Monitoring of damages to cultural heritage across Europe using satellite earth observation: assessment of indexed and grey literature

Branka Cuca[1] - Deodato Tapete[2] - Federico Zaina[1]

[1]Politecnico di Milano, Dept. Of Architecture, Built environment and Engineering
[2] Italian Spatial Agency (ASI)

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PRESENTATION STRUCTURE

- Introduction to the subject
- Methodological framework and terminology
- Workflow of the research: data and methodology
- Main results
- Some first conclusions
- Future outlooks

Intro to the subject: an overview of previous indexed literature

Publication	Main topic	Time range	Geographic area	Outcomes
Agapiou and Lysandrou ***JASR*** 2015	Remote sensing in archaeology	1999-2015	Europe	Substantial increase of RS for archaeology. Authors identify a need for common repository to share knowledge.
Tapete and Cigna ***JARS*** 2017	SAR for Cult. Her.	1985-2016	World	SAR as an increasingly accessible and practical technique for monitoring multiple threats.
Luo et al. ***RSE*** 2019	Air/spaceborne imag. for C.H.	1907-2017	World	Different RS image techniques for different applications. Increase of access archive and novel data.
Luo et al. ***RS*** 2019	Google Earth application	2005-2016	World	GE as a basic efficient and open-access tool for cultural heritage monitoring.
Tapete and Cigna ***RS*** 2019	Looting detection	2006-2019	World	Substantial body of different satellite image-based processing methods. Lack of common practices, needs for more dissemination and user uptake.
Cuca and Zaina ***IEEE*** 2022	Most endangered types of cultural heritage	1969-2021	World	Substantial discepancy between damage documented and damage studied.

State-of-the-art on satellite applied to cultural heritage

PREVIOUS RECOMMENDATIONS

- More attention to **match properties** of current and future satellite **and** research questions and needs related to built cultural heritage and landscapes.
- It is necessary to raise awareness among archaeologists and CH experts on the range of uses of available satellites via more investments in **training and education**.
- Need to **expand and share the datasets** to increase the types of analyses.

→ Increasing although still limited level of engagement of experts in the field (e.g. archeologists, preservation specialists…).

→ Increase of international capacity building and training projects from 2015 onwards.

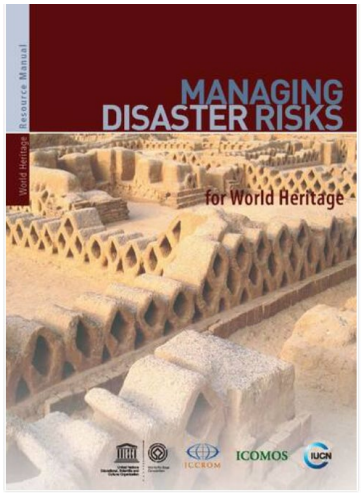
→ Satellite imagery archive platforms newly released (Sentinel-Hub) or improved (USGS).

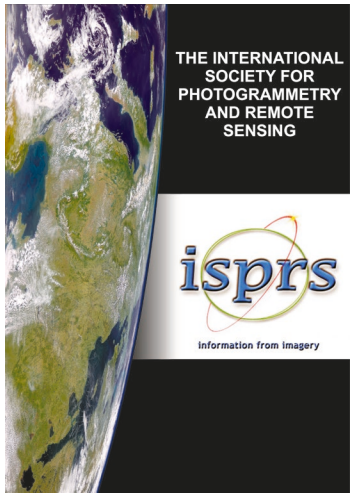
OPEN QUESTIONS

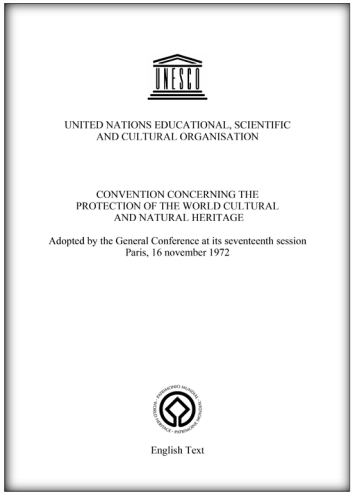
- What are the types of damage to cultural heritage studied using satellite imagery in Europe so far? Are all the types equally addressed?
- Is there a correlation between a specific type of damage and satellite-based technology?
- What is the affiliation of the authors? Are they mainly from universities, research centres, public institutions or private companies?

Methodological framework: terminology

- For the definition of the **types of damage** we relied upon the UNESCO *Managing disaster risks (2010)* updated with the web version (https://whc.unesco.org/en/factors/).
- The definition of the **geomatic technologies** was based on the International Society for Photogrammetry and Remote Sensing (ISPRS, https://www.isprs.org/)
- For the definition of the **types of heritage** we integrated four different conventions: 1. UNESCO World Heritage Convention (1972); 2. UNESCO Underwater Heritage Convention (2001); 3. UNESCO Intangible Heritage Convention (2003) 4. Council of Europe Landscape Convention (2020).







Methodological framework: Types of hazard

Examples of types of hazard as defined by UNESCO DRM (2010)

Looting and conflict

Buildings and Transports

Resource extraction

Service infrastructure

Climate change

Management

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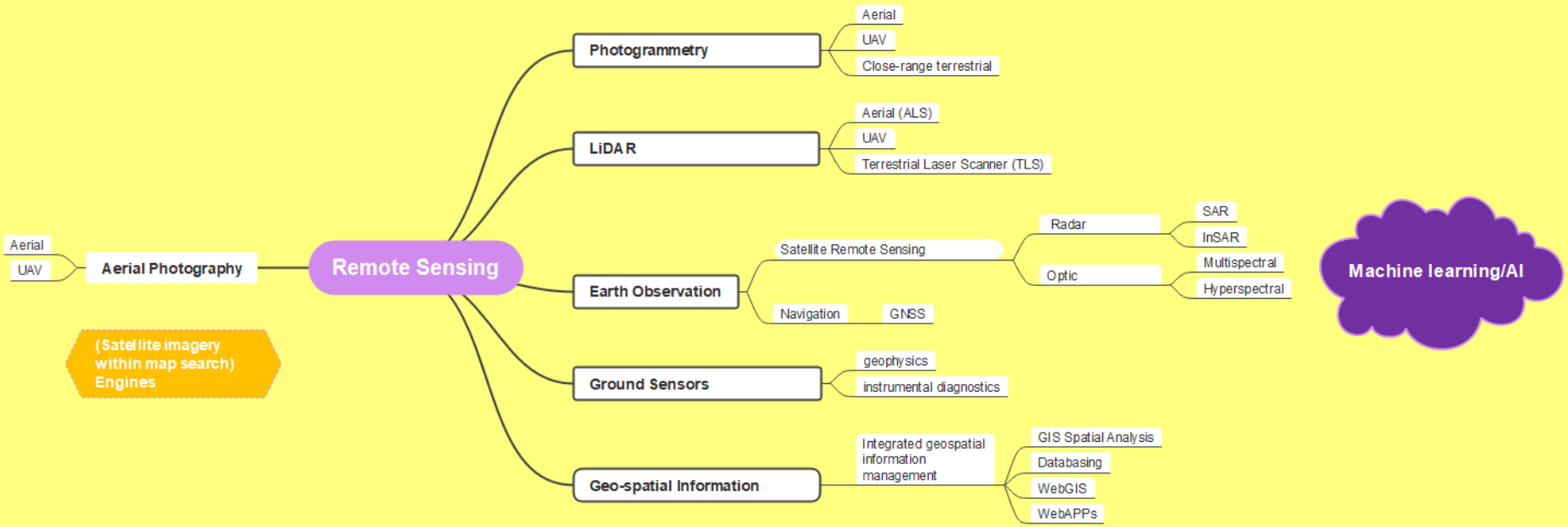
Methodological framework: Tecnologies



Methodological framework: Keywords

Scopus

TYPE OF TERMINOLOGY RESEARCH

ALL (Title, Keywords, Abstract)

CRITERIA

SUBJECT

Satellite AND Heritage AND Archaeology AND Hazards *
Satellite AND Heritage AND Archaeology AND Disaster *
Satellite AND Heritage AND Archaeology AND Threat *
Satellite AND Heritage AND Archaeology AND Risk*
Satellite AND Heritage AND Archaeology AND Damage*
Satellite AND Heritage AND Archaeology AND Destruction*

AREA

Affiliations from all EU countries

+

PERIOD

2000 - 2022

TOTAL of Step 1 (Automatic Data Collection on Scopus) = 1646 papers

TOTAL of Step 2 (Automatic duplicate values removal) = 749 papers

Methodological framework: “grey” literature

Motivations:

- Limitations of journal papers: mostly focused on applied research, methodological developments, proof of concept or case studies
- Not all demonstration activities have translated into papers or be presented at indexed conferences

Search rationale: similar to that applied to scientific literature

Sample:

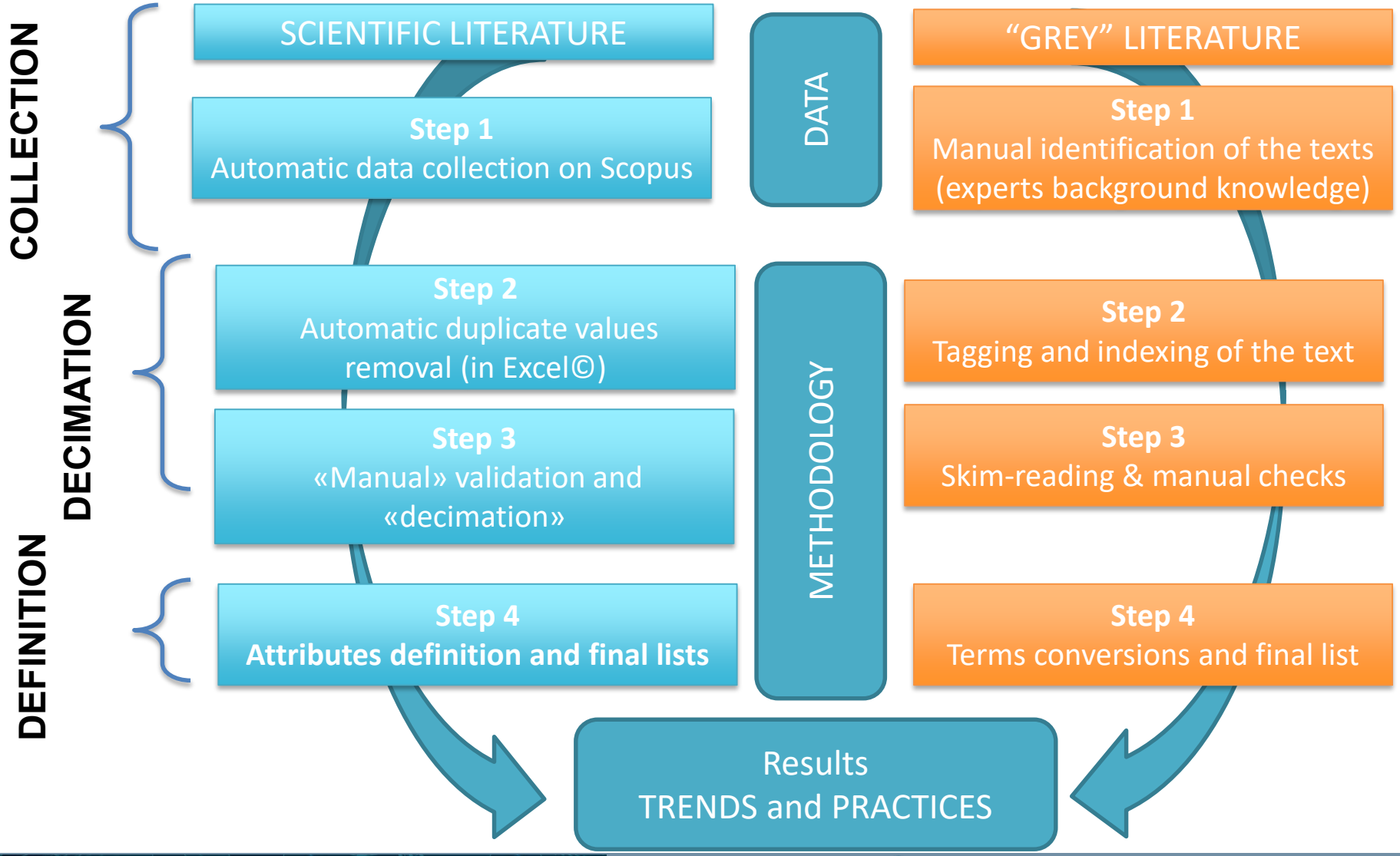
1. Guidance documents, standards, recommendations
2. Institutional / organisation documents
3. National Plans
4. Management Plans
5. Technical reports
6. Non-indexed conference proceedings

1 & 2

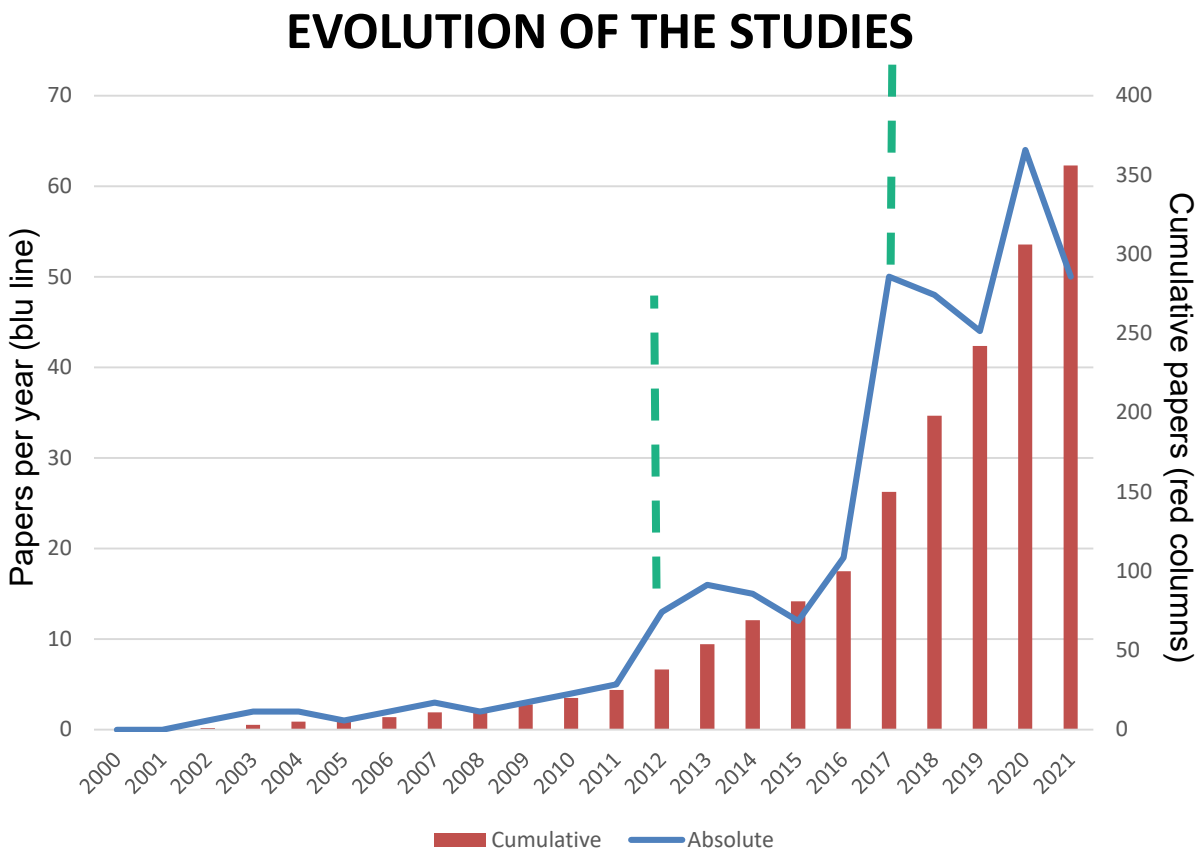
3 & 4

6

Workflow: data and methodology set-up



Scientific literature results: number of studies



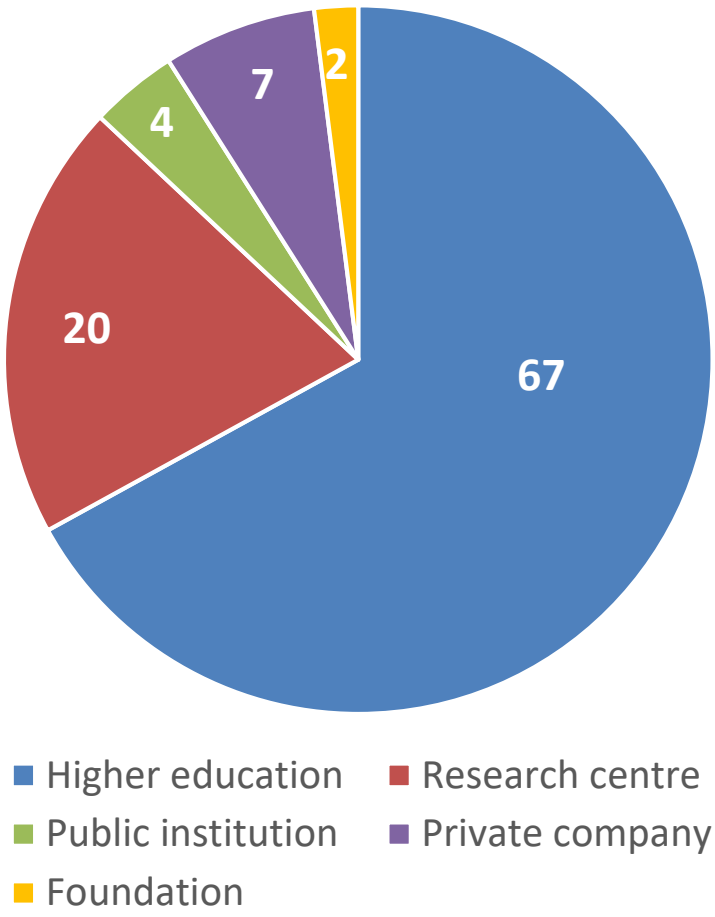
2000-2012: around 4-5 academic papers per year

2012-2016: around 15 academic papers per year

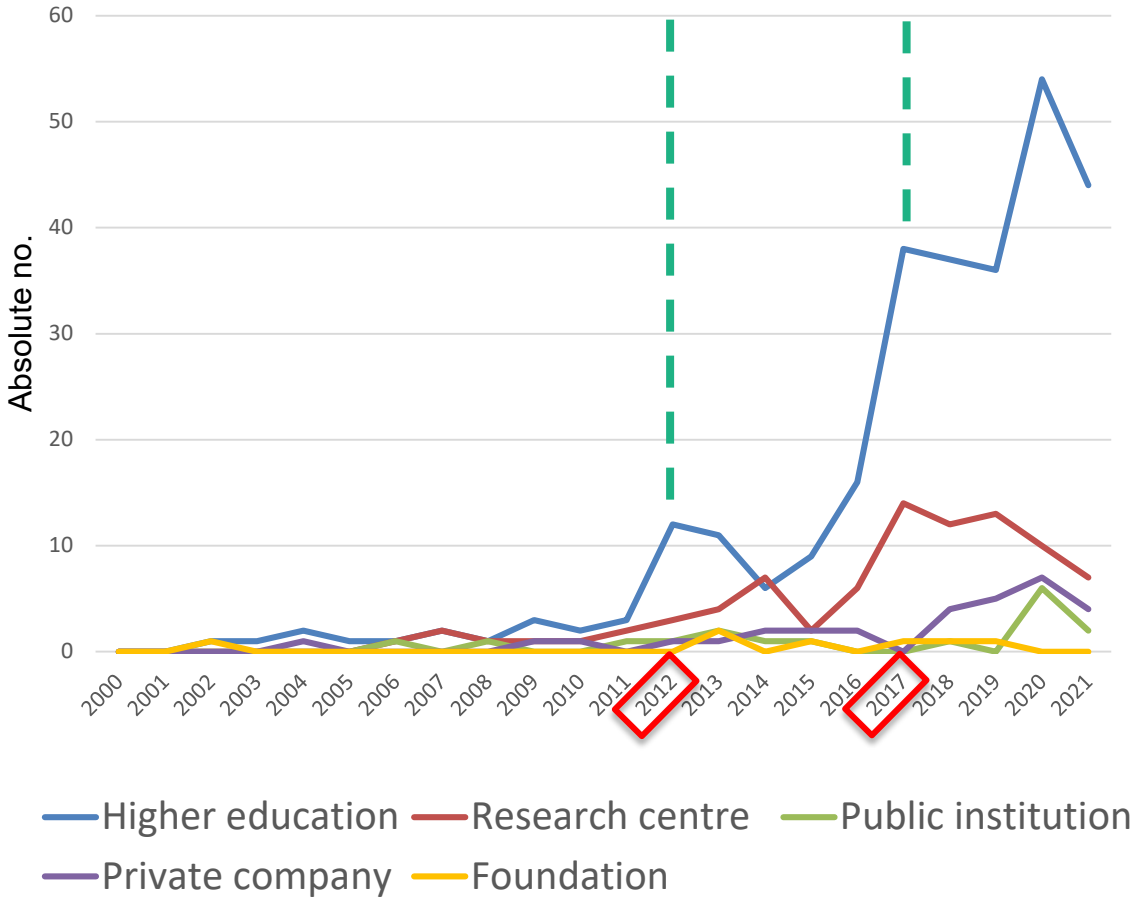
2017-today: around 50 academic papers per year

Scientific literature results: type of institutions

TYPE OF INSTITUTION (%)

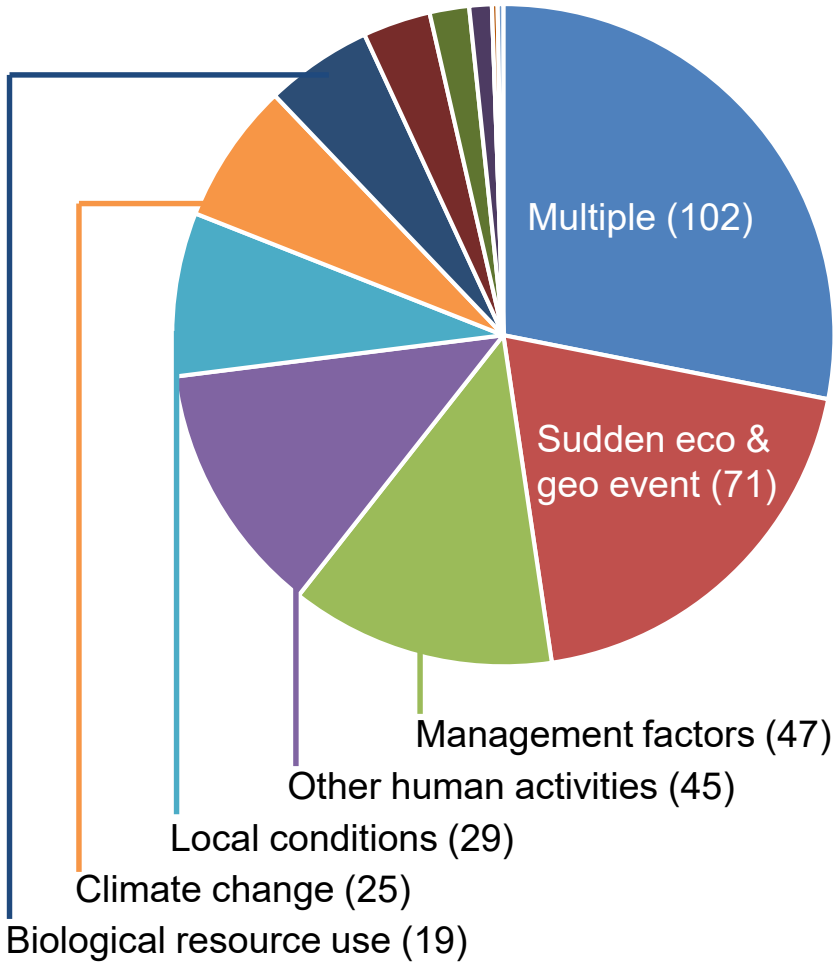


TYPE OF INSTITUTION (PER YEAR)

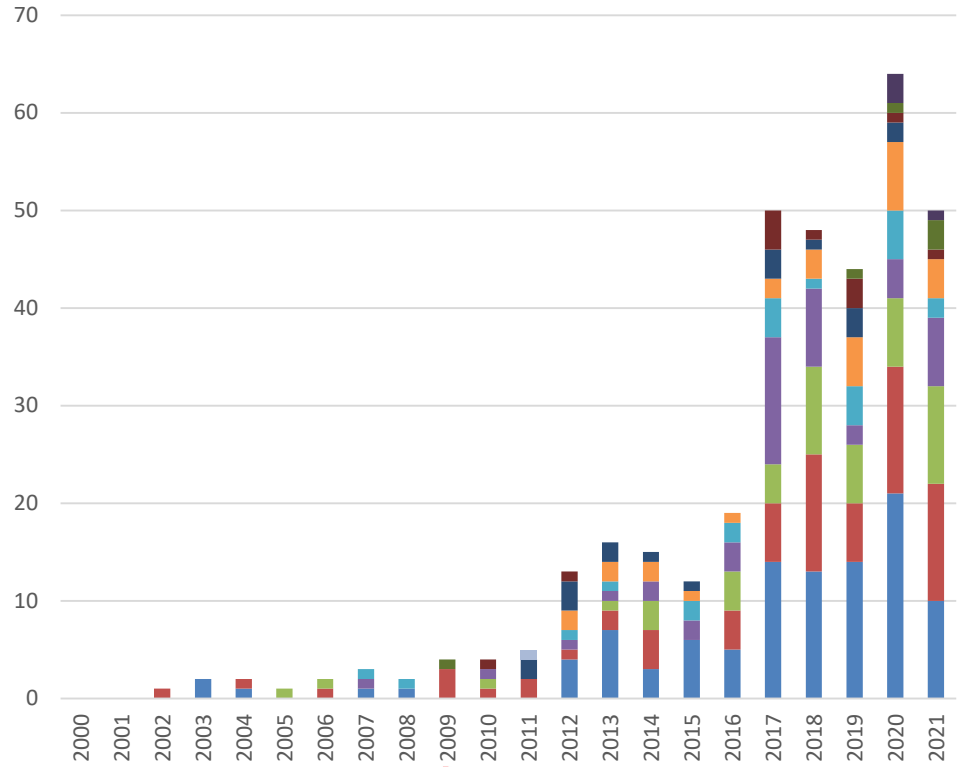


Scientific literature results: damaging factors

PRIMARY FACTORS



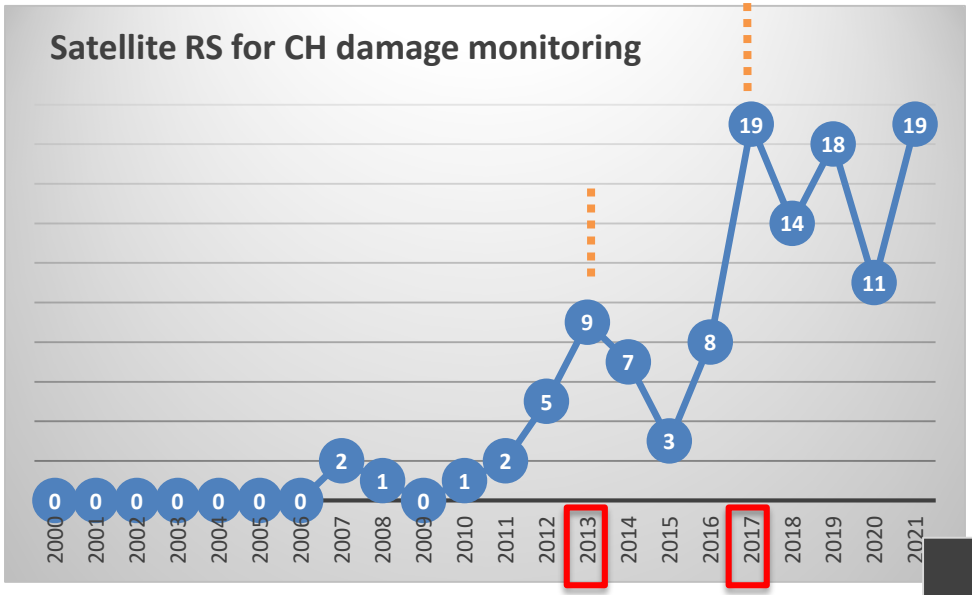
EVOLUTION OF THE STUDIES BY FACTOR



2 Up to 2 single types of factors analyzed

Up to 10 single types of factors analyzed 10

Scientific literature results: EO technologies

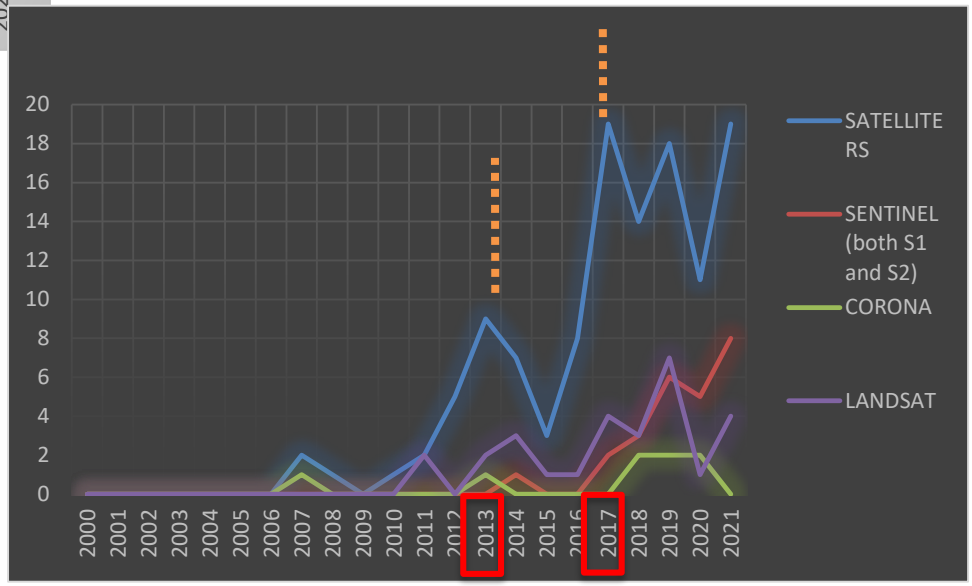


Use of Satellite Remote Sensing technologies
for damage monitoring
on cultural heritage sites in Europe

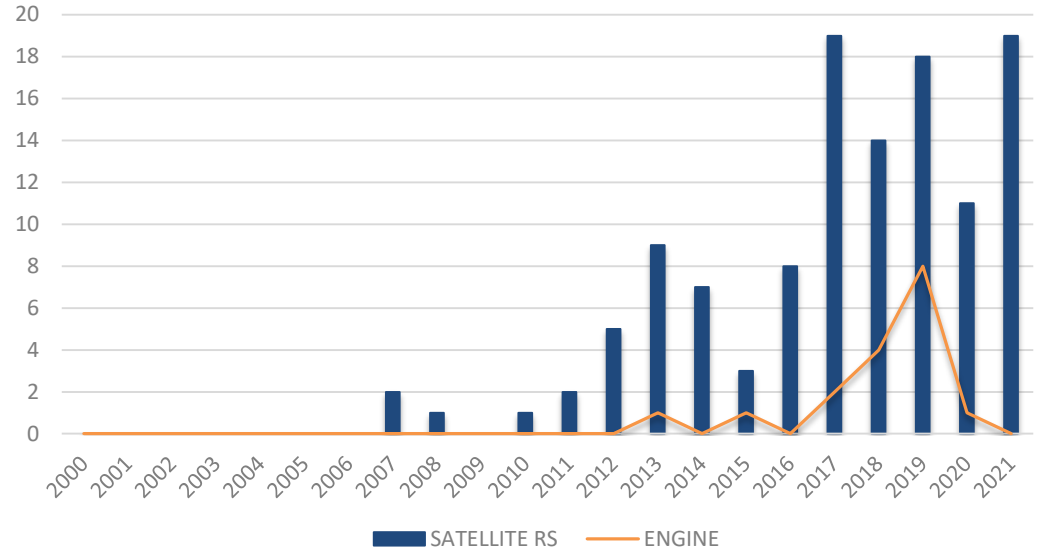
Close-up on Satellite Technologies in Europe per programme (2000-2021)

→ Categories further refined including SAR and InSAR, other data types/sources

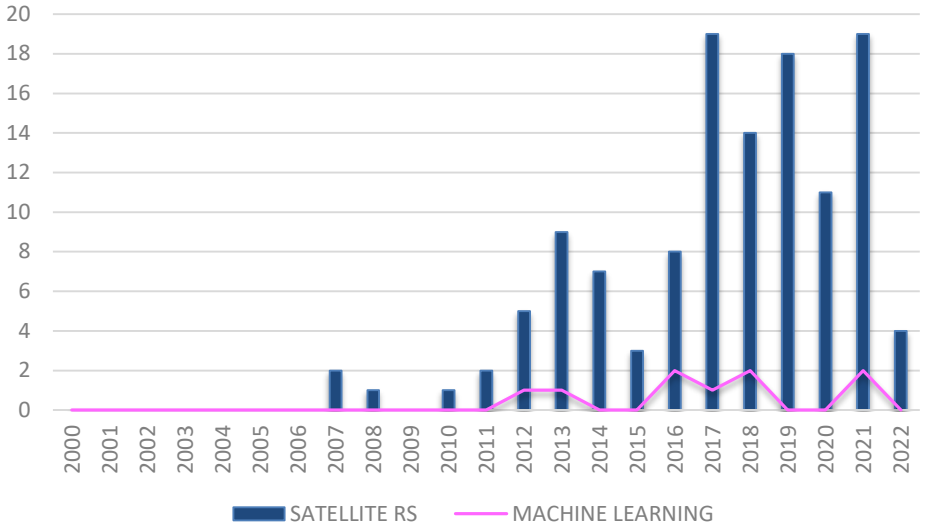
→ (work-in-progress)



Scientific literature results: EO technologies



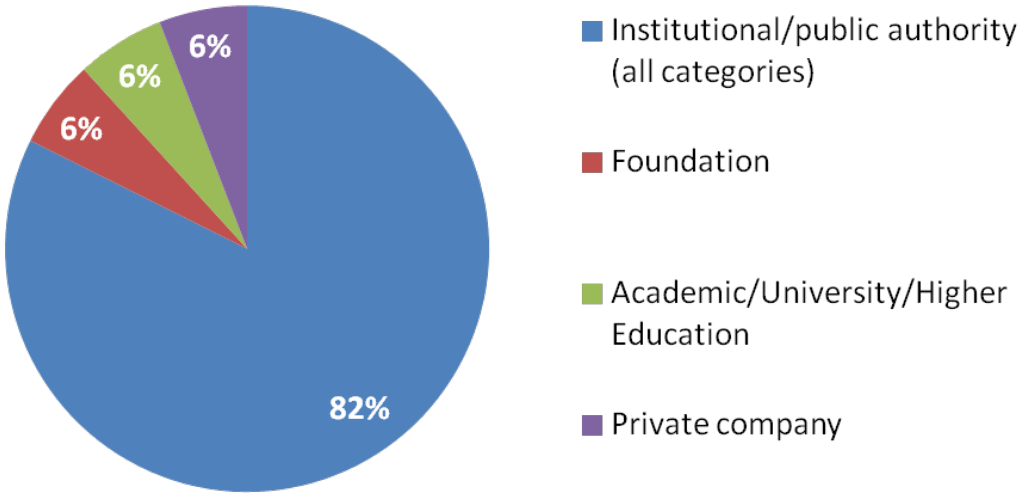
Overview of the use of Satellite Remote Sensing technologies: **Image processing methodologies vs. use of engines**



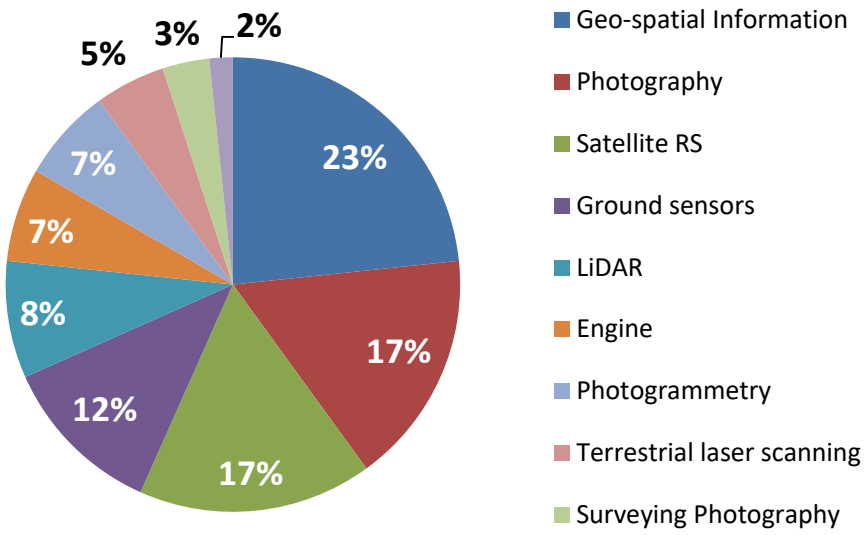
Overview of the use of Satellite Remote Sensing technologies: insight into machine learning
(work-in-progress)

Grey literature results: type of institutions & expertise

- Relative % distribution reflects the type of searched documents
- No distinction between Archaeology & Cultural Heritage for Institutional / public authority and Foundation
- More specializations for Academic/University/Higher Education
- Explicit ITC expertise mostly at private company collaborating with academia and/or public authorities



Grey literature results: technologies

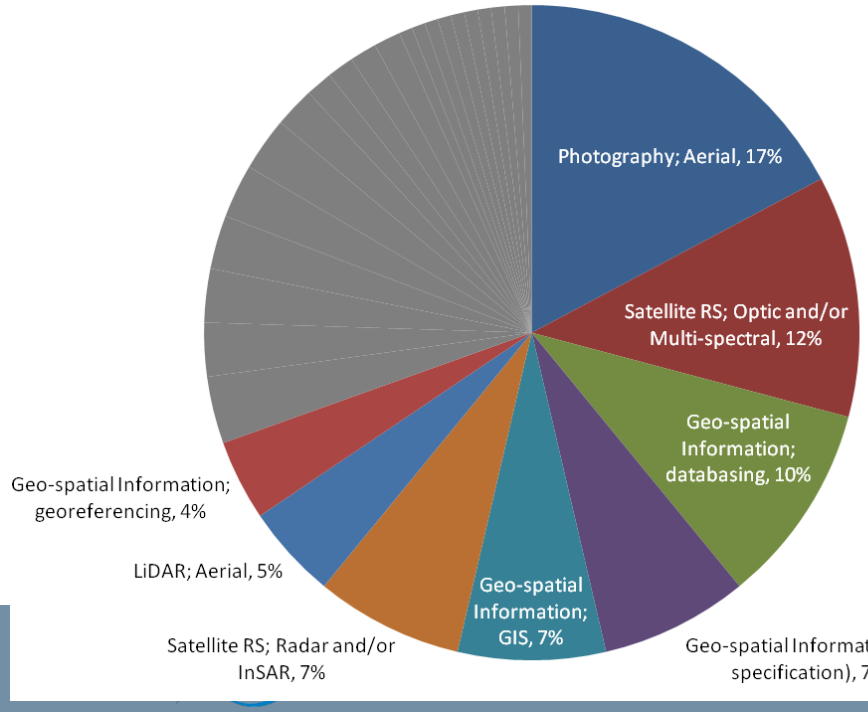


Technology macro-category

- "Geo-spatial information" is 1st and cross-cutting across countries
- "Photography" matches with long-standing tradition of aerial photography and familiarity with Google Earth imagery (see "Engine")
- "Satellite Remote Sensing" is 3rd with several sub-categories

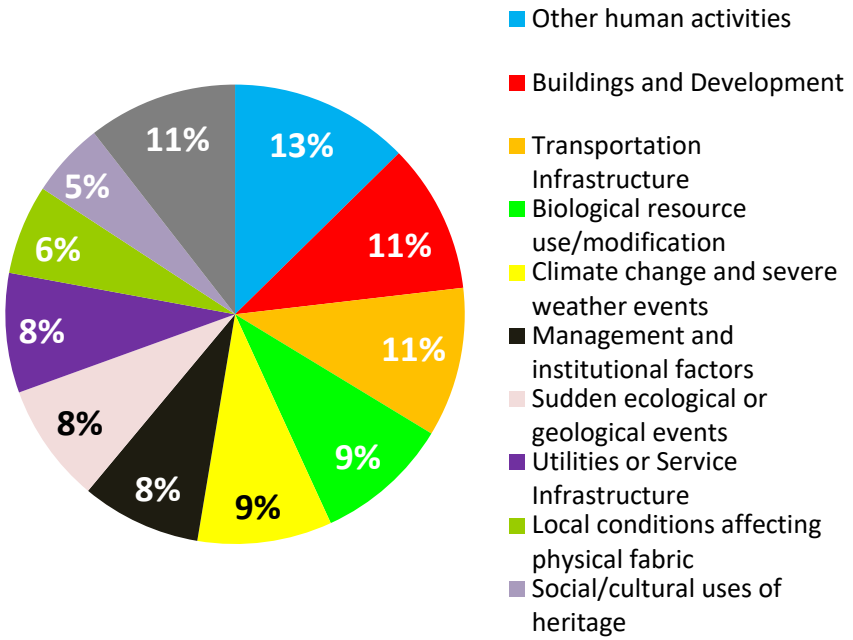
Technology sub-category (focusing on top-ranked)

- Within "Satellite Remote Sensing" use of "optical" > "SAR / InSAR" data
- Within "Geo-spatial information", "databasing" and "georeferencing" highlight the use of GNSS, GPS, NAV technologies for specific activities of digital documentation, inventorying/cataloguing, mapping



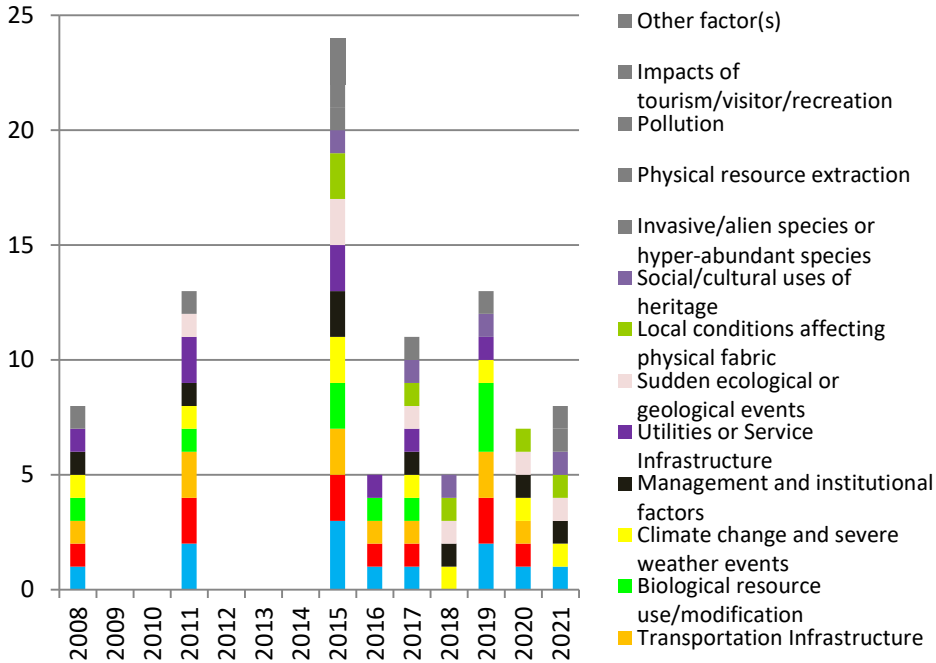
Grey literature results: damaging factors

Primary factor



- **No predominant factor!**
- First sources of concern: Human actions, impacts due to modern development, use of natural resources
- Climate and severe weather events
- Factors related to maintenance & management
- Weathering, erosion, etc. lower in the rank but mostly addressed with other types of technologies

Primary factor through time



- First sources of concern & climate are consistently present through time
- No specific trend is observed, given that the analyzed documents cover more than one factor
- **Plurality of threats to account for and mitigate**

Some first findings and conclusions

- The **unbalanced concentration of studies** on specific types of damage to cultural heritage in Europe using satellite imagery makes it necessary to understand **whether this trend reflects the actual damage** encountered by those in charge of sites management and preservation. As previously suggested by Cuca and Zaina (2022) it is possible that there is a **discrepancy** between the types of damage most studied and real problems.

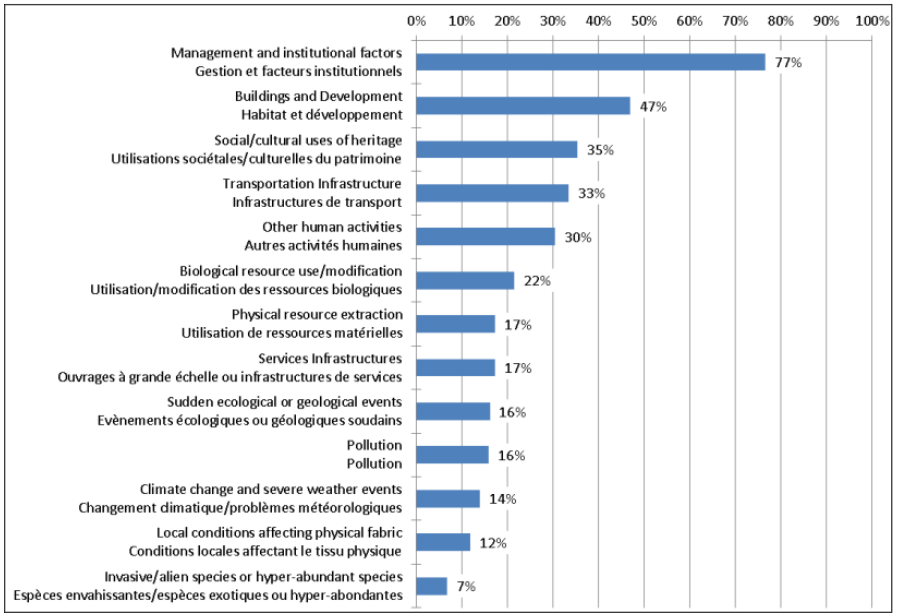
- Scientific papers show a **significant imbalance** between researchers from Higher Education and Research centres and other stakeholders. Therefore, more efforts must be put in **multidisciplinary collaborations** and in the **involvement of public institutions, foundations and private companies** at all levels of research.

FUTURE ANSWERS ON: Is there a correlation between **a specific type of damage and satellite-based technology**?

Future outlooks

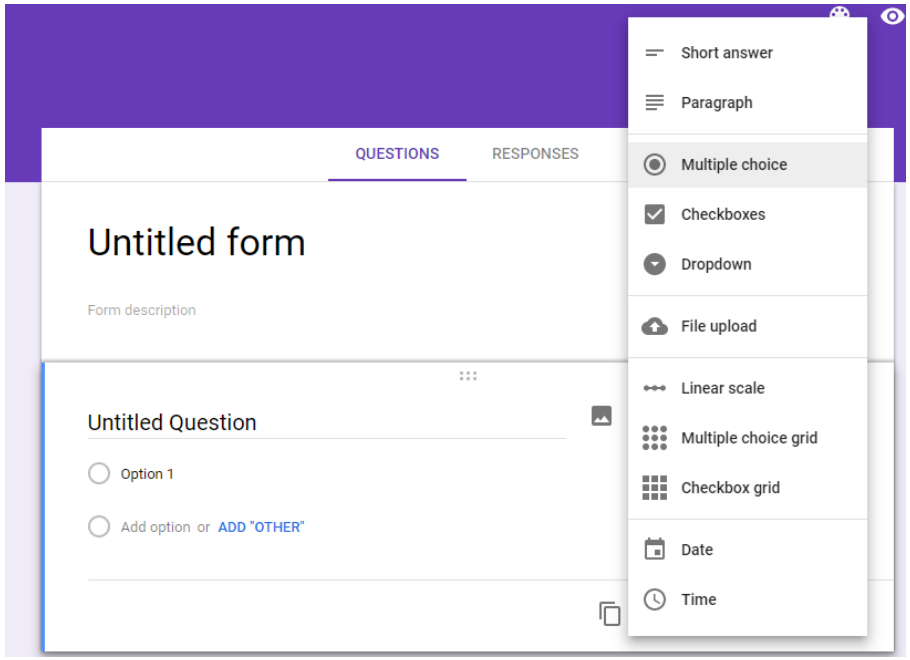
Increasing understanding towards the necessities of public and private stakeholders for an efficient and user-friendly use of satellite remote sensing for conservation and monitoring of cultural heritage.

HOW?



Quantitative correlation between types of damage considered by academic research and public/private stakeholders reports (e.g. UNESCO SOCs) over the last to decades (2000-2021).

Google form interviews to private and public stakeholders for better framing current issues and needs.



THANK YOU!

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