibilities for EU Member States to monitor, report on and manage air quality. As a result, EU Member States are required to ensure that up-to-date information on ambient concentrations of the different pollutants is routinely made

[16] https://ec.europa.eu/environment/water/water-framework/index_en.html

[17] https://ec.europa.eu/environment/water/water-framework/info/intro_en.htm

[18] "A set of procedures for identifying that point for a given body of water and establishing chemical or hydro-morphological standards to achieve it, is provided, together with a system for ensuring that each Member State interprets the procedure in a consistent way (to ensure comparability). The system is somewhat complicated, but this is inevitable given the extent of ecological variability, and the large number of parameters, which must be dealt with." EU WFD

[19] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02008L0050-20150918&from=EN

available to the public as well as to other organisations. This is done by providing information on websites, in the press and by public displays. The information needs to be updated as appropriate to the averaging periods. The relation to the different limit and target values needs to be clear. When information or alert thresholds are exceeded, Member States need to inform the public about the exceedance and the actions that are eventually taken.

After 10 years of the AAQ being in effect, review[20] of the directive by ClientEarth, EEB, AirClim, HEAL and Transport & Environment produced 10 actionable recommendations for the update and improvement of the AAQ. Recommendation 6 explicitly stated "*The Commission should also review new air quality assessment technologies (such as satellite data) and consider what role they can play for competent authorities and citizens in Europe.*" The use of EO in helping monitor and meet the aims of the AAQ is something that clearly needs to be pushed at the regulatory level. Key decision-makers should be made more aware of the benefits and applicability of EO for this.

3.4.3 Natural disasters and crisis response

Several regulations and directives dictate how Europe should be prepared for and respond to natural disasters. A wide set of EU policies and funds aim to strengthen collective safety and resilience against adverse events. Under the **EU Civil Protection Mechanism**[21], 27 EU countries regularly exchange information on disaster risks. The Mechanism aims to strengthen cooperation between the EU Member States on civil protection to improve prevention, preparedness, and response to disasters. Following a request for assistance through the Mechanism, the **Emergency Response Coordination Centre (ERCC)**[22] mobilises assistance or expertise. The ERCC monitors events around the globe 24/7 and ensures rapid deployment of emergency support through a direct link with national civil protection authorities. Specialised teams and equipment, such as forest firefighting planes, search and rescue and medical teams can be mobilised at short notice for deployments inside and outside Europe.

EO plays no small role in all of this, with the **Copernicus Emergency Management Service**[23] producing maps to support civil protection operations wherever and whenever needed. Copernicus provides timely and precise geospatial information that is useful to delineate affected areas and plan disaster relief operations. In developing countries, civil protection assistance typically goes hand in hand with EU humanitarian aid. Experts in both fields work closely together to ensure the most coherent analysis and response, particularly in response to complex emergencies.

Specific natural disasters such as flooding are also covered under directives. For example, the **EU Floods Directive**[24] which was established in 2007 requires Member States to assess if all watercourses and coast lines are at risk from flooding, to map the flood extent and assets at risk in these areas and to take adequate and co-ordinated measures to reduce this flood risk. Again, the applicability of EO under such a directive is clear.

3.5 Innovation and Entrepreneurship threads

EO-based services and data can help to stimulate the creation of new businesses. There is a lot of potential and room for innovative services based on EO data to make processes for stakeholders involved in the monitoring or provision of public wellbeing services to be more efficient and effective.

[20] https://www.env-health.org/wp-content/uploads/2018/09/The-first-ten-years-of-the-eu-ambient-air-quality-directive.pdf

[21] https://ec.europa.eu/echo/what/civil-protection/eu-civil-protection-mechanism_en

[22] https://ec.europa.eu/echo/what/civil-protection/emergency-response-coordination-centre-ercc_en

[23] https://emergency.copernicus.eu/

[24] https://ec.europa.eu/environment/water/flood_risk/

In particular, there are three distinct indicators that stand out in representing the potential for innovation and entrepreneurship of EO in public wellbeing applications; changed business practices, the creation and sustainability of start-ups and the tracking of patents[25]. The following elaborates on these three indicators and how they were present (or not) in the SeBS cases.

Moreover, a current initiative by the EU known as "Europe's Digital Decade"[26] is driving the digitasation of our economies and ways of life. The digital decade will run up until 2030 and as part of this initiative focus will be placed on start-ups and scale-ups to further adopt the use of digital technologies. The following sections exemplify just how the adoption of EO in public wellbeing applications contributes to the goals of the digital decade.

3.5.1 Changed Business Practice

Many stakeholders who are involved in delivering public services are still relatively unaware of EO and its benefits, however, when adopted, EO can revolutionise working practices for the better. In several SeBS cases, we have seen that this often implies strong benefits for both the supplier of the service in terms of new employment and for the primary user, in terms of more efficient business practices.

In many instances, EO services are developed within new companies (i.e. start-ups creating wholly new business practices) or through a new business line within an existing company (e.g. engineering companies; making processes more efficient). Both can lead to new jobs which fall under the economic dimension.

In the Aquifer Management in Spain case, it allowed a company like DARES to build a viable business model around the delivery of innovative products, grow fast and provide quality services to clients across the globe. Secondly, it allows a public organisation such as CHS to introduce innovative technologies into its workflow with the help of another public institution (IGME). In the Water Quality Management in Germany case, the primary user, LUBW, could introduce new, EO-powered processes into a public agency. Moreover, in both the Navigation through Sea-Ice off Greenland and Winter Navigation in the Baltic, we see stakeholders involved in the maintenance of key transport links completely overhauling the ways in which they plan and execute operations thanks to the adoption of EO-powered services.

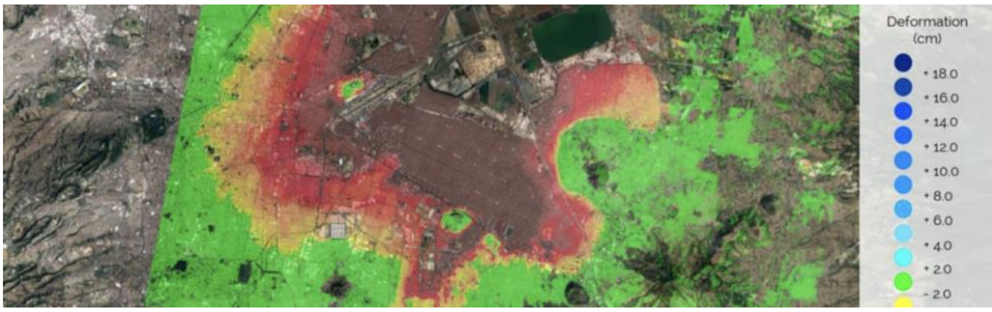

Figure 3-2: Thanks to EO, companies such as DARES can serve clients in new ways. Here is a snapshot of subsidence monitoring in Mexico[27]

3.5.2 Creation of Start-Ups

Satellite data are helping to create wholly new types of businesses. It is especially the free and open data such as Copernicus Sentinel data that are making this development possible. While remote

[25] See here: https://earsc.org/sebs/wp-content/uploads/2020/12/SeBS-Methodology-2020.pdf

[26] https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age/europes-digital-decade-digital-targets-2030_en

[27] https://earsc.org/sebs/wp-content/uploads/2020/10/Aquifer-Management-in-Spain_vf.pdf

sensing companies and value-added services have existed before this “revolution” of the last decade, with more and more EO companies entering the market, these overtook other types of remote sensing data (e.g. airborne) or commercial data that were relatively expensive.

Thanks to the availability of EO data, start-ups are empowered like never before. Given its free and open data policy, Copernicus Sentinel data in particular really lends itself to the formation and sustainable growth of EO-powered start-ups as large data costs can be saved right off the bat. Throughout the course of the Sentinel Benefits Study, several new companies active in the various domains of public wellbeing have been created such as DARES[28] that would not exist without the Copernicus programme and its Sentinel fleet. It is the availability of free Sentinel data that makes these young EO companies and their business models viable as the programme ensures continuity including sufficient frequency of fresh data, adequate spatial resolution, and accuracy as well as zero-marginal cost per hectare for automated solutions. Other companies such as EOMAP[29], who existed before the use of Sentinel data, later took advantage of its free and open data to help lower costs and expand their business.

3.5.3 Patents

The registration of patents is hard to monitor, particularly in the EO sector. However, given its innovative and entrepreneurial nature and ability to offer wholly new services that were not possible before, it is almost certain that EO companies focused on the various dimensions of public wellbeing discussed within this report will patent their innovative products and services based on EO with a national authority or the European Patent Office. With a quick research and as a rough indicator, the EPA’s database finds some 50,000 registered patents related to Earth Observation and air quality, water quality, disaster relief and essential amenities.[30] Some of those are certainly related to equipment or devices, but it shows that patents are used to protect innovations from public wellbing-related EO services, an indicator of the positive socio-economic impact since patents and employment are often correlated in high-tech sectors.

3.6 Science threads

3.6.1 Better science and more high-quality data

EO can unlock several new approaches to science in the domain of public wellbeing. Thanks in large part to its spatial and temporal coverage of our earth, it provides new and unique sources of data to provide invaluable insights which can contribute to furthering scientific understanding.

From the Ground Movement Monitoring in Norway case, we learned about the InSAR Norway map, which monitors ground deformation across the entire country of Norway using Sentinel-1 data. Thanks to the free and open nature of the map itself along with its data, clear scientific developments are constantly being realised. In fact, The InSAR Norway ground motion service has spawned improved algorithms for generating the InSAR measurements along with the computational side of improved data-handling, processing, storage, scaling and visualisation. and other factors linked to the overall accuracy of the map and the efficiency with which it is generated. Moreover, the map allows new studies and more frequent monitoring of risky areas, furthering geological understanding of how landslides occur and how to better predict them. In this way, the map is fulfilling its core purpose for an operational research topic.

[28] http://dares.tech/

[29] https://www.eomap.com/

[30] https://worldwide.espacenet.com/patent/

The abundance of EO data showed its efficacy in the [Water Quality Management in Germany] case. While the knowledge on how to abstract information on water quality parameters from satellite images is quite well-developed, the regular and frequent availability of images from the likes of EO data is unprecedented and can help to understand the ecosystem at local, regional, and global levels. The data derived from satellites is unique and is not obtainable through other tools – at least not at an affordable price. Multiple measurements per week, of key water parameters, over the whole country – indeed the whole surface of the Earth – is impossible without satellites.

3.7 Societal threads

As is the nature of this report on public wellbeing, the societal dimension is extremely relevant. EO brings huge and impactful benefits to society, from ensuring the safety and stability of critical infrastructures, to upkeep of public health to the maintenance of essential supply chains.

The indicators used to judge the societal impacts as well as their descriptions, all drawn from the SeBS methodology, are shown below.

Societal	Impacts related to broader societal aspects, such as public health, citizen security and welfare.
Public Health	Improvements to public health through reduced exposure to pollutants, reduced disease etc
Civil Security	Reinforcement of citizens' sense of safety and protection
Geostrategic Value	Support to broader political or strategic goals
Public Awareness	Provision of information to the general public with the aim of supporting public duties, raising awareness of hazards or danger, or improving transparency
Public Utility	Provision of increased access to a public utility, or reduction of withdrawn access (e.g. mobility, energy, water)
Community and Quality of Life	Increasing sense of community and the quality of life through enhanced perception of the country/region/town etc as a place to live.
Improved Oversight	Contribution to stakeholder coordination and improved governance through a common operational picture

These are not exhaustive and shall evolve with time as additional cases yield more insights and lead to further indicators.

3.7.1 Public Health

The e-shape project has a dedicated showcase on health. Within this showcase the various pilots are exploring the likes of EO-powered air quality monitoring, pollution monitoring and disease monitoring, with a view to improving the health of citizens and society. As has been already argued in this report, the applications for EO in contributing to the maintenance and monitoring of public health are profound. To really emphasise how important the likes of air quality and water quality are, the WHO have estimated that 7 million[31] people die each year from air pollution and 3.5 million[32] die each year

[31] https://ourworldindata.org/data-review-air-pollution-deaths#:~:text=The%20WHO%20estimates%20that%3A,all%20sources%20of%20air%20pollution.

[32] https://www.theworldcounts.com/challenges/planet-earth/freshwater/deaths-from-dirty-water/story

from water-related diseases. For EO to even play a small part in reducing these numbers is a testament to its value in our lives.

3.7.2 Public utilities

Ensuring citizens have access to high-quality and essential amenities is at the forefront of most public utility providers. Within the various SeBS cases we have seen how EO is ensuring critical supply chains and transport links remain operational for people in vulnerable areas (again, see Navigation through Sea-Ice off Greenland and Winter Navigation in the Baltic). We also see in the Ground Movement Monitoring in Norway case how EO is ensuring public roads are safe while also helping in the pre-emptive detection of landslides. Within e-shape, several pilots are developing services which aim to bolster access and the sustainability of public utilities. Within the energy showcase in particular, Pilot 3.3 – Merging Offshore Wind Products aims to Improve offshore wind resource estimates, thus helping wind farm planning. Similar to this, Pilot 3.4 – WindSight – First Class Input Data for Wind Energy Models is working on developing a sustainable business case for the provisioning of EO data and derived products over land to the wind energy industry. Both of these ultimately aim to contribute to assuring the delivery of clean energy for end customers. Staying within the clean energy sector, Pilot 3.2 – High Photovoltaic Penetration at Urban Scale is leveraging EO to optimise citizens' PV self-consumption with the help of PV system developers

3.7.3 Civil Security

The Disasters showcase within e-shape shows just how valuable EO can be when it comes to civil security and crisis response. Pilot 6.6 – MountaiNow is helping keep citizens in the Alps safe from dangerous conditions, while Pilot 6.2 – GEOSS for Disasters in Urban Environment is aiming to develop precise forecasts and early warnings systems for high-impact weather events. Again, the SeBS case Flood Management in Ireland has strong parallels with a number of the pilots in the Disasters showcase and lays out in detail how EO can be deployed to quickly and effectively aid in civil protection relief efforts.

Figure 3-3: Flood delineation map over Limerick produced using Sentinel-1[33]

[33] https://earsc.org/sebs/wp-content/uploads/2019/03/Flood-management-Ireland-Full-case.pdf

4 FUTURE CHALLENGES

This report primarily addresses the socioeconomic benefits associated with the use of EO in public wellbeing. However, there still exists many huge challenges within the various public wellbeing dimensions discussed, including the following:

- Improving the accuracy and coverage of both air quality and water quality monitoring;
- Reducing the risk and spread of various diseases;
- Providing access to better and more effective critical infrastructures;
- Creating more efficient clean energy sources;
- Improving pre-emptive detection of natural disasters;
- Ensuring resilient supply chains and transport links to bolster civil security;
- Developing better crisis response mechanisms;
- Building resilience to future crises and natural disasters;

All of these challenges require concerted efforts from many stakeholders, from high-level decision makers and international organisations to technological innovators, research scientists and even members of the general public. There can be no doubt that e-shape and its pilots are contributing to the fight against the negative outcomes of many of these challenges, with the likes of Pilot 5.1 – Improved Historical Water Availability & Quality Information Service, Pilot 2.4 – EYWA – Early Warning System for Mosquito-Borne Diseases, Pilot 3.4 – WindSight – First Class Input Data for Wind Energy Models, and Pilot 6.1 – EO4D ASH all aiming to directly address these daunting but extremely important issues. EO will undoubtedly continue to be adopted in ever more innovative ways to ensure public health, safety, security, and the quality of life of millions of citizens is protected.

5 CONCLUSION & NEXT STEPS

From the various applications and innovations discussed within this report, it is clear that the use of EO in public wellbeing applications holds huge promise and will undoubtedly improve the lives of huge swathes of society. It is also clear that in adopting EO in such applications, several positive economic and environmental impacts are being felt by stakeholders involved in the utilisation of the data and technology.

Building upon the various well-understood benefits of EO added value exemplified within the SeBS cases, this document illustrates just some of the possibilities of EO in public wellbeing applications. The pilots within e-shape will undoubtedly impact the various sectors discussed within this report in their own way, contributing the continued success of this extremely exciting innovation ecosystem. This document is the second of three socio-economic value analysis reports within e-shape. The final publication will focus on natural capital and the environment and will be published in M40 of the project.