EARTH OBSERVATION FOR SDG TARGETS AND INDICATORS, LOT-1

SDG 15.2.1 EO PATHFINDER: EO FOR SUSTAINABLE FOREST MANAGEMENT

D5.2 Product Validation Report

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EO4SDG-Forest

SUSTAINABLE FOREST MANAGEMENT

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Acronyms and Abbreviations

Abbr.	Description
AGB	Above-Ground Biomass Stock
EA	Early Adopter
EO	Earth Observation
ESA	European Space Agency
FCM	Forest Condition Monitoring
FER	Change in Erosion Risk / Landslide Risk
FLM	Landscape Metrics
FM	Forest Mask
FNC	Forest Area Net Change Rate
F-TEP	Forestry Thematic Exploitation Platform
SDG	Sustainable Development Goals

Applicable Documents

Ref.	Title	Version	Date
[AD01]	Ref.: EOP-SD-SOW-0158 Statement of Work ESA Express Procurement - [EXPRO+], Earth Observation for SDG Targets and Indicators Lot-1	1.0	2021/10/14
[AD02]	Congalton, R. G. (2001). Accuracy assessment and validation of remotely sensed. International Journal of Wildland Fire, 10, 321-328. https://doi.org/10.1071/WF01031		2001

Web References

Ref.	URL	Description	Last access
[URL01]	https://forobs.jrc.ec.europa.eu/TMF/data#downloads	Tropical Moist Forests product - Data Access	2024/06/28
[URL02]	https://www.globalforestwatch.org/	Global Forest Watch	2024/06/28
[URL03]	https://www.dlr.de/content/en/articles/news/2019/02/20190506_globale-tandem-x-waldkarte-verfuegbar.html	Global TanDEM-X forest map (50m)	2024/06/28
[URL04]	https://glad.umd.edu/dataset/gedi/	GEDI Global Forest Canopy Height 2019 (30m map covering latitudes between 52° N and 52° S)	2024/06/28
[URL05]	https://www.eorc.jaxa.jp/ALOS/en/dataset/fnf_e.htm	Global PALSAR-2/PALSAR/JERS-1 Forest/Non-Forest Map	2024/06/28
[URL06]	https://www.esa-landcover-cci.org/	ESA CCI landcover	2024/06/28
[URL07]	https://www.wur.nl/en/Research-Results/Chair-groups/Environmental-Sciences/Laboratory-of-Geo-information-Science-and-Remote-Sensing/Research/Integrated-land-monitoring/Forest_Biomass.htm	Pan-tropical biomass map for the 2000's (1km)	2024/06/28
[URL08]	https://globbiomass.org/products/global-mapping/	GlobBiomass map for the year 2010 (1km)	2024/06/28
[URL09]	https://climate.esa.int/en/projects/biomass/	CCI-Biomass global maps 2010, 2017, 2018, 2020 (100m)	2024/06/28
[URL10]	https://earthdata.nasa.gov/maap-biomass/products/cci_biomass?map=29.5634%2C-1.2563%2C4.69&lState=	JPL's Biomass map: global map for 2020 (100m), and time series of biomass maps from 2000-2020 (10km)	2024/06/28

1 Scope

This document provides the details about the validation of the EO4SDG products, based on the results of the national demonstrators (D5.1). Section 2 describes the validation plan with a presentation of the methodology, the reference data used for inter-comparison and quality assessment of the products, the validation scheme set up for the evaluation of the various EO services, and some limitations in this validation process. Section 3 is dedicated to the results of the validation with subsections for each forest indicator. Section 4 addresses the user's appraisal of the products and the platforms/interfaces on which they are made available.

2 Product Validation Plan

The validation plan aims at providing a common framework for assessing and reporting the accuracy of the EO4SDG products, and is designed to meet the following objectives:

- Performing a robust assessment of product accuracy and understanding error sources,
- Detecting potentially unknown errors and ensuring that measures are correctly taken to address these problems,
- Building Early Adopters (EA) confidence in the EO4SDG products,
- Increasing the acceptance and legitimacy of the products,
- Collecting suggestions or recommendations for further improvement of the products.

The validation principles, methods, rules and guidelines detailed in this document create a structure that guarantees the overall documented and continuous quality of the EO4SDG products. The goal is to ensure that all products meet the required levels of accuracy, availability and affordability requested and expected by the end-users.

Before going further with the methodological description of the validation process, a brief presentation of the National Demonstrators is provided in the following sub-section.

2.1 Presentation of the National demonstrators

The EO solutions developed in the first phases of the EO4SDG project have been scaled-up over large geographical areas, to demonstrate their algorithmic robustness and transferability. Taking into account the work carried out over the pilot sites during the algorithm trade-off and proof of concept phase and the commitment of the various EA, Vietnam and Ethiopia have been selected as the best candidates for the National Demonstrations (or National Demonstrators).

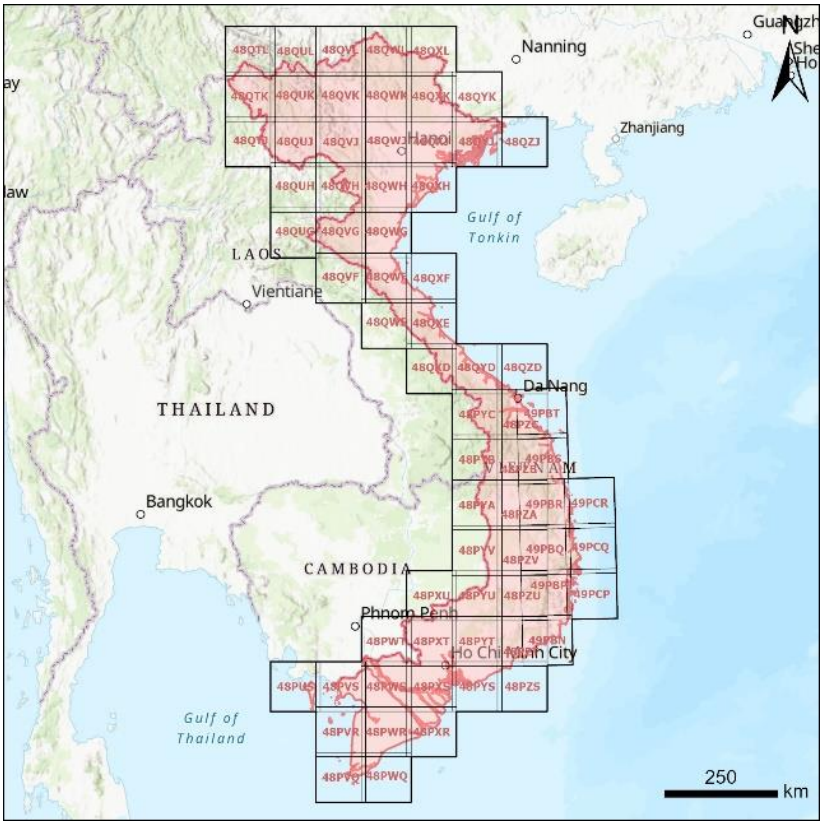
The 

Figure 1 and Figure 2 provide an overview of both National Demonstrators, illustrating the number of Sentinel-2 tiles necessary to completely cover the Ethiopian and Vietnamese territory. The number of tiles is in both cases much larger than those needed to cover the pilot sites.

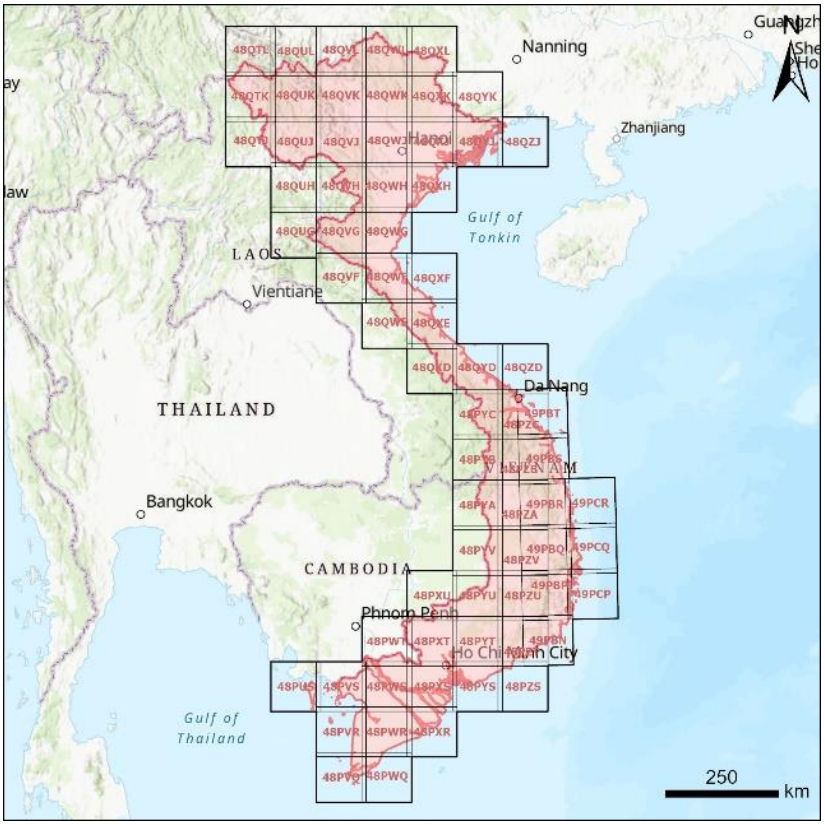


Figure 1: National Demonstrator over Vietnam with the corresponding Sentinel-2 tiles coverage

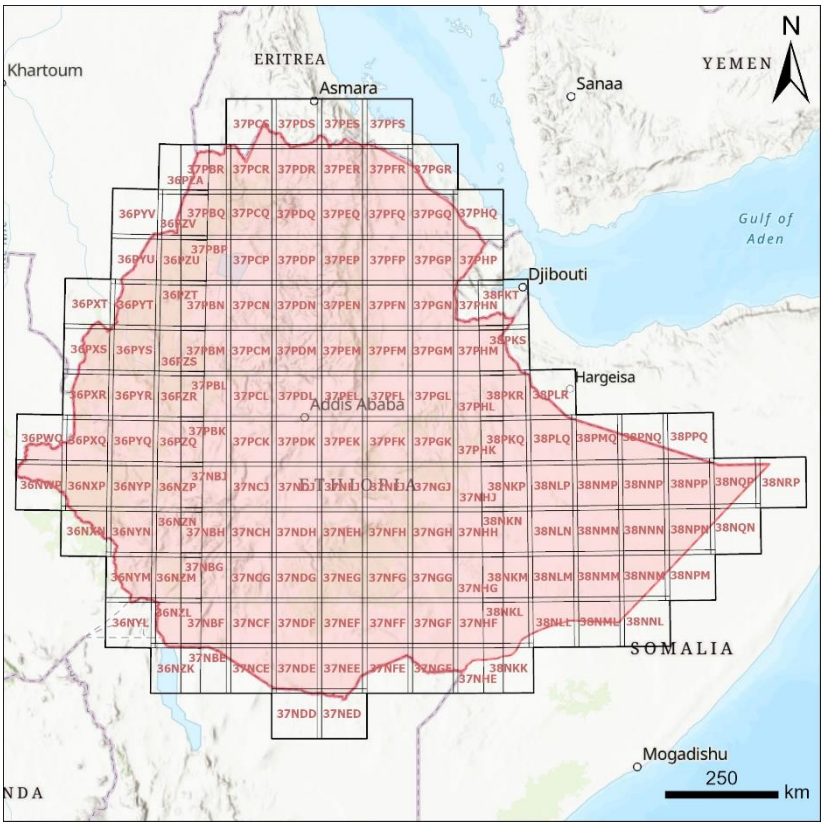


Figure 2: National Demonstrator over Ethiopia with the corresponding Sentinel-2 tiles coverage

The Table 1 below shows which EO4SDG products are generated for each National Demonstrator. The complete set of products are not generated over Ethiopia nor Vietnam, but all of them are produced over at least one country.

Table 1. Inventory of the EO4SDG products implemented for the National Demonstrators (Vietnam and/or Ethiopia)

Product	National Demonstrator	
	Vietnam	Ethiopia
FM	✗	✓
FNC	✗	✓
AGB	✓	✓
FCM - Vitality	✗	✓
FCM – Disturbance	✓	✗
FER – Erosion Risk	✓	✗
FER – Landslide Risk	✓	✗
FLM	✓	✗

The next sub-section provides some details about the procedures used to evaluate the results of the National Demonstrators, and to report uncertainty statistics in a standardized way.

2.2 Validation methods and metrics

As Congalton explains in his article [AD02] an accuracy assessment or validation process of projects using spatial data is essential for different reasons, including:

- The need to know how well perform the methods used in a project, and to learn from the mistakes;
- The ability to quantitatively compare methods;
- The ability to use the information resulting from spatial data analysis in some decision-making process.

Congalton mentions in his paper that there are a number of ways to investigate the accuracy/error in spatial data (visual inspection, non-site specific analysis, difference image creation, etc.). For evaluating the EO4SDG products, this process is divided into 4 main categories/phases:

- Qualitative Validation,
- Cross-comparison with freely available datasets,
- Quantitative Validation,
- User appraisal.

A qualitative validation is performed as an initial step, consisting basically in a visual inspection and consistency checks of the considered product. Traditionally, consistency checks internal contradictions

of a product (for instance between different components or with respect to specific set requirements). No reference source is required for data. This step is obviously not sufficient. However, it is important to control that the product does not present major issues, and that we can proceed with a thorough validation.

To go further in the analysis, a cross-comparison/verification with reference datasets, either provided by the EA in the ideal case, or freely available, is realized. Unlike the qualitative validation that can be done without any external reference data, an intercomparison can only be done in the case where suitable and comparable datasets can be found. If this is the case, the choice of the reference layers depends on the product to evaluate. A number of potentially usable reference datasets is listed in the Table 2.

Regarding the methodology, various possibilities exist for the intercomparison step. For instance, the "non-site-specific analysis" consists in comparing the various datasets coverage by evaluating the overall amount of areas for each of them. This analysis is interesting but does not provide enough information as it does not inform on how the layers are geographically distributed. Therefore, a "difference image creation" can complement the analysis, produced by comparing the product to validate with the reference dataset, pixel by pixel, allowing visualising the areas of agreement and disagreement.

Reference datasets
Tropical Moist Forest [URL01]
Global forest watch [URL02]
Tandem-X forest mask [URL03]
Global Forest Canopy Height, 2019 [URL04]
Global PALSAR-2/PALSAR/JERS-1 Forest/Non-Forest Map [URL05]
ESA CCI landcover [URL06]
Pan-tropical biomass for the 2000's (University of Wageningen) [URL07]
GlobBiomass map for the year 2010 [URL08]
ESA's CCI-Biomass global maps for 2010, 2017, 2018, 2020 [URL09]
JPL's global biomass maps from 2000-2020 [URL10]

Table 2: List of freely available datasets possibly used for the validation process along with the corresponding EO4SDG targeted products

Then, a quantitative accuracy assessment is implemented by comparing the EO4SDG products with appropriate reference data (when possible) on a set of random sample points. The ideal case is to use field measurements to get a high confidence level in the validation results, but in practice such data is almost never available, or simply do not exist. Other possibilities consist in using either comparable datasets or satellite imagery as ground truth. Statistically sound sampling approaches are implemented in order to be efficient while guaranteeing that the inspection results can be extrapolated to the population at a certain level of confidence and within a controlled margin of error.

Various sampling protocols (sampling scheme, sample size, sampling unit, etc.) can be used to carry out a statistically rigorous accuracy assessment. This choice depends on the elements that need to be evaluated. Once these parameters are defined and the samples generated, the validation process can start. When all the product has been controlled over all the samples, a confusion matrix (also called error matrix or contingency table) is used as a starting point for a series of descriptive and analytical statistical techniques (for instance overall accuracy, producer's and user's accuracy, Cohen's kappa coefficient).

Last but not least, submitting the results of the National Demonstrators to the EA to collect their feedback is another way to evaluate the products. It is complementary to the quality assessment realized by the project partners. To facilitate the EA feedback collection, a questionnaire has been created including several sections covering the products evaluation through various aspects, as well as the platforms where the products have been made available. Having a user's perspective is also interesting to get ideas or suggestions of improvements.

The following sub-section gives more details about the validation scheme that has been defined to evaluate the various EO4SDG products generated over the National Demonstrators.

2.3 Validation scheme

To perform the validation process, all the steps listed in the previous Validation methods and metricschapter (qualitative validation, cross-comparison with external datasets, quantitative validation, user appraisal) are considered. The qualitative validation can be realized for all the products, by the partner who is in charge of the product generation. Then depending on the availability of comparable and usable reference datasets, the intercomparison and quantitative validation steps can be performed. To increase the confidence in the results, it is necessary to ensure an independent validation. Concretely this means that the process of product's generation and validation cannot be executed by the same partner. The user feedback can be collected for all the EO4SDG products, in particular through the dedicated questionnaire.

The following Table 3 and Table 4 allow summarizing which validation steps are performed over each National Demonstrator, and the partner responsible for each of these tasks. As the set of products generated over Ethiopia and Vietnam are not completely the same (**Error! Reference source not found.**), the list of products provided in each table are therefore different.

Product	Qualitative validation		Cross-comparison		Quantitative validation		User
	Validation	Partner in charge	Validation	Partner in charge	Validation	Partner in charge	
FCM	✓	IABG	✓	SERTIT	✗	-	✓
AGB	✓	IABG	✓	IABG	?	IABG	✓
FER	✓	SERTIT	✗	-	✗	-	✓
FLM	✓	IABG	✗	-	✗	-	✓

Table 3: Validation scheme for the National Demonstrator over Vietnam

In both cases, all the products generated are evaluated through qualitative validation, and are submitted to the EA. The cross-comparison with external datasets are performed only for the FM and AGB products over both countries. Regarding the quantitative validation, only the FM, AGB and FNC products are concerned, even if it is still unclear whether suitable reference data can be used and hence whether this step can be performed or not.

Product	Qualitative validation		Cross-comparison		Quantitative validation		User
	Validation	Partner in charge	Validation	Partner in charge	Validation	Partner in charge	
FM	✓	RSS	✓	SERTIT	✓	SERTIT	✓
FNC	✓	RSS	✗	-	?	IABG	✓
AGB	✓	RSS	✓	IABG	?	-	✓
FCM	✓	RSS	✗	-	✗	-	✓

Table 4: Validation scheme for the National Demonstrator over Ethiopia

The next section provides the details of the validation results for each of the products mentioned in the Table 3 and Table 4.

3 Validation Results

3.1 Forest Mask (FM)

3.1.1 Vietnam

3.1.1.1 Qualitative validation

3.1.1.2 Cross-comparison with existing datasets

3.1.1.3 Quantitative validation

3.1.2 Ethiopia

3.1.2.1 Qualitative validation

3.1.2.2 Cross-comparison with existing datasets

3.1.2.3 Quantitative validation

3.2 Forest Area Net Change Rate (FNC)

3.2.1 Vietnam

3.2.1.1 Qualitative validation

3.2.1.2 Quantitative validation

3.2.2 Ethiopia

3.2.2.1 Qualitative validation

3.2.2.2 Quantitative validation

3.3 Above-Ground Biomass Stock (AGB)

3.3.1 Vietnam

3.3.1.1 Qualitative validation

3.3.1.2 Cross-comparison with existing datasets

3.3.1.3 Quantitative validation

3.3.2 Ethiopia

3.3.2.1 Qualitative validation

3.3.2.2 Cross-comparison with existing datasets

3.3.2.3 Quantitative validation

3.4 Forest Condition Monitoring (FCM)

3.4.1 Vitality

3.4.1.1 Qualitative validation

3.4.2 Disturbance

3.4.2.1 Qualitative validation

3.5 Change in Erosion Risk / Landslide Risk (FER)

3.5.1 Erosion Risk

3.5.1.1 Qualitative validation

3.5.2 Landslide Risk

3.5.2.1 Qualitative validation

3.6 Landscape Metrics (FLM)

3.6.1.1 Qualitative validation

4 Early Adopter appraisal of the EO products

The validation process realized internally by the project partners is essential, but collecting the Early Adopter feedback about the EO4SDG products/services is also very important. Their experience and knowledge are complementary from the partners, and they can bring some valuable insights.

The aim is to make sure that the EO4SDG products developed, as well as the platforms used for the services distribution, are fit-for-purpose. For that this user feedback collection is a helping tool for:

- Assessing the EA satisfaction with the products developed and the platforms where they are available,
- Identifying factors that may limit the operational use of the products and/or may negatively impact on users' workflows,
- Identifying possible improvements suggested by them from a practical point of view,

For gathering this information a questionnaire has been realized, containing the sections shown and described in the Table 5 below. The whole questionnaire provided to the Early Adopters can be found in Annex 1.

Section	Content
User Information	Personal information; Previous experience with similar/comparable products
Product evaluation	EA opinion about the EO4SDG products regarding their benefit and usability (integrity, adequacy, compliance, etc…) within an operational environment
Impact of EO4SDG products on user workflow	EA opinion about the positive/negative impacts the EO4SDG products could have in their workflow in general
Platform evaluation	EA assessment on how well the platforms where the products have been developed and deployed are usable, fit-for-purpose and user-friendly
Overall evaluation	EA overall perception of the EO4SDG products and the platforms on which they are distributed

Table 5: User questionnaire sections and respective content

Annex 1 EO4SDG Questionnaire – Product quality assessment

1 Introduction

This questionnaire is designed to evaluate the relevance, quality and consistency of the products/services developed within the EO4SDG project, from a user's perspective, by assessing the added value and the impact of these products on a user's workflow.

The participation of any potential Early Adopter of the EO4SDG products/services, is crucial in evaluating the products, since their experience and knowledge are of great relevance for this purpose. Learning from user feedback is necessary to further improve the developed products/services.

This user feedback collection aims to ensure the usability of the products/services developed within the EO4SDG project, as well as to make sure that the platforms on which the products are made available are fit-for-purpose.

2 User information

User details	
Name of your organization	Add text
Country	Add text
Name of the point of contact	Add text
Position within your organization	Add text
Email address	Add email
Phone number	Add tel number

2.1. Please select the option that better summarizes the nature of the activity(ies) your department/unit undertakes:

☐ Strategy and policy development ☐ Decision making

☐ Programme and project ☐ Field operations

☐ Other (Specify): Add text

User experience	
2.2. Have you got previous experience using similar/comparable products?	○ Yes ○ No

If yes, can you specify the products you are the most familiar with? And how are these products included in your workflow?

Add text

3 Product evaluation

In this section, we would like to know your opinion about the EO4SDG products considering their benefit and usability (integrity, adequacy, compliance, etc...) within an operational environment.

3.1. Which EO4SDG products are the most interested in? Which products have you mostly used?
Place ticks for each product

- ☐ Forest Mask (FM)
- ☐ Forest Area Net Change Rate (FNC)
- ☐ Above-Ground Biomass Stock (AGB)
- ☐ Forest Condition Monitoring (FCM) - Vitality
- ☐ Forest Condition Monitoring (FCM) - Disturbance
- ☐ Change in Erosion Risk / Landslide Risk (FER) - Erosion Risk
- ☐ Change in Erosion Risk / Landslide Risk (FER) - Landslide Risk
- ☐ Landscape Metrics (FLM)

3.2. How have you used the EO4SDG products?
Add text

3.3. How would you evaluate the following aspects of EO4SDG products?
Place ticks for each product selecting one option for each column criteria: Easiness to understand the product (legends, attribute table, texts, terminology, etc.) and Product format (content, file format, etc.)
Use the scale from 1 to 5 (1-Very poor, 2-Poor, 3-Average, 4-Good, 5-Very good)

Product	Easiness to understand the product					Product Format				
	1	2	3	4	5	1	2	3	4	5
FM	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
FNC	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
AGB	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
FCM - Vitality	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
FCM – Disturbance	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
FER – Erosion Risk	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
FER – Landslide Risk	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
FLM	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

3.4. How would you rate the importance and potential impact of EO4SDG products?

Place ticks for each product selecting one option for each column criteria (Importance and Impact on work)

Product	Importance			Impact on work		
	Not Important (1)	Important (2)	Essential (3)	Unusable (1)	Alternative Use (2)	Intended Use (3)
FM	☐	☐	☐	☐	☐	☐
FNC	☐	☐	☐	☐	☐	☐
AGB	☐	☐	☐	☐	☐	☐
FCM - Vitality	☐	☐	☐	☐	☐	☐
FCM – Disturbance	☐	☐	☐	☐	☐	☐
FER – Erosion Risk	☐	☐	☐	☐	☐	☐
FER – Landslide Risk	☐	☐	☐	☐	☐	☐
FLM	☐	☐	☐	☐	☐	☐

3.5. How would you rate in general the various EO4SDG products? (usefulness, accuracy, etc.)

Place ticks for each product selecting one option

Use the scale from 1 to 5 (1-Very poor, 2-Poor, 3-Average, 4-Good, 5-Very good)

Product	General Rating					Additional comments (suggested improvements)
	1	2	3	4	5	
FM	☐	☐	☐	☐	☐	Add text
FNC	☐	☐	☐	☐	☐	Add text
AGB	☐	☐	☐	☐	☐	Add text
FCM - Vitality	☐	☐	☐	☐	☐	Add text
FCM – Disturbance	☐	☐	☐	☐	☐	Add text
FER – Erosion Risk	☐	☐	☐	☐	☐	Add text
FER – Landslide Risk	☐	☐	☐	☐	☐	Add text
FLM	☐	☐	☐	☐	☐	Add text

4 Impact of EO4SDG products on user workflow

The following questions are related to the positive/negative impacts the EO4SDG products could have in your workflow in general.

4.1. Do you think that the EO4SDG products could be useful/beneficial for your operational procedure?	○ Yes ○ No
If yes, what are, in your opinion, the possible advantages/benefits introduced by EO4SDG products to your operational workflow? Add text	
4.2. How do you find the EO4SDG products compared with other existing products? Are there significant differences?	○ Yes ○ No
If necessary, elaborate Add text	
4.3. Would you like to highlight any inconsistencies that you have found in the EO4SDG products?	○ Yes ○ No
If yes, please elaborate Add text	
4.4. Do you think you could share the EO4SDG products with other potential stakeholders?	○ Yes ○ No
If yes, please specify Add text	

5 Platform evaluation

The following questions are meant to assess how well the platforms where the products have been developed and deployed are usable, fit-for-purpose and user-friendly.

Use the scale from 1 to 5 (1-Very poor, 2-Poor, 3-Average, 4-Good, 5-Very good).

F-TEP	
5.1.1. How easy is it to find and launch the services for the processing of EOSDG products?	◉ 1 ○ 2 ○ 3 ○ 4 ○ 5
If necessary, elaborate Add text	
5.1.2. In general, how intuitive and user-friendly do you find the platform?	○ 1 ○ 2 ○ 3 ○ 4 ○ 5
If necessary, indicate possible improvements Add text	

Dashboard	
5.2.1. Do you find that the platform allows to easily display information (content, legend), navigate, zoom in/out?	◉ 1 ○ 2 ○ 3 ○ 4 ○ 5
5.2.2. Do you find that the symbology used to visualize the different EO4SDG products is appropriate?	◉ 1 ○ 2 ○ 3 ○ 4 ○ 5
If no, please elaborate Add text	
5.2.3. In general, how intuitive and user-friendly do you find the platform?	◉ 1 ○ 2 ○ 3 ○ 4 ○ 5
If necessary, indicate possible improvements Add text	

6 Overall evaluation

In this section, we would like to know your overall perception of the EO4SDG products and the platforms on which they are made available, in terms of:

6.1. Strengths? Add text
6.2. Weaknesses? Add text
6.3. Added value? Add text
6.4. Have you noticed any technical issue? (e.g. bugs, inconsistencies, etc.) ○ Yes ○ No
If yes, please explain and describe the problem(s) Add text
6.5. Would you recommend EO4SDG products/services? ○ Yes ○ No
Why? / Why not? Add text
6.6. Have you other comments, explanations of answers or recommendations for improvements to provide? Add text

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