ANALYSIS OF USE CASES TOWARDS THE EVOLUTION OF EUROPE'S CONTRIBUTION TO GEOSS

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ABSTRACT:

The European Commission (EC), being the co-lead of the European Regional Group on Earth Observations (EuroGEO), is currently outlining an ecosystem that will interconnect European technologies, digital infrastructures and data and enable the implementation of policy-relevant use cases using shared standards. This ecosystem will in turn strengthen Europe's contribution to GEOSS, which is the Global Earth Observation System of Systems. To evaluate and demonstrate the potential of this ecosystem, prioritization of use cases is necessary. This work presents a methodology for this prioritization, taking into consideration policy relevance, data and digital infrastructures and adherence to European approaches, principles and values. This methodology can also be used for identifying noteworthy research projects in the Earth observation (EO) domain that possess policy relevance and have the potential to be transformed into sustained and operational services beyond the funding period, focusing on research projects funded by Horizon 2020 (H2020) and Horizon Europe EU Framework Programmes for Research and Innovation. We applied this methodology to an H2020 project named "EuroGEO Showcases: Applications Powered by Europe (e-shape)", composed of 37 pilots, and here we present the results. This process led to the identification of a priority pilot on solar energy potential assessment in urban areas, for which EC Knowledge Centre on Earth Observation (KCEO) will participate in co-design activities with ARMINES, the leader of this pilot. We finally present the pilot shortly and elaborate on the next steps.

1. BACKGROUND

1.1 GEO and EuroGEO

Earth observation (EO) plays a significant role in the European Union's (EU) policy priorities, particularly in areas related to environmental protection and conservation, climate change mitigation and adaptation, disaster management and sustainable living. Appendix B provides a list of policy areas defined by the European Commission (EC) Knowledge Centre on Earth Observation (KCEO). Some of these are interconnected, which also enables the use of EO in supporting policy coherence. The EU emphasizes the use of EO to support the development and implementation of measures for environmental protection and conservation, assess the environmental impact of policies and track progress towards environmental goals. This relates to several policy areas defined by the KCEO, such as biodiversity, marine pollution and soils. In addition, EO plays a substantial role in understanding climate change processes, assessing the effectiveness of climate policies and supporting adaptation measures to address the impacts of climate change on ecosystems, infrastructures and human populations. In the context of disaster management, EO is indispensable for modern early warning and monitoring systems of natural hazards such as floods, wildfires and droughts and on-demand mapping for specific emergencies. These support all phases of disaster management: preparedness, emergency response and post-disaster recovery. Finally, EO supports sustainability by providing information on processes such as land use, urbanization and agricultural practices. In all of these policy use cases, EO contributes to evidence-based decision-making and policy development and monitoring progress towards policy objectives by providing objective and reliable information. Furthermore, often EU policy priorities are linked and in some cases, a response to commitments to global treaties and conventions (e.g., United Nations Framework Convention on Climate Change (UNFCCC) related to climate, Convention on Biological Diversity (CBD) related to biodiversity, United Nations Convention to Combat Desertification (UNCCD) related to desertification, Sustainable Development Goals (SDGs)) and EO can support both the global and EU dimensions of these policies. As a consequence, the EU actively supports global initiatives such as Group on Earth Observations (GEO) intergovernmental initiative, through related research activities in Horizon 2020 and Horizon Europe and the Copernicus Programme (Goor et al., 2021).

Europe is one of the world leaders in EO and is a strong component of GEO. GEO is an intergovernmental body that transcends national and disciplinary boundaries and aims to inform research, decision- and policy-making and actions by establishing open, coordinated, comprehensive and sustained EO data, information and services. One of the goals of GEO is to build a Global Earth Observation System of Systems (GEOSS), which is a framework that brings together EO-based data, information and services from various sources worldwide. Boldrini et al. (2023) expand on GEO and GEOSS and analyse what the GEOSS Platform provides and how users are utilizing them. Di Leo et al. (2023), taking a more comprehensive approach,

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review the landscape of EO digital platforms and classify them based on the services offered.

Europe is actively participating in GEO through EuroGEO, a regional contribution that aims to improve the efficiency and effectiveness of EO data utilization, especially in the context of regional policy priorities and environmental challenges. EuroGEO focuses specifically on the European context, fostering collaboration among European countries, research institutions, industry and user communities to enhance access and use of EO data and information. By promoting data sharing, interoperability and capacity-building, EuroGEO aims to contribute to a more sustainable and resilient Europe, supporting evidence-based policies and actions. EC, as the co-lead of EuroGEO, is currently outlining an ecosystem that will interconnect European technologies, digital infrastructures and data and enable the implementation of policy-relevant use cases using shared standards. This objective is aligned with the broader GEOSS vision and actively contributes to the global efforts of sharing EO data and information and fostering international cooperation in EO initiatives. To evaluate and demonstrate the potential of this ecosystem, prioritization of use cases is necessary. These use cases, beyond just being implemented and further developed in a prototypical ecosystem, also hold the potential to guide the identification of the requirements, design principles and architecture for the future and operational ecosystem.

1.2 H2020 e-shape Project

The EU Framework Programmes for Research and Innovation, most recently named Horizon 2020 (H2020) and Horizon Europe, have dedicated substantial investments in developing prototype and demonstration products and services based on EO. Although attempts are being made increasingly within the projects themselves, no systematic assessment has been undertaken regarding their policy relevance and technical aspects. To address this gap, we have developed a methodology for identifying noteworthy research projects in the EO domain that possess policy relevance and have the potential to be transformed into sustained and operational services beyond the funding period. This methodology has been applied to an EU flagship project funded through the H2020 programme, "EuroGEO Showcases: Applications Powered by Europe (e-shape)" (Ranchin et al., 2021) (May 2019–April 2023) and the initial results are presented and discussed here. The e-shape project aimed to have various applications (37 pilots) using EO data and cloud capabilities as services and establish a stronger connection between GEO and the Copernicus Programme. The pilots of the e-shape project have been considered for implementation and further development by the KCEO.

2. MEASURES DEFINED FOR ANALYSIS

The present work aims to identify the most prominent and policy-relevant pilots of the e-shape project that require heterogeneous data to be shared with EuroGEO via the KCEO. To accomplish this, the methodology we conceived considers various dimensions of the pilots, i.e., policy relevance, data and digital infrastructures and adherence to European approaches, principles and values. These dimensions and the rationale for the adopted measures for the analysis are reported hereafter.

Starting with policy relevance, the use cases should be highly relevant to the EU policy agenda. To evaluate their relevance, the policies/legislation in use such as the Renewable Energy Directive, Farm to Fork Strategy, Urban Agenda for the EU, EU Biodiversity Strategy for 2030, EU Common Foreign and Security Policy and EU Directive on European Critical Infrastructures, among others, are linked to the pilots if a link has already been established in the pilots' descriptive text on the e-shape website (https://e-shape.eu/), the webinars of the e-shape project or the information disseminated on other platforms related to the pilots. Additionally, the policy areas outlined in the policy typology given in Appendix B are associated with the pilots to paint an overall picture of emphasis in the e-shape project, but are not considered for prioritization as all the pilots relate to these general policy areas.

Secondly, the selected use cases preferably already have ties with GEO so that the European research and development projects can be brought to the attention of the GEO community and possibly influence its strategic decisions, namely drafting of the GEO Work Programme, to reflect European research and development priorities more easily. This would also foster cooperation with non-European partners through GEO, rather than on a bilateral basis. In this regard, having a relation to the Flagships, Initiatives or EuroGEO in the GEO Work Programme 2020–2022 and GEO Work Programme 2023–2025 is used as a measure. However, a new tie with GEO for a project may be created if it is not already in place, so this measure is not considered essential.

Finally, the selected use cases should ideally have international relevance, and in this respect, the four global priority engagement areas of GEO are significant, which are the United Nations 2030 Agenda for Sustainable Development, Paris Agreement, Sendai Framework for Disaster Risk Reduction and Resilient Cities and Human Settlements. A relation to these engagement areas if stated in the sources related to the pilots is certainly established, yet also extended by the authors if deemed appropriate. In terms of the Agenda's SDGs, only the goal is identified by the authors; the target and indicator level of the SDGs have not been considered so far. Finally, for establishing the relevance to the Sendai Framework, hazard information profiles (HIPs) defined by Murray et al. (2021) are used for reference.

Regarding data and digital infrastructures, firstly, the use cases should preferably use data from the Copernicus component of the EU Space Programme. In this respect, data from the Copernicus Sentinel Missions are expected to be used in the selected use cases. In case the spatial resolution is not sufficient, using data from the Copernicus Contributing Missions is also considered positive. Additionally, using Copernicus Services, which are dedicated to delivering specific data products and information in key thematic areas through Copernicus Atmosphere Monitoring Service (CAMS), Copernicus Climate Change Service (C3S), Copernicus Land Monitoring Service (CLMS), Copernicus Emergency Management Service (CEMS), Copernicus Marine Environment Monitoring Service (CMEMS) and Copernicus Security Service (CSS) is deemed as positive as using data from the Missions. Copernicus Services provide users with operational and user-oriented information, enabling them to address environmental challenges, monitor trends and respond to emergencies effectively.

The input data are also expected to be heterogeneous in terms of their source. More specifically, they are expected to be from a combination of capturing mechanisms that are (a) satellites or aircraft (remotely sensed), (b) in-situ measurement devices and (c) citizen science or data collection projects (crowdsourced). Data derived from remotely-sensed data are also considered

remotely sensed. Data collection projects may be surveys, a feedback collection mechanism, OpenStreetMap (OSM), social media, etc. The use of data obtained from two of these three mechanisms leads to a positive evaluation of this measure. Heterogeneous data enhance the quality of a research project's results, as the listed data sources have different strengths and weaknesses. For instance, while remotely-sensed data cover a large geospatial region, in-situ data can inform on some phenomena that cannot be sensed remotely, refer to a position in space that is more granular and can be used for validation. In addition, human intelligence can provide inputs that neither of the above-mentioned technologies can yet provide as reliably, such as identifying species of the biosphere, street names, etc. Among the crowdsourced data, social media data can assist in understanding the groups of people and accessing data otherwise hard to access, such as field photos from around the world.

Moreover, the continuity potential of the input data is taken into account as the chosen use cases are desired to exist as far into the future as possible or at least not be interrupted due to the unavailability of data. Data from the Copernicus Programme, more specifically Sentinel satellites and Copernicus Services are considered to have a high potential for continuity. Also, the Landsat program and some well-established projects such as OSM and Long-term Ecosystem Research in Europe (eLTER) are considered to most likely continue their operation in the relevant period. On the other hand, satellite missions that are not stated to be replaced with another and in-situ and crowdsourced data that are not tied to a long-standing project are considered to have a low continuity potential.

The selected use cases also preferably take advantage of the existing European digital infrastructures, notably offered by the Copernicus Data Space Ecosystem (CDSE) (formerly named Data and Information Access Services (DIAS)), WEkEO, the European Open Science Cloud (EOSC) and the Infrastructure for Spatial Information in Europe (INSPIRE). Additionally, the use of GEO Discovery and Access Broker (GEO DAB), which is a brokering framework that enables discovery, access and use of data, information and services shared by GEOSS providers, is considered positive. The involvement with GEO DAB may be in two different ways. Firstly, a use case may use GEO DAB to access resources. Secondly, the results of a use case may be published via GEO DAB in the GEOSS Portal. Both are favourable as in the first case, it is more likely to go through more resources that meet the requirements of a use case and following this approach may lead to the reuse of a service such as Open Geospatial Consortium (OGC) Web Processing Service (WPS) or Web Map Tile Service (WMTS) and the avoidance of setting up an infrastructure to deliver these services and in the second case, the GEO mission is supported by making the research results available to the wider public.

Additionally, it should be possible to generalise the selected use cases to a larger geographic region if necessary. The extended region depends on the topic of the use case. The influencing factors include environmental features such as climatic or soil properties and political boundaries. It may be ideal to define the region as the whole Earth in some use cases. If getting the results of a pilot for an extended region that is most well-suited to comprehend the topic under study or deliver the policy requirements is impossible due to various reasons, such as mandatory in-situ data being unavailable or a model that has been developed for a specific region, it renders the pilot less favourable. For each e-shape pilot, the ideal region is defined.

A final important aspect is the adoption of European approaches, principles and values, in terms of the use and sharing of data and software. In light of the recent EU policies and legislation such as the European Strategy for Data (European Commission, 2020a), the Open Data Directive (European Parliament and Council of the European Union, 2019), the Open Source Software Strategy 2020–2023 (European Commission, 2020b) and the Interoperable Europe Act (European Commission, 2022), use cases that adhere to open principles in terms of data, software code and science are more likely to be prioritized. More specifically, an open data repository for the outputs of a project, open code for the implementation of the methodology and open-access scientific publications are expected. If a pilot has commercial pursuits, following open principles is not expected principally, yet these pilots are not treated differently in the analysis. Following these principles enhance the reproducibility potential of a use case. Finally, if applicable, a use case should respect the General Data Protection Regulation (GDPR) when managing personal data.

An aspect that hasn't been considered yet during the prioritization process is the publication of documentation along with the released code and data. This is as well an important element to consider as the lack of documentation hinders the reproducibility of a use case, which is fundamental if the pilots are to transition to a sustained operational setting in support of policy. Moreover, the technology readiness level (TRL) could be taken into account as use cases with a high TRL level are more mature and therefore more suitable for operationalization. In this respect, the e-shape project has developed a methodology named pilot exploitation readiness level (PERL) (e shape, 2021) that incorporates technical, operational and market-related parameters in the assessment of the readiness of an EO-based solution. This approach may be used during the prioritization process, as it examines beyond technology-related aspects considered by TRL.

3. RESULTS

Using the measures defined above, the analysis of the e-shape pilots has been performed, yet will be reviewed following the formal end of the project in April 2023, and the results will be shared with the public. The analysis that has been performed so far reveals that all the pilots of the e-shape project are related to at least one of the policy areas defined by the KCEO, yet a little less than half of them have been explicitly linked to the EU policies/legislation in use by the teams executing the pilots. This may be due to the fact that the e-shape project has an emphasis also on market uptake. Furthermore, similarly to the EU policy areas, all the pilots have a connection to the United Nations 2030 Agenda for Sustainable Development, Paris Agreement, Sendai Framework for Disaster Risk Reduction or Resilient Cities and Human Settlements. On the other hand, approximately half of the pilots have a connection to the Flagships, Initiatives or EuroGEO in the GEO Work Programme 2020–2022 and GEO Work Programme 2023–2025. In terms of data, most pilots use data from the Copernicus Programme and around three over four of the pilots use heterogeneous data. Moreover, about one over four of the pilots' data sources have high continuity potential and similarly, around one over four of the pilots can either be generalised to their ideal geographic region without any modification to the data sources or methodologies used or already cover their ideal geographic region. Close to half of the pilots use one or more of the existing digital infrastructures listed in the measures and almost all the pilots

are registered to GEOSS. Furthermore, rarely the results of the pilots, namely the data, code and scientific publications, are all open. Finally, adherence to GDPR is mostly not relevant.

In the analysis process, the pilots that can be reused or extended by the Joint Research Centre (JRC) have been noted. This would potentially enable to use the expertise of the JRC, including on the science-policy interface, and to further develop and tailor the products and services so that they are fit-for-purpose for policy. The primary goal has been to identify a specific project related to a pilot, which is rarely the case. However, if only a Directorate or Unit which works on the same or a similar topic can be identified, it still has been taken into consideration, which is the case most times.

These results reflect the current landscape, certainly in the e-shape project and to some extent in the European EO research scene in general, with respect to the methodology defined, and reveal in which areas more effort is needed and in which others the desired state has already been achieved. Some of these results are visualized to enable better comprehension. Firstly, an alluvial diagram displays the relationships among the SDGs and e-shape pilots, which shows that SDG 13 (climate action) has been the most addressed SDG in the e-shape project, while the second most addressed is SDG 2 (zero hunger) (Figure 1). Moreover, a matrix plot shows the mapping across the KCEO policy areas and e-shape pilots (Figure 2), which is also supplemented by Table 1 to potentially enable easier reading. This mapping reveals the most emphasized policy areas, which are related to climate change, mitigation and adaptation combined, with 20 associated pilots and support to natural and man-made disasters, with 18 associated pilots. More precise results for the rest of the measures will be published in the report following this article.

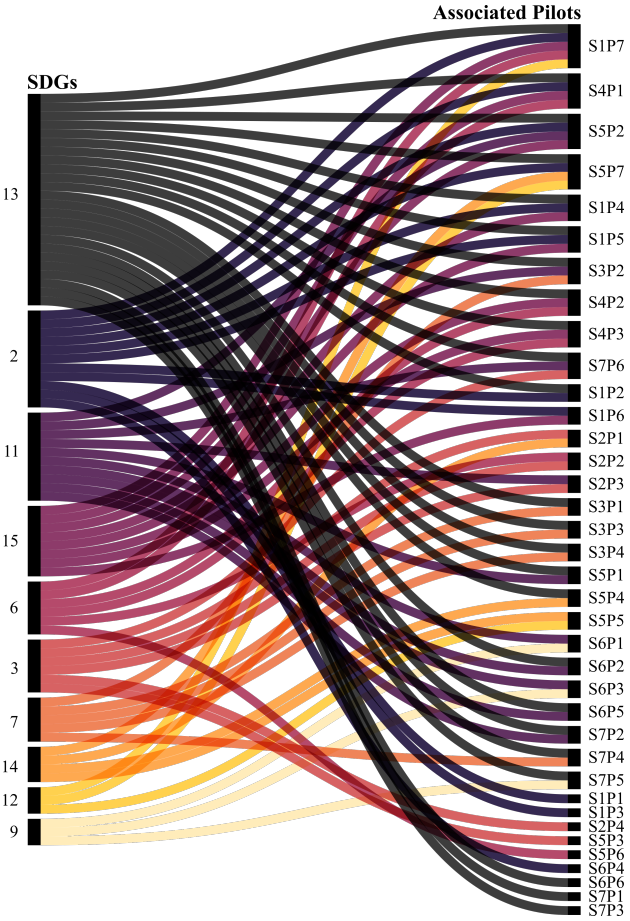

Figure 1. Relatioships among SDGs and e-shape pilots.

4. CONCLUSIONS AND NEXT STEPS

As a result of the analysis, we have seen that even though none of the pilots provided a positive response to all of the measures, some of them stand out with higher overall positive results. The results achieved, together with the current focus of activities of the KCEO, led to the selection of the pilot titled High Photovoltaic Penetration at Urban Scale (S3P2: showcase 3, pilot 2), led by ARMINES (Appendix A) as a use case to contribute to the evolution of Europe's contribution to GEOSS. Co-design activities (Barbier et al., 2021) are taking place between the KCEO and ARMINES for the development of this use case. Such activities may take place also with other pilots of the e-shape project that most closely follow the measures. The first selected pilot focuses on solar energy potential assessment in urban areas in line with the Horizon Europe Climate-Neutral and Smart Cities and Adaptation to Climate Change Missions. In addition, it contributes to SDGs 7 (affordable and clean energy) (in particular target 7.1 "by 2030, ensure universal access to affordable, reliable and modern energy services" and target 7.2 "by 2030, increase substantially the share of renewable energy in the global energy mix"), 11 (sustainable cities and communities) and 13. It is also related to the Paris Agreement, Resilient Cities and Human Settlements, European Green Deal, Renewable Energy Directive, REPowerEU, EU Solar Energy Strategy and European Solar Rooftops Initiative. This pilot is also part of the GEO-VENER Initiative in both the previous and current GEO Work Programmes. In terms of the KCEO policy areas, it relates to climate change mitigation, energy, regional and urban policies and SDGs. Furthermore, this pilot uses data from Sentinel-1 and -2, CAMS and C3S; combines remotely-sensed, in-situ and crowdsourced data and executes the processing on WEkEO. It is also registered to GEOSS via GEO DAB. In addition, this pilot is developed following open principles for the most part. Finally, the GDPR does not apply to this project. The bottleneck in this pilot is the use of 2D cadastral data and high-resolution DSM from the National Institute of Geographic and Forest Information (IGN, France), airborne EO data and in-situ data that may not be available/updated in the future and restricts the generalization of the pilot to the areas where similar datasets are available, which cover less than the ideal geographic region. Building on this pilot, it is also possible to collaborate with the JRC colleagues who are working on the Photovoltaic Geographical Information System (PVGIS) project. In summary, the next steps include the review and publication of the detailed analysis of each pilot of the e-shape project and the co-design and development of the selected one.

DISCLAIMER

The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official positio nof the European Commission.

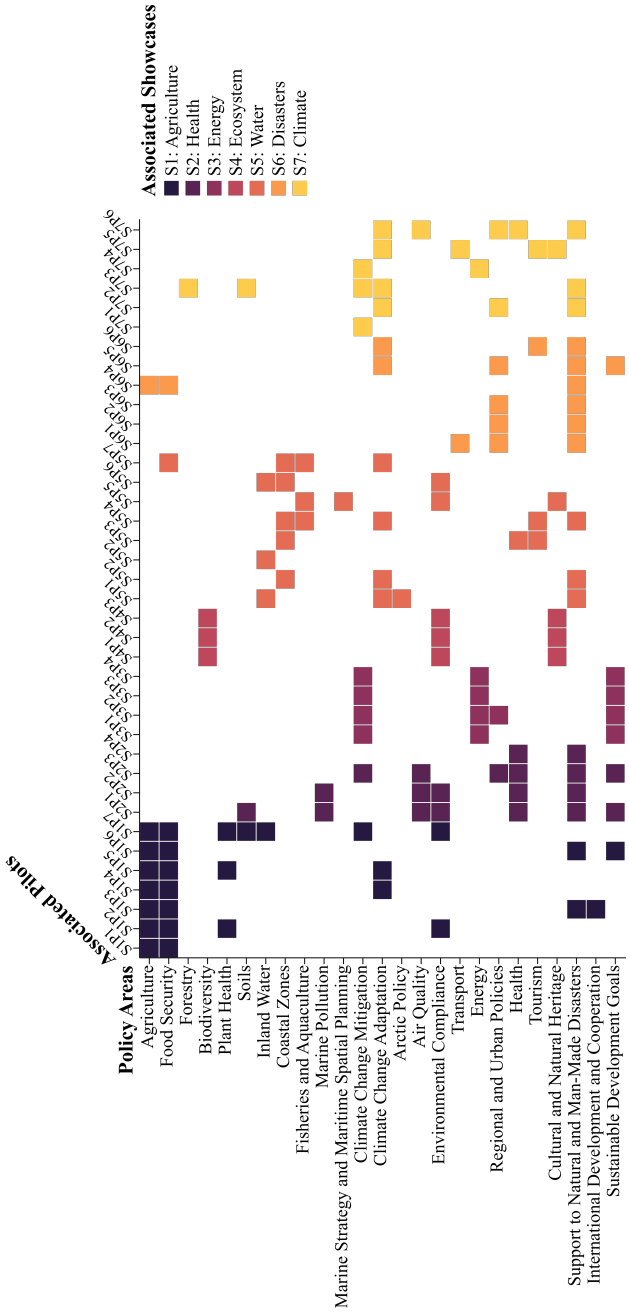

Figure 2. Mapping across KCEO policy areas and e-shape pilots.

A. APPENDIX: E-SHAPE PILOTS

- S1P1: GEOGLAM
- S1P2: EU-CAP Support
- S1P3: Vegetation-Index Crop-Insurance in Ethiopia
- S1P4: Agro Industry
- S1P5: Linking EO and Farm IoT for Automated Decision Support
- S1P6: Service for SDG 2.4.1 and 15.3.1 Indicators Assessment
- S1P7: DynaCrop: Unlocking EO Intelligence Across the Food Value Chain
- S2P1: EO-based Surveillance of Mercury Pollution
- S2P2: EO-based Surveillance of POPs Pollution
- S2P3: EO-based Pollution-Health Risks Profiling in the Urban Environment
- S2P4: EYWA: EarlY WArning System for Mosquito-Borne Diseases
- S3P1: nextSENSE: Solar Energy Nowcasting & Short-Term Forecasting System
- S3P2: High Photovoltaic Penetration at Urban Scale
- S3P3: Merging Offshore Wind Products
- S3P4: WindSight: First Class Input Data for Wind Energy Models
- S4P1: mySPACE
- S4P2: mySITE
- S4P3: myVARIABLE
- S5P1: Improved Historical Water Availability & Quality Information Service
- S5P2: Satellite Earth Observation-Derived Water Bodies & Floodwater Record Over Europe
- S5P3: Dive: Diver Information on Visibility in Europe
- S5P4: Sargassum Detection for Seasonal Planning
- S5P5: Monitoring Fishing Activity
- S5P6: EO-based Phytoplankton Biomass for WFD Reporting
- S5P7: Rheticus® AquaculturePlus
- S6P1: EO4D_ASH: EO Data for Detection, Discrimination & Distribution (4D) of Volcanic Ash
- S6P2: GEOSS for Disasters in Urban Environment
- S6P3: Assessing Geo-hazard Vulnerability of Cities & Critical Infrastructures
- S6P4: ReSAgri: Resilient & Sustainable ecosystems including Agriculture & food
- S6P5: FRIEND
- S6P6: MountaiNow
- S7P1: Global Carbon and Greenhouse Gas Emissions
- S7P2: Urban Resilience to Extreme Weather: Climate Service
- S7P3: Forestry Conditions: Climate Service
- S7P4: Hydropower in Snow Reservoir: Climate Service
- S7P5: Seasonal Preparedness
- S7P6: Super-resolution Air Quality Monitoring Service

B. APPENDIX: KCEO POLICY AREAS AND E-SHAPE PILOTS

Policy Area	Associated Pilots
Agriculture	S1P1, S1P2, S1P3, S1P4, S1P5, S1P6, S1P7, S6P4
Food Security	S1P1, S1P2, S1P3, S1P4, S1P5, S1P6, S1P7, S5P7, S6P4
Forestry	S7P3
Biodiversity	S4P1, S4P2, S4P3
Plant Health	S1P2, S1P5, S1P7
Soils	S1P7, S2P1, S7P3

Inland Water	S1P7, S5P1, S5P2, S5P6
Coastal Zones	S5P2, S5P3, S5P4, S5P6, S5P7
Fisheries and Aquaculture	S5P4, S5P5, S5P7
Marine Pollution	S2P1, S2P2
Marine Strategy and Maritime Spatial Planning	S5P5
Climate Change Mitigation	S1P7, S2P3, S3P1, S3P2, S3P3, S3P4, S7P1, S7P3, S7P4
Climate Change Adaptation	S1P4, S1P5, S5P1, S5P2, S5P4, S5P7, S6P5, S6P6, S7P2, S7P3, S7P5, S7P6
Arctic Policy	S5P1
Air Quality	S2P1, S2P2, S2P3, S7P6
Environmental Compliance	S1P2, S1P7, S2P1, S2P2, S4P1, S4P2, S4P3, S5P5, S5P6
Transport	S6P1, S7P5
Energy	S3P1, S3P2, S3P3, S3P4, S7P4
Regional and Urban Policies	S2P3, S3P2, S6P1, S6P2, S6P3, S6P5, S7P2, S7P6
Health	S2P1, S2P2, S2P3, S2P4, S5P3, S7P6
Tourism	S5P3, S5P4, S6P6, S7P5
Cultural and Natural Heritage	S4P1, S4P2, S4P3, S5P5, S7P5
Support to Natural and Man-Made Disasters	S1P3, S1P6, S2P1, S2P2, S2P3, S2P4, S5P1, S5P2, S5P4, S6P1, S6P2, S6P3, S6P4, S6P5, S6P6, S7P2, S7P3, S7P6
International Development and Cooperation	S1P3
Sustainable Development Goals	S1P6, S2P1, S2P3, S3P1, S3P2, S3P3, S3P4, S6P5

Table 1. Mapping across KCEO policy areas and e-shape pilots.

The rest of the policy areas that do not have associated pilots are Raw Materials, Migration and Home Affairs and Security and Defence.

REFERENCES

Barbier, R., Ben Yahia, S., Le Masson, P., Weil, B., 2021. EXPANDING USAGES OF EARTH OBSERVATION DATA: A CO-DESIGN APPROACH TO GROW AN ECOSYSTEM OF EFFICIENT SERVICE DESIGNERS. *International Geoscience and Remote Sensing Symposium (IGARSS)*, Brussels, Belgium.

Boldrini, E., Nativi, S., Hradec, J., Santoro, M., Mazzetti, P., Craglia, M., 2023. GEOSS Platform data content and use. *International Journal of Digital Earth*, 16(1), 715–740. https://doi.org/10.1080/17538947.2023.2174193.

Di Leo, M., Minghini, M., Kona, A., Spadaro, N., Kotsev, A., Dusart, J., Lumnitz, S., Ilie, C. M., Kilsedar, C. E., Tzotsos, A., 2023. DIGITAL EARTH OBSERVATION INFRASTRUCTURES AND INITIATIVES: A REVIEW FRAMEWORK BASED ON OPEN PRINCIPLES. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLVIII-4/W7-2023, 33–40. https://isprs-archives.copernicus.org/articles/XLVIII-4-W7-2023/33/2023/.

e shape, 2021. PERL definitions.

European Commission, 2020a. A European strategy for data. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0066.

European Commission, 2020b. Open source software strategy 2020–2023. https://commission.europa.eu/system/files/2023-02/en_ec_open_source_strategy_2020-2023.pdf.

European Commission, 2022. Interoperable Europe Act. https://commission.europa.eu/system/files/2022-11/com2022720_0.pdf.

European Parliament and Council of the European Union, 2019. Directive (EU) 2019/1024 on open data and the re-use of public sector information (recast). https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1561563110433&uri=CELEX:32019L1024.

Goor, E., Freytag, I., Le Bouler, G., Dusart, J., Van Meerloo, M., Ollier, G., Ramhoer, J., 2021. EuroGEO – The European Component of GEO. *International Geoscience and Remote Sensing Symposium (IGARSS)*, IEEE, 290–292.

Murray, V., Abrahams, J., Abdallah, C., Ahmed, Kanza: Angeles, L., Benouar, D., Brenes Torres, A., Chang Hun, C., Cox, S., Douris, J., Fagan, L., Fra Paleo, U., Han, Q., Handmer, J., Hodson, S., Khim, W., Mayner, L., Moody, N., Moraes, L. L., Osvaldo, Nagy, M., Norris, J., Peduzzi, P., Perwaiz, A., Peters, K., Radisch, J., Reichstein, M., Schneider, J., Smith, A., Souch, C., Anne-Sophie, S., Triyanti, A., Weir, M., Wright, N., 2021. Hazard Information Profiles: Supplement To UNDRR-ISC Hazard Definition & Classification Review. Technical report, UNDRR.

Ranchin, T., Ménard, L., Fichaux, N., Reboul, M., 2021. e-shape – EUROGEO SHOWCASES: APPLICATION POWERED BY EUROPE CONTRIBUTION TO EUROGEO AND TO THE DEVELOPMENT OF THE EO INDUSTRY. *International Geoscience and Remote Sensing Symposium (IGARSS)*, Brussels, Belgium.