European Commission

JRC TECHNICAL REPORT

Structured template for documenting agricultural land monitoring systems

Zieliński R., Milenov P., Sima A., Devos W.

2022

Contact information
Name: Rafał Zieliński
Email: rafal.zielinski@ec.europa.eu

EU Science Hub
https://joint-research-centre.ec.europa.eu

JRC130662

Ispra: European Commission, 2022

How to cite this report: Zieliński R., Milenov P., Sima A., Devos W, *Structured template for documenting agricultural land monitoring systems*, Ispra, 2022, JRC130662.

Contents

Abstract

This document presents a structured template for documenting agricultural land monitoring systems from a conceptual and use case points of view. It was initially developed to allow for transparent, systematic, and structured documentation of the key elements of the agricultural land monitoring systems relying on EO-based signal processing to facilitate information exchange between different stakeholders. The modular design of the template allows for selective usage of sections, if only part of the system needs to be documented. Example documentation of mowing detection on temporal grassland using sections 1 to 7 of the template is provided in the Annex. Several sections of this template have already been successfully used for information exchange within the Checks by Monitoring Outreach 2021 initiative. The feedback collected from the project stakeholders acknowledged the feasibility of the proposed approach and allowed for its further upgrade.

The design of the structure and the elements of the template considered the latest developments in the standardized ontologies for land cover and land use, such as the revised ISO 19144-2 (Land Cover Mate Language) and the future ISO 19144-3 (Land Use Meta Language). It also considered the recent standardization efforts by the Open Geospatial Consortium[1] and International Organization for Standardization[2] (19156 and 19157) in relation to the collection and quality check of EO-based data. Still, the template is generic enough to be applicable for any type of sensor and observation method (e.g. aerial survey), as well as to be used in any other land monitoring domain (environment, climate, territorial development).

[1] https://www.ogc.org/ (accessed on 28/09/2022)
[2] https://www.iso.org/ (accessed on 28/09/2022)

Acknowledgements

The authors wish to thank the experts actively collaborating within the Checks by Monitoring outreach 2021 project for sharing their knowledge about relevant practices and linked direct payment requirements at the national level. Justina Vitkute from the Danish Agricultural Agency and Eoin Dooley from Department of Agriculture, Food and the Marine in Ireland are thanked for reviewing the document and providing valuable feedback. The authors thank Laura Acquafresca for providing feedback on a prototype template and Natasa Luketic for her feedback on the template structure and content.

Authors

Zieliński Rafał, Milenov Pavel, Sima Aleksandra, Devos Wim

1 Introduction

1.1 Development

With the arrival of free Copernicus Sentinels data covering all the globe with high temporal frequency (Breger, 2017; European Commission, 2013), a paradigm shift in the checks for Common Agricultural Policy (CAP) subsidies was made possible. The Commission Implementing Regulation (EU) 2018/746 amending Implementing Regulation (EU) No 809/2014 allowed for the Checks by Monitoring (CbM) to be used as a substitute for the On-The-Spot Checks.

The Commission services and five volunteering Member States (MS) joined forces to incrementally gain an understanding of the challenges and resolve inconclusive situations. Until 2020 these five EU countries increased their area under CbM, but no new Member State joined. The fast pace of the incremental learning process was accelerated through collaboration on the development of a common quality assurance (QA) methodology, proposing a common benchmark to ensure a coherent assessment, irrespective of the CbM design choice. In 2021 the number of MS using CbM increased to 10, represented by 28 Paying Agencies, including 16 in Spain, 3 in Germany and 2 in Belgium.

To lower the CbM uptake threshold to the remaining Member States (or Paying Agencies), the JRC and DGAgri jointly proposed a 2021 CbM outreach initiative aiming to:

1. provide better understanding of the overall potential of Copernicus Sentinel satellite data in their landscape through the customised extraction of information needed for their CAP processes, and,
2. lower the technology threshold by offering JRC's publicly available toolkit built on standardized access to data and services.

In a collaborative approach between the 19 participating PA/MS and the JRC, the first draft of this documentation template was created few months after the project's kick-off. This facilitated information exchange about grassland mowing practices and the relevant schemes and requirements. It partially covered sections 2-5 and 10.1 of the current document and was reviewed and accepted by 13 project users.

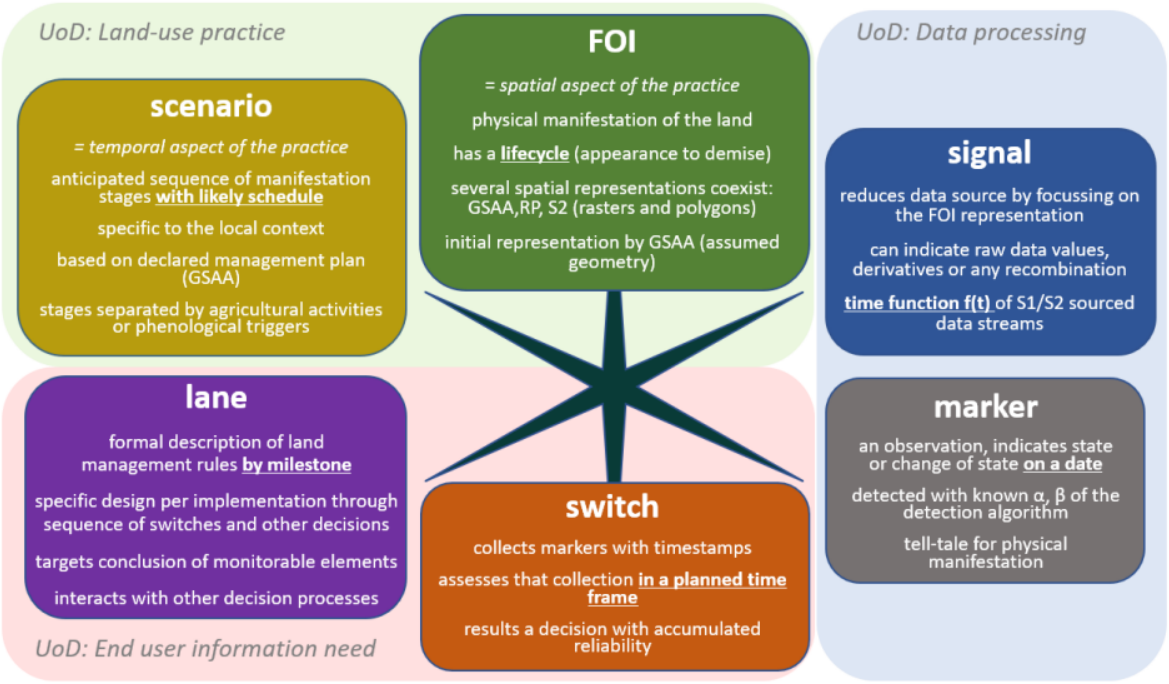
The variety of the CbM design choices, even within a single Member State, the ambiguity of the underlying phenomenon, the complexity of the processing workflows, and the need to share the experiences in a structured manner between different stakeholders and with the wider community, triggered an extension of that original template. The extension covers the remaining parts of the land monitoring systems in a way that is generic and inclusive enough to accommodate the wide range of CbM implementations.

1.2 Concepts and monitoring system design steps

The logic and semantic of the process documentation relies on the key CbM concepts described in (Devos et al., 2021) and is only briefly summarised here below (see also Figures 1 and Figure 2 for details).

- The concept of signal reflects a time series of Sentinel data values or their derivatives.
- The concept of marker describes a factual observation of land-cover manifestation depicted in Sentinels signals.
- The concept of feature of interest (FOI), relates to the observable unit of land subject to the practice (most often the real-world field, crop or unit of management).
- The concept of scenario relates to the anticipated land cover behaviour resulting from the local practice, likely to be depicted by the signal.
- Lane: processing path leading to a required conclusion; relies on results of switches.
- Switch: a test mechanism collecting markers and resulting in a decision.

Figure 1. Key concepts of Checks by Monitoring, linking the three universes of discourse (UoD): end user information need (or requirements), data processing and land-use practice.



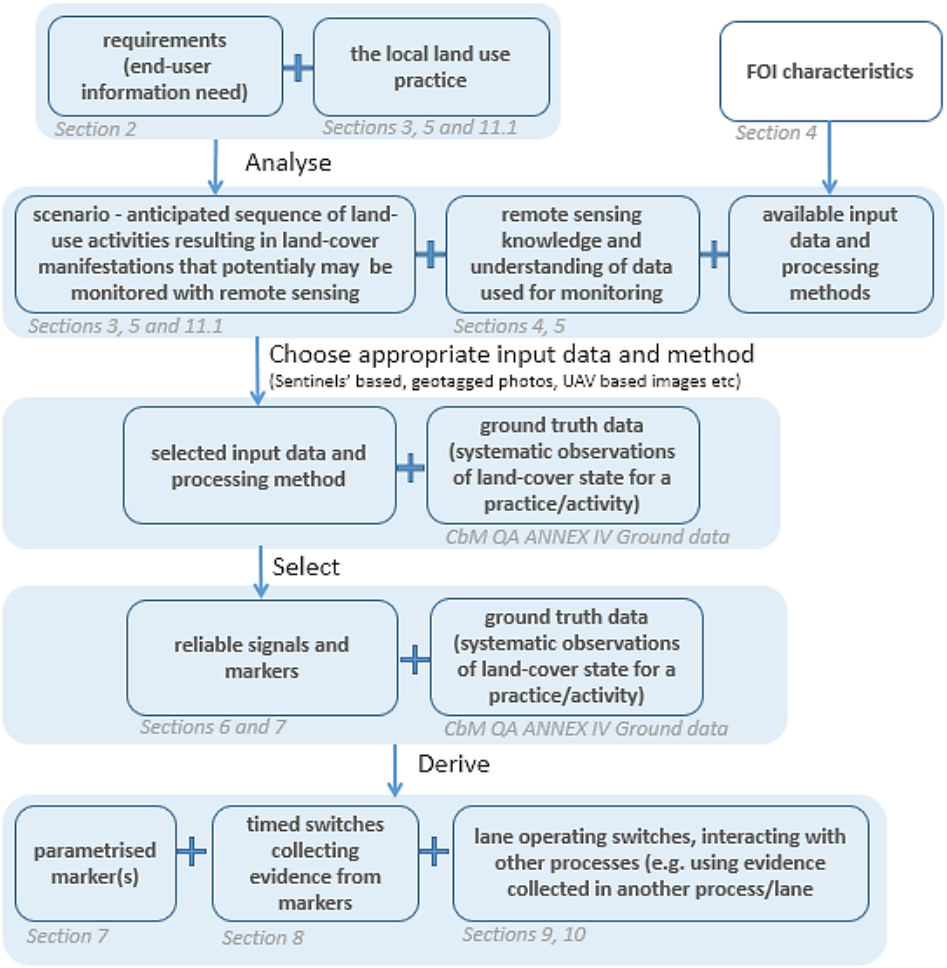
Source: Devos et al., 2021a, Figure 2.

In the land monitoring systems, and thus in the CbM, the data processing design (see Figure 2) is based on analyses of requirements (universe of discourse (UoD): end user information needs) that potentially may be monitored using the chosen sensor/signal and based on the knowledge of the local land use practice (activities and their approximate timing). Consequently, a scenario can be described to provide the anticipated sequence of land use activities that trigger land cover manifestations that, in turn, should be observable on remote sensing data. In parallel, the most appropriate FOI monitoring approach should be derived considering the characteristics of the FOI population (e.g. size or shape restrictions) and the available input data and processing methods (top right in Figure 2).

In addition, the most effective/reliable signal and markers (UoD: data processing) should be selected (based on remote sensing knowledge and signal analyses, supported by the appropriate ground truth on the required activity/ process. Selected markers should be further parametrized/tuned (again, using that ground truth data) for optimal performance in the local conditions.

Operational monitoring is all about gathering sufficient evidence (e.g., several markers indicating required activity) to allow the switches in a lane drive a decision about the compliance of the FOI. For the collection and compilation of ground truth data, the guidance given in Annex IV of the CbM QA documentation [Devos et al., 2021b] could be used.

Figure 2. Workflow of land monitoring system design following the concepts presented in (Devos et. al., 2021), indicating the template sections covering the relevant elements of the system design.



Source: GTCAP

1.3 Objectives of the template

The CbM process documentation template was developed to facilitate systematic documentation and information exchange about processes taking place in land monitoring systems relying on EO-based signal processing. Although such system documentation is a choice of every system administrator it may become handy when the paying agencies responsible for the implementation of the CbM need to communicate with other CAP stakeholders and EU administration bodies. A systematic description covering all the key elements of a land monitoring system proposed below may also help the system designers to improve or optimize the information flow or learn and recover elements from other systems. Nonetheless, thanks to its modular design, sections of the choice may be used in isolation to document selected elements.

In the specific case of Checks by Monitoring, the data processing mostly relies on data provided by Copernicus Sentinel-1 and Sentinel-2, and this has influenced the current version of the template. A future template can be however easily extended to include documentation of other data (i.e., geotagged photos, machinery tracks, include documentation of the expert judgement protocols etc) and processing loops used in the monitoring process.

2 Documentation of agricultural land monitoring systems

2.1 Application of the template

The CbM process documentation template presented below (section 3) is composed of eleven complementary sections, designed to cover all the key parts required to understand how to replicate the data flow and actual processes used in land monitoring systems (see also Figure 2).

- The first section includes generic information on the process purpose, origins, authors and contact details.
- Section 2 summarises the user information needs. Here the required and banned activities/processes relevant for particular land cover/ crop type and their timing are summarised.
- Section 3 provides the characteristics of the land use practices potentially monitorable with remote sensing. Understanding the link between the land cover manifestations resulting from activities conducted on the ground and the timed signal response captured by the relevant sensor is the key to find effective and reliable markers.
- Section 4 covers definition and content of the feature of interest, being the basis of all computations in marker-based land monitoring systems.
- Section 5 describes the actual state of the land cover within the FOI using a standardised ontology (Land Cover Meta Language - ISO 19144-2). Such a description, although optional in the CbM context, may be very useful for an interoperable exchange of knowledge about the observed phenomenon.
- Sections 6 aims at documenting signals, their statistical descriptors and pre-processing steps used in the analysis.
- Section 7 describes how the markers work and how they are linked with land phenomena.
- Section 8 summarises behaviour of switches collecting evidence from markers, e.g. logical operators between the expected markers, the link with the requirements, timing of processing etc.
- Section 9 documents the processing within a lane: it lists relevant switches and the logical operators and priorities between them.
- Section 10 allows for documentation of image classification method and parameters, if used instead of or complementary to marker detection approach.
- In section 11 additional information may be recorded, such as crop calendar or more detailed information about the payment schemes.

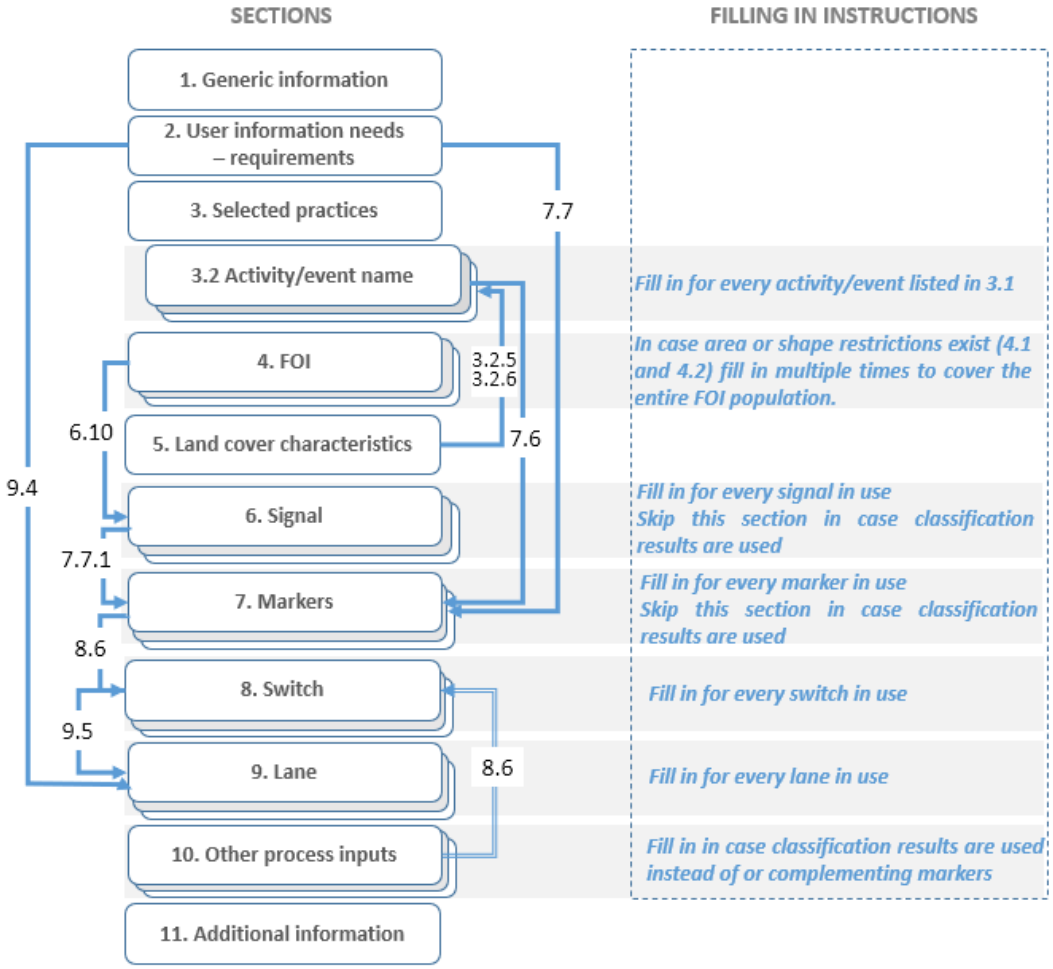
The modular design of the proposed template allows for repetitive or isolated use of individual sections. The level of details provided in different template sections should be relevant for the scope of the process documentation and the end user needs. As the template was designed to include information relevant for a payment scheme or a land use practice that needs to be monitored (whatever is more relevant and suited to provide clear description of the processes), documentation of the entire system process may become very complex. For example, as shown in Figure 3, cases where several requirements (2.2) need to be monitored, some of the following sections (e.g., section 7. Markers) need to be populated for every listed requirement. Similarly multiple markers should be described if multiple activities need to be monitored. Figure 3 summarises connections between different template sections and provides further guideline on how to complete them.

In cases when image classification results are used instead of markers to derive the conclusion on the FOI compliance with the requirements, sections *6. Signal* and *7. Markers* should be omitted and section *10. Other process inputs filled* in instead. Results of an image classification product should be further evaluated by the switches and processed in lanes and relevant sections (*8. Switch* and *9. Lane*) should be completed regardless of the chosen data processing method.

An example documentation of mowing detection on temporal grassland based on a real case provided by one of the Member States is presented in the Annex. Sections 1-7 of the template were completed to document the requirements (user information needs), details and timing of potential activities to be performed by the farmer, the relevant type of FOIs and the land cover characteristics. This example covers also sections documenting signal and markers. Being very system specific and requiring precise

information on the information flow, decision rules and risk acceptance levels of a monitoring system, sections 8-10 were not covered in the example.

Figure 3. Links between sections of the documentation template with a summary of the filling instructions for sections requiring multiple instances.



Source: GTCAP

2.2 Technical considerations

CbM processes deal with land cover manifestations that are observable with remote sensing. In the CbM context, the manifestation is an observable display, in a given timeframe, of the presence/absence of a physical feature or feature characteristics within the land unit. Consequently, the present document deals in principle with factual observations, which involve physical appearances captured by a sensor at a given moment of time.

Physical features are real-world phenomena present on Earth's surface, which could be considered as discrete entities, countable and with a spatial dimension. In the agricultural and semi-natural environment, such physical features are mostly of biotic material and refer to different types of vegetation features grown on the surface (herbs, shrubs, trees). There can also be features of abiotic material, such as patches of bare soil, rocks, water bodies, but also artificial features such as greenhouses or individual buildings. The characteristics of a given feature depend on its origin. For vegetation these are: the outer appearance (herbaceous or woody), phenology (annual, perennial), plant height, etc. For water bodies these are: physical state (ice, liquid water), water persistence, nutrient level, etc. For bare soil these could be the colour, the surface roughness, the water content, etc.

This document adopts a simplified semantic meta-model, based on the revised Land Cover Meta Language (LCML, ISO 19144-2:2012), to describe the phenomena (Figure 4) being subject to the

agricultural practices and related events in the scope of CbM and agricultural land monitoring. It assumes, in its essence, that the physical feature is either:

— natural bare surface (bare soil, rock, deposit), artificial sealed surface, or water, situated on the ground (Stratum 0),

— herbaceous vegetation (annual crop or grass), situated above the ground (Stratum 1),

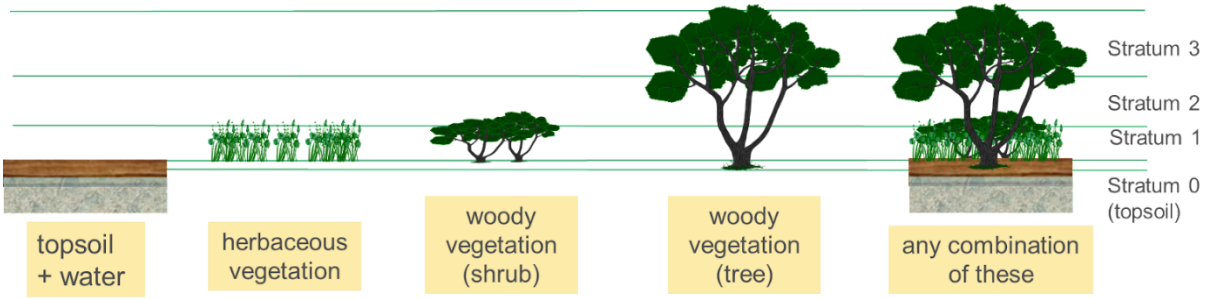
— shrubs (cultivated or natural), situated higher than the herbaceous vegetation (Stratum 2),

— trees (cultivated or natural), situated higher than the shrubs (Stratum 3),

— any combination of the above-mentioned elements in the vertical direction (uniform spatial distribution for all elements in all strata),

— any combination of the above-mentioned elements in the vertical direction and horizontal directions (typical for the intrinsic mix of different physical features with specific spatial distribution, usually represented through pro-rata).

Figure 4. Elements of the physical feature in the simplified model of phenomena description.



Source: GTCAP, cliparts from: Antonio di Gregorio, “Land Cover Classification System - Classification concepts and user manual”, FAO-UN, 2005

Either a farmer's activity or a natural event could affect and change the situation on the ground. These incidents can either “replace” the physical feature with another one (for example grass being removed and only bare soil remains) or modify the given feature characteristic/property (for example, the height of the grass is being reduced).

The main feature characteristics considered to play a role in agricultural land monitoring are given in the table below. The present code list could be extended with local specific entries (Table 1).

Table 1. Main feature characteristics considered to play a role in agricultural land monitoring.

Stratum	Feature/Element	Characteristics	Characteristics	Characteristics
0	Natural bare surface (rock, gravel and sand)	NA	NA	NA
0	Natural bare surface (bare soil)	Colour: according to Munsel system	Surface roughness: — rough — smooth	Wetness: — wet — dry
0	Natural bare surface (organic deposit)	Colour: according to Munsel system	Vegetation presence: — present — absent	Wetness: — wet — dry
0	Artificial sealed surface	Type: — built-up	Height (in cm)	Built-up material: — concrete

		— non built-up		— glass — plastic
0	Water body (standing)	Physical state: — ice — liquid water	Persistence: — year-round — seasonal — drying-up	Nutrient level: — oligotrophic — mesotrophic — eurotrophic
1	Herbaceous vegetation	Phenology stage: — emerging — fully developed — flowering — senescent — regrown	Height (in cm)	Cover*: — close (>60%) — open (15-60%) — sparse (<15%) .
2	Shrubs	Phenology stage: — with leaves — without leaves	Height (in cm)	Cover: — close (>60%) — open (15-60%) — sparse (<15%)
3	Trees	Phenology stage: — with leaves — without leaves	Height (in cm)	Cover: — close (>60%) — open (15-60%) — sparse (<15%)

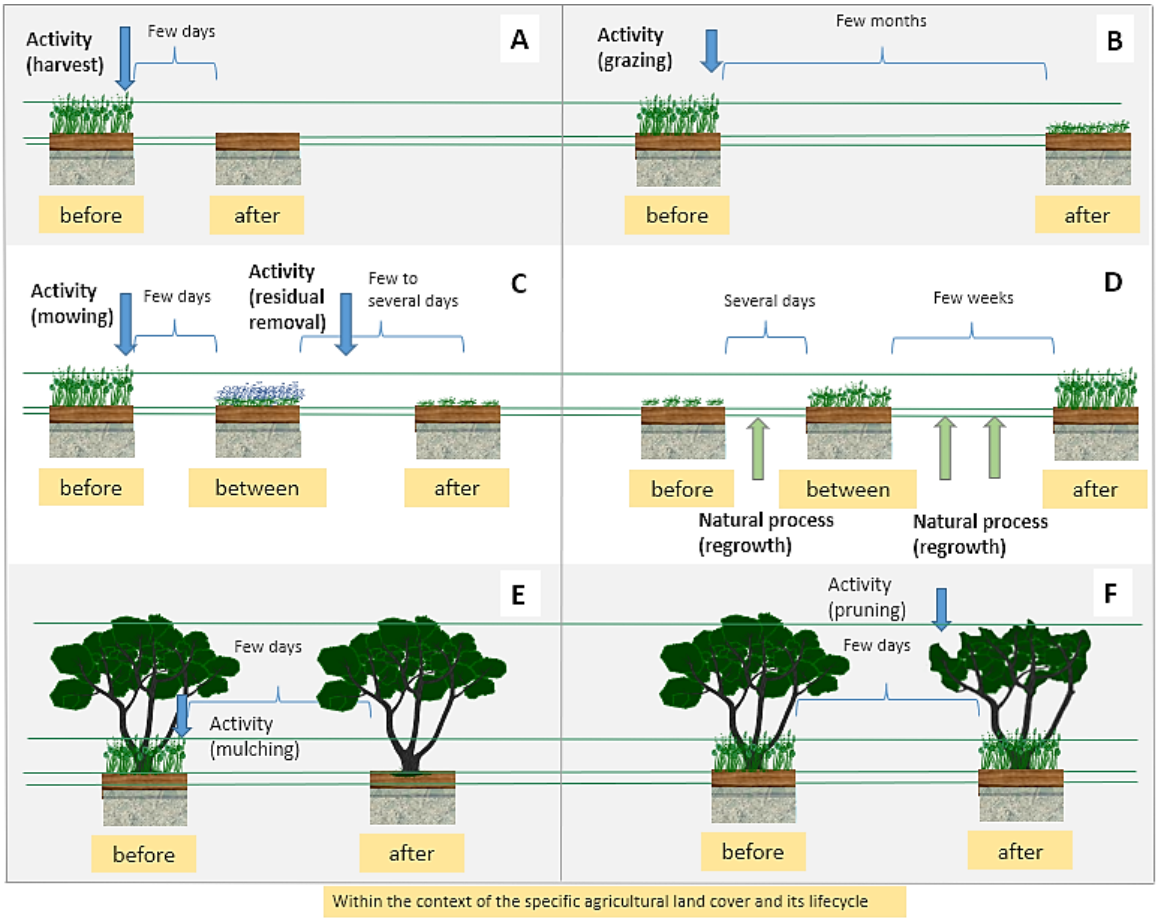
Note: *Cover %: area of incidence of the growth form over the bare ground in percentage.

Source: GTCAP

For practical reasons, when characterising herbaceous vegetation in Table 1, only these phenological stages are listed that relate to the specific "physiognomic appearance" of the plant/crop community and/or its cover over the surface, and could be visually perceived. The phenology was introduced to reflect in sufficient detail, the spatio-temporal aspects of the land cover feature/phenomenon, even if the given phenology stages are not explicitly defined in the LCML (ISO 19144-2:2012).

Figure 5. below shows four examples of possible changes of a phenomenon triggered by a farmer's activities. Harvest and mowing (Figure 5. a and 5c) imply almost immediate change in the land cover manifestation but their manifestations will differ. In terms of grazing (Figure 5. b) the grass will be eaten slowly and the resulting change will not be so abrupt and homogenous (in terms of spatial pattern). In terms of mulching under dense tree canopy (Figure 5. d) the land cover manifestation may not be observable at all with remote sensing techniques.

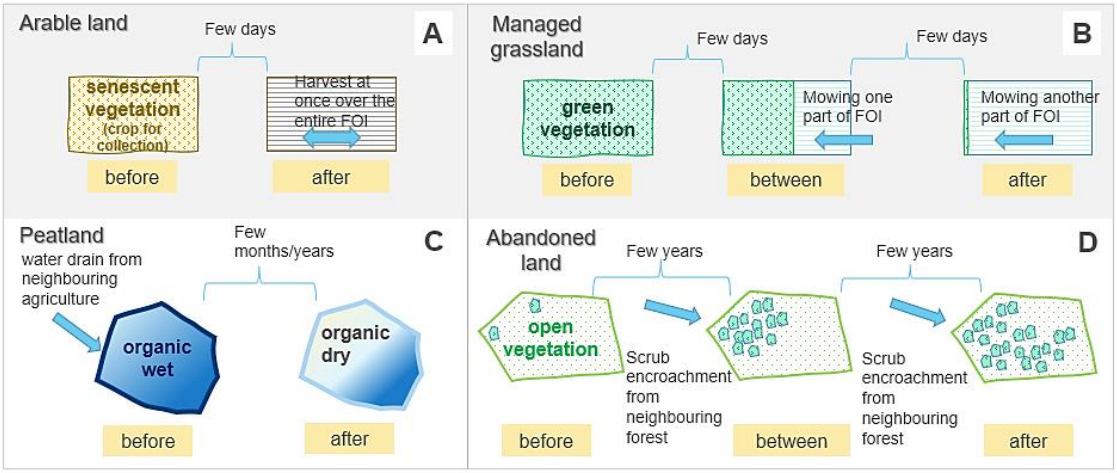
Figure 5. Examples of manifested changes of state following a) harvest of arable crop, b) grazing, c) mowing, d) grass regrowth, e) mulching and f) pruning.



Source: GTCAP

The change of state of the phenomenon could occur instantaneously over the entire spatial extent of the physical feature occupying the land unit (FOI), or it could propagate gradually or intermittently through it. Figure 6 shows some examples of possible spatial propagations, depending on the type of land cover.

Figure 6. Types of spatial propagation of changes within FOI: a) harvest of a crop on entire area of the FOI at once, b) intermittent mowing of a grassland, c) long term water draining, gradual and unevenly distributed, d) slow long-term encroachment of vegetation, gradual and unevenly distributed.



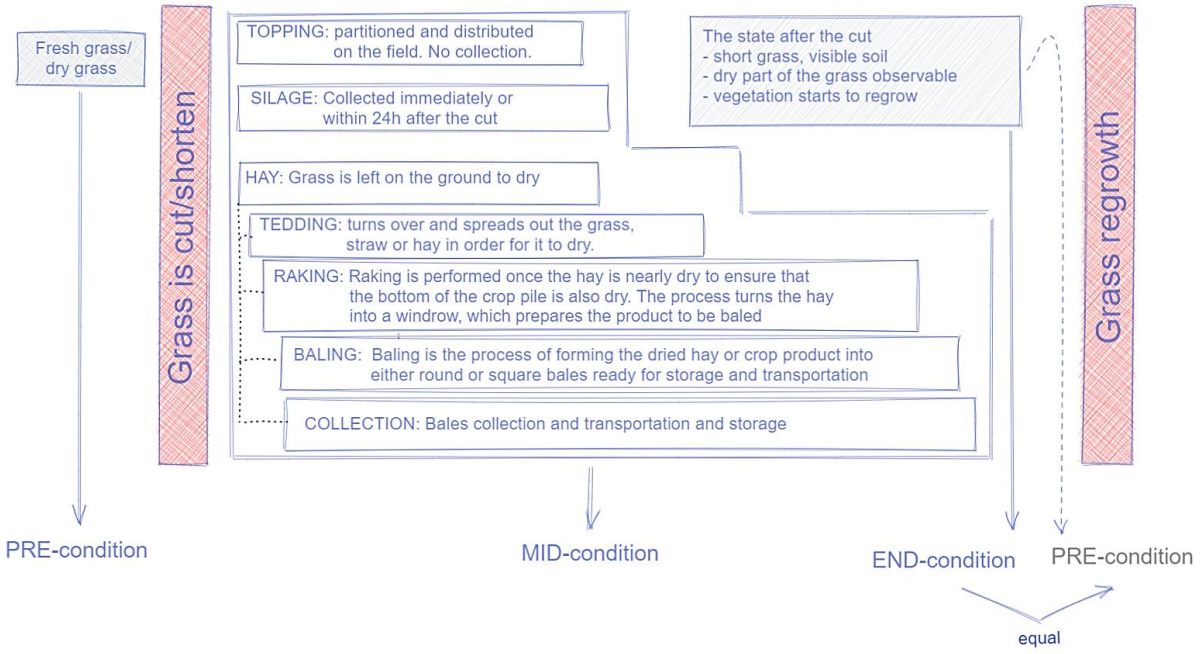
Source: GTCAP

In principle, CbM works under the assumption that all observable phenomena of relevance are explicitly tied to/associated with a spatial entity on the ground alone, being the land unit. However, there are certain phenomena (for example precipitation) where such association could be established with the entire population of parcels in the area affected. Also, depending on the type of phenomena and user needs, the given observation can be related to spatial primitive smaller than the land unit (sub-FOI elements, such as pixel or image segment).

Appropriate documentation of the agricultural practices (section 3) is very much relevant for the correct choice of signals and markers being a motor of an efficient land monitoring system. The specific pre-, mid- and end-conditions of a land cover manifestation are characterised in fields 3.2.7, 3.2.8 and 3.2.9 respectively and aim to capture the change of the land cover shortly before, during and after the described practice or natural event. For abrupt changes in land phenomena, e.g. after ploughing, the description of its mid condition may be almost irrelevant. On the other hand, for longer lasting changes, such us vegetation encroachment, natural vegetation sparsening or even mowing for hay, documentation of the intermediate condition may help to understand the corresponding signal response captured by the sensor.

Figure 7 shows an example of different mowing types (mowing for hay, for silage and topping) description with application of these conditions. The mid-condition actually holds most of the differences between the mowing types, that when linked with corresponding changes in the image data, may allow to confirm/exclude farmer's fulfilment of requirements and the corresponding timing.

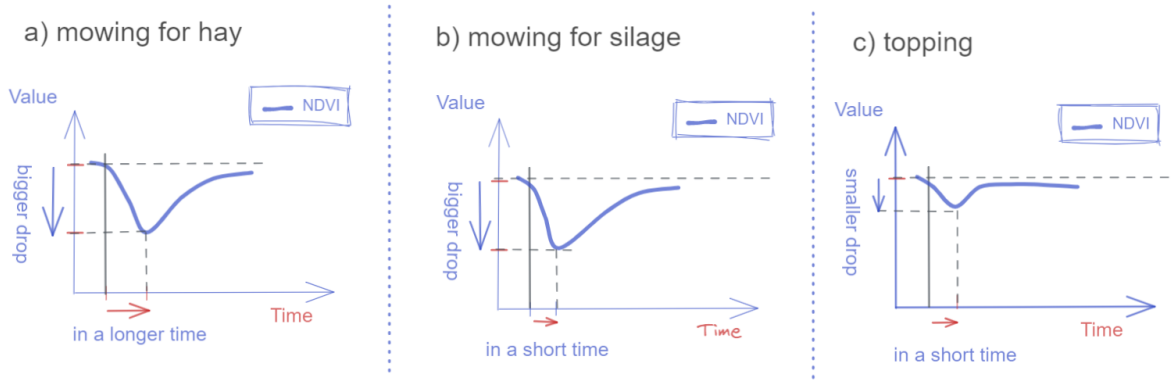
Figure 7. Example of pre-, mid- and end-condition for different mowing types.



Source: GTCAP

Figure 8 shows an example of a potential difference of the signal characteristics for three mowing types. In this example mowing for hay and for silage results in the same amount of biomass reduction, but in the case of mowing for hay, the changes become visible with some delay due to grass residues left to dry on the ground. In the case of topping, only the upper portion of the grass is cut thus only small, in comparison to hay/silage case, reduction of biomass is foreseen. The knowledge of local practice helps in understanding the corresponding signal behaviour.

Figure 8. An example of potential NDVI signal change for different mowing types: a) mowing for hay; b) mowing for silage; c) topping.



Source: GTCAP

3 Structured template for documenting agricultural land monitoring systems

Table 2. Structured template for documenting agricultural land monitoring systems.

Code	Topic	Value
1	**Generic information**	
1.1	Project name	CbM
1.2	Template version	v.1.0
1.3	Name and contact details of person providing the information	Name surname: Institution: Contact details: e-mail:
1.4	MS/PA code	*e.g. DE-SH, BG, HR*
1.5	Date of entry	DD.MM.YYYY
1.6	Template ID	*Unique identification number: i.e. PL.01*
1.7	Very short description of the activity/practice/scheme being the subject of monitoring	*Short information about the purpose of the description i.e. grasslands management, mowing detection, or grassland - minimum activity*
1.8	Keywords	
2	**User information needs (requirements) relevant for scenario**	
2.1	Related payment scheme	*Free text insert here: e.g. (SPS, BPS, SFS, VCS, GRE,)* Add text here
2.2	Minimum set of eligibility criteria	*Free text with information derived from national rules, including validity, compliance and non-compliance rules.* Req1: Req2: Req3:
2.3	Period(s) when the requirement is to be observed (time frame)	*Free text or standardised structure based on ISO/INSPIRE* *e.g. Jan-Dec, May-Sep* [DD/MM] – [DD/MM] Req1: Req2:
2.4	Temporal reference of the scheme	Possible answers: ☐ Agronomic year ☐ Calendar year

Code	Topic	Value
		☐ No data *In case of agronomic year, please indicate the period: e.g. [01/05]-[01/09]* [DD/MM]- [DD/MM]
2.5	Specific crop type associated	*Indicate the crop type concerned (any information that could possibly facilitate understanding/interpretation of the corresponding earth observation data)*
2.6	*Specific land cover type associated*	*Indicate the agricultural land cover types (defined in ETS Annex III of the LPIS QAF), e.g. A: arable land, G: permanent grassland, N: natural grassland. MS own nomenclature/ coding can be additionally indicated.* *Select from:* *A arable land* *G permanent grassland* *N natural grassland* *H greenhouse* *T permanent tree crop* *S permanent scrub crop* *C permanent herbaceous crop* *P short rotation coppice (plantation, P1-Deciduous Tree Crop(s) and P2- Evergreen Tree Crop(s))* *R (irrigated) rice* *K kitchen gardens (SAPS only)* *HV herbaceous vegetation* *XB Waterlogged natural vegetation* *YA Afforested areas* *The selected answer:*
2.7	Geographic extent	Based on NUTS/LAU: ☐ Full country ☐ Region-specific* ☐ Not indicated **Add specifics here:*
3	**Selected practices relevant for scenario** *Please repeat section 3.2 for every activity or event listed in 3.1*	
3.1	Practices/activities/events affecting the physical state or triggering change of state of the agricultural land cover- that should be picked up by markers	*ACT=activities=anthropogenic* *EVT=events=natural* *E.g. for grassland: assuming, ACT1 - mowing*

Code	Topic	Value
		ACT2 – grazing, the sequence might be expressed as: ACT1, ACT2, ACT1, ACT1 *corresponding to a sequence of likely to happen.* *e.g. for arable crop a likely sequence could be: ploughing, seed bed preparation and sowing, vegetation growth, crop maturing/yellowing, harvest.* *Full crop calendar with linked practices is to be provided in point 11.1* The selected answer:
3.2	Activity/event name	*Repeat section 3.2 for every activity/event listed in 3.1*
3.2.1	Duration (temporal granularity)	Indicate the duration (from start to end) of the single activity/event: Possible answers: ☐ Days ☐ Weeks ☐ Months ☐ Years
3.2.2	Spatial propagation	Possible answers: ☐ Instantaneous ☐ Gradual ☐ Intermittent *e.g. partial mowing, entire field at once, etc.*
3.2.3	Timing (time frame)	Indicate a period when activity/event is likely to happen: [DD/MM] – [DD/MM]
3.2.4	Temporal units	Possible answers: ☒ Calendar time ☐ Thermal time
3.2.5	Observed aspects of phenomena affected by the given activity/event	*This field should use Table 1 to indicate the:* • *material* • *type of feature(s)/ element(s)* • *presence of specific intrinsic mix* • *stratum* *E.g. In the case of managed grassland, it will be:* • *Material: biotic* • *Feature/Element Characteristic: Herbaceous Vegetation* • *Portion of a mix: No* • *Stratum: 1 (ground level)In case multiple features/elements in different strata are affected, all should be listed here.*

Code	Topic	Value			
3.2.6	Related characteristics/properties affected by the given activity/event	*This field should use Table 1 to indicate the type of the relevant feature(s)/ element(s) characteristic(s)* *E.g. In the case of managed grassland, it will be:* • *Element: Herbaceous Vegetation* • *Phenological stages affected: a possible pre-defined value should be given here (emerging, full development, senescent), but further details can be provided, if needed* • *Height range (ex. [3-30] cm) NOTE: For hight range, the min and max value of the height of the plant for its life cycle should be given* • *Ground cover (or range of ground cover)*			
3.2.7	Pre-conditions in time	*Values of the characteristics before the event. e.g. like a fresh grass, 10-50cm long, emerging or at full development, close vegetation cover*			
3.2.8	Mid-conditions in time	*Values of the characteristics during the event*			
3.2.9	Post-conditions in time	*Values of the characteristics after the activity/event. e.g. shorten grass: 5-15cm, emerging, open cover, residuals collected from the filed immediately, residuals left to dry*			
3.3	Local (contextual) conditions to account for *(a list of potential factors that do have an influence on the event or phenomenon behaviour in time)*	No	Yes	No Data	Category
		☐	☐	☐	Climate (bio-geographic region) *e.g. crop emergence date may be influenced by persisting frost occurring for longer periods in a specific region. Provide all relevant information.*
		☐	☐	☐	Land form (level, sloping, steep) *e.g. some FOIs could be located on areas prone to erosion. Please provide all relevant information.*
		☐	☐	☐	Topography (relief/altitude) *e.g. high altitudes may be linked with shorter vegetation seasons, different emergence and harvest dates. Please provide all relevant information.*
		☐	☐	☐	Soil (type/texture)
		☐	☐	☐	Water supply (rainfed, irrigated, post-flooding)
3.4	*Local natural disturbances*	*Information about local natural disturbances, i.e.:*			

Code	Topic	Value
		- drought [likely period] *- waterlogged /floods [likely period]* *- burning/fire [likely period]* *- snow cover [likely period]* *- frost or pest [likely period]*
4	**FOI** *In case area or shape restrictions exist (4.1 and 4.2) please fill in this section multiple times to characterise the entire FOI population.*	
4.1	FOI type ID	*in case no size/shape restriction exists there is only one FOI type. If different monitoring techniques are used depending on the FOI size/shape characteristics the entire section should be completed multiple times with different FOI type IDs.*
4.2	FOI geometry: area restrictions	*Insert a free text: e.g. FOI with area greater than 2000m2 are to be analysed*
4.3	FOI geometry: shape restrictions	*Insert a free text: e.g. elongation, complexity, shape index, elongated parcel with a smallest length than 3m are to be excluded*
4.4	FOI geometry: type	Possible answers: ☐ Single polygon ☐ Multi-polygon
4.5	How was FOI created?	*Indicate relation of FOI with the GSAA. Free text insert here:* *i.e.* • *image based,* • *declaration based,* • *LPIS based,* • *other.*
4.6	Single agricultural land cover?	Possible answers: ☐ Yes ☐ No ☐ Other*: * insert free text:
4.7	Is single management practice verified for the FOI as a systematic check?	Possible answers: ☐ Yes ☐ No If YES, please specify how and when:
4.8	Sub-FOI analyses foreseen? *i.e. for partial mowing*	Possible answers: ☐ Yes ☐ No

Code	Topic	Value
		If yes, please provide more information concerning conditions:
4.9	Entire FOI used to derive signal statistics?	Possible answers: ☐ Yes ☐ No If no, explain, e.g.: a negative buffer of Xm applied for each FOI
4.10	Planned monitoring method	e.g. based on: • Sentinel-, • aerial photo, • UAV, • geotagged photos, • other.
5	**Land cover characteristics** *(optional element, providing extra contextual information to the observable aspects of the land cover feature/phenomenon, described in 3.2.5 and 3.2.6)*	
5.1	Material	Possible answers: ☐ Biotic ☐ Abiotic *E.g. In the case of managed grassland, it will be: biotic*
5.2	Outer Appearance Abiotic	*If other elements observable:* ☐ Natural Bare Surface - Rock, gravel, sand ☐ Natural Bare Surface - Bare soil ☐ Natural Bare Surface - Organic deposit ☐ Artificial Surface - Built- up (building, road) ☐ Artificial Surface - Non built-up (dumpsite, quarry) ☐ No data
5.3	Outer Appearance Biotic (Life form)	Possible answers: ☐ Woody ☐ Herbaceous ☐ Other (ex. Lichen, Mosses)
5.4	Phenology (Life cycle)	Possible answers: ☐ Perennial ☐ Biennial ☐ Annual ☐ Other

Code	Topic	Value
		Free text here:
5.5	Floristic aspect	Possible answers: ☐ Single plant specie ☐ Group of plant species Further indicate the name of plant species: If *Single plant species* is flagged, indicate the dominant or most frequent species in the layer: If Group of plant species is flagged, indicate, either the • statistically_derived_plant_group, or • non_statistically_derived_plant_group
5.6	Observable characteristics that are always present	*Use the options from Table 1 (in Section 2.2)*
5.7	Horizontal distribution/pattern	*Structured information about the intrinsic mix, if present. E.g. for pro-rata or polders, presence of channels.*
5.8	Observable characteristic(s) that is/are occasionally present	*Depends on the values reported for the cover and the presence of other elements in an intrinsic mix (when the value for the [Portion of a mix] is Yes). E.g. possible woody vegetation in the parcel*
5.9	Vertical distribution (strata)	*List the number of strata present.* *In the simplest case of managed vegetation, it should be: Stratum 1*
5.10	Inter-strata relationship	*Indicate with free text whether the presence of an element in a stratum depends on the presence of an element in another stratum. For example, the cover and vitality of grass in Spanish dehesas depends on the presence of trees.* *Could be relevant for agroforestry*
6	**Signal** *In case of multiple signals used, this section should be filled in multiple times. In case image classification results are used this section is replaced by section 10. Other process inputs.*	
6.1	Signal ID	*i.e. S2_NDVI_1*
6.2	Source	Possible answers: ☐ Sentinel 1 ☐ Sentinel 2 ☐ Thematic dataset (not classification) ☐ Other*

Code	Topic	Value
		*Please specify: *i.e: aerial, satellite based orthophoto GSD = Xm, geotagged photos (if relevant add here more information)*
6.3	Type	*Please indicate the band, bandwidth, or band derivatives, type of processing+ resolution* *(i.e. S2_B4, NDVI, S1_CoH6, weekly composite of…)*
6.4	Statistical descriptor	*Please indicate the statistical descriptor used* *i.e: mean, stdev , Q25, Q50*
6.5	Normalisation	*i.e. NDVI : values <0,1>* *Band X – resampled to 10mGSD*
6.6	Data de-noising	*i.e. S2: SCL selection*
6.7	Resampling or missing data interpolation	Possible answers: ☐ Yes * ☐ No *If yes, then please explain how this process was performed:
6.8	Smoothing	Possible answers: ☐ Yes * ☐ No *If yes, then please explain how this process was performed:
6.9	Associated spatial entity/primitive	Possible answers: ☐ FOI ☐ Image segment ☐ Image pixel/point
6.10	Associated FOI type	*Please provide the associated FOI type ID from section 4.1.*
6.11	Signal constraints	*e.g. unavailability in specific periods of the desired monitoring time (linked with 3.2.4)*
7	**Markers** *Repeat entre section for every marker used. In case image classification results are used this section is replaced by section 10. Other process inputs.*	
7.1	Marker name	*Provide name, e.g. M1, M2*
7.2	Marker ID	

Code	Topic	Value
7.3	Aspects of the real-world phenomenon addressed by the prototype marker:	Possible answers: ☐ Spatial ☐ Temporal ☐ Spatio-Temporal
7.4	Types	*G1: cardinality between GSAA/CbM-derived FOI representations* *G2: spatial variability within a representation* *T1: an occurrence of an abrupt land cover change* *T2: evidence of a gradual land cover transition (multiannual results)* *T3: an observation of a tell-tale event (event markers)* *T4: the identification of a crop.* *C1: temporal intra-parcel variability*
7.5	Role of the marker	Possible answers: ☐ Manifestation scenario ☐ Absence scenario ☐ Other
7.6	Activity/event the marker is associated with	*Name of activity/event from section 3.2*
7.7	User information need the marker is associated with	*Name of the requirement from section 2.2*
7.8	Marker core	*Description of the marker core*
7.8.1	Signal associated	*Which signal(s) is associated to the marker core: i.e. NDVI (S2 based) or Signal_ID (6.1)*
7.8.2	LC manifestation the marker is searching for	*Information about state or change of stage of LC manifestation that should be associated to an activity* *i.e. in case of mowing, grass is cut or grass is shorten*
7.8.3	Signal behaviour	*Which particular signal behaviour is related to marker (i.e., drop of signal value after the activity happens on the field)* Possible answers: ☐ Decrease ☐ Increase ☐ Constant ☐ Other* *Please specify here: *(if relevant add here more information)*
7.9	Marker parameters	*Add any parameters used to control detection of the marker.*

Code	Topic	Value
7.9.1	Related to signal value	*i.e. drop of the signal value, gather equal to 0.2 or a threshold*
7.9.2	Related to time	*i.e. the drop should be recorded in 2 weeks of time*
7.9.3	Other constraints	Add another constrain, if any, that are used to control marker: *i.e. at least 2 valid observations in time series must be available,* • required signal availability (signal sampling frequency): • signal quality: • characteristics of signal which makes it invalid: *(i.e. lack of data for a period of x weeks – 6.11)*
7.10	Period when the marker is activated	[DD.MM] – [DD.MM] *i.e. Period from 01/01- 31/06: information for lane*
7.11	More information	Any other information to add here:
7.12	Marker output	Possible answers: Result: ☐ Found / Not found ☐ Signal quality-based validity of observation ☐ Time stamp: Single date ☐ Time stamp: Period (from to) Please specify how the date/period is derived: add here ☐ Other: please specify here
7.13	Estimated sensitivity and selectivity (α and β)	α= β=
8	**Switch** *Repeat entire section for every switch used*	
8.1	Name	Sw1: *Switch on ……..(name used later in section describing the lane)*
8.2	Switch_ID	
8.3	Main function	*Short information about the relevant requirement (point 2.2) it evaluates (collects evidence for)*

Code	Topic	Value
8.4	Type:	Linked with: ☐ compliance rules ☐ non-compliance rule ☐ validity rules ☐ other
8.5	Operating time	Period from-to [DD.MM.YYYY-DD.MM.YYYY]
8.6	Operated markers or other processing method result (signal/thematic layer)	*e.g., marker ID (section 7.2) or process input ID (section 10.1)*
8.7	Logical operators and priorities between markers	*Please provide the logical expression*
8.8	Link with classification results (to be filled only if classification is used instead of marker detection)	How is the result of classification linked with the eligibility criterion?
8.9	Possible output	Possible answers: ☐ decision (Y/N) ☐ inconclusive ☐ other *If other, please specify*
8.10	Timing of evidence processing	Timing of switches processing ☐ as soon as processing results available ☐ monthly ☐ quarterly ☐ yearly ☐ other: please specify:
8.11	Relevant lane(s)	*Provide name or ID*
9	**Lane** *Repeat sections: 9.1-9.8 for every lane used*	
9.1	Name	
9.2	Lane ID	
9.3	Main function	*Short information on what it processes?*
9.4	User information need associated with the lane	*Please provide the associated user information needs from section 2.2 (e.g., Req1, Req2 etc).*
9.5	Operated switches	*Use names as indicated in section 6*

Code	Topic	Value
9.6	Logical operators between switches and switch priorities (?)	*Please provide the logical expression*
9.7	Warnings	Sent when: ☐ declaration requires revision (e.g., invalid FOI) ☐ additional information needed ☐ other If other, please specify
9.8	Output	Possible answers: ☐ conclusive (green/red) ☐ inconclusive (yellow)
9.9	Graphical representation of the processing workflow	link to the file
10	**Other process inputs (i.e. image classification results)**	
10.1	Process input ID	
10.2	Source image	Possible answers: ☐ Sentinel 1 ☐ Sentinel 2 ☐ Other* *Please specify: *i.e: aerial, satellite based orthophoto GSD = Xm, geotagged photos (if relevant add here more information)*
10.3	Temporal coverage (image)	*The temporal range of data used as input* *Possible answers* ☐ Single date ☐ Period* *Please indicate the period: [DD.MM.YYYY]-[DD.MM.YYYY] If multiple images are used covering a period, please indicate an average number of images per period or spacing between the used images:
10.4	Algorithm	*Possible answers:* ☐ Unsupervised ☐ Supervised *Possible answers:* ☐ FOI based

Code	Topic	Value
		☐ object based (other than FOI) ☐ pixel based *Free text:* *Name or/and references of algorithm used to produce the image classification result.*
10.4.1	Input data type	*Please indicate the band, (for airborne sensors also spectral band characteristics), or band derivatives with their ground sampling distance, type of processing.* *Indicate if other datasets are used (DEM, soil, bio-physical parameters, etc..)* *(i.e. S2_B4, NDVI, S1_CoH6, weekly composite of…)*
10.4.2	Key algorithm parameters values used	*Parameter 1: Value 1 Parameter 1: Value 1* *Parameter 1: Value 1* *i.e. prediction threshold - example value: majority; a mismatch is tagged if the majority of predicted labels is different from the FOI label.* *i.e. probability threshold- the predicted class is assigned on the basis of the maximum probability. This could be thresholded, for instance, by requiring the maximum to be > 0.50.*
10.4.3	Output result used in the process	*Possible answers* ☐ classification labels ☐ probability layer ☐ other* *if other, please specify here:
10.4.4	Data training (for supervised only)	*Please specified the training strategy* *Training set size:* *i.e. 20% of the full set of parcels*
10.4.5	Training classes	*List the training classes (i.e. archive result of the crop classification). Including a composition of crop categories, if applicable*
10.5	Output data per FOI	*Please indicate an output data format* ☐ single class per FOI ☐ list of probable classes per FOI ☐ pixels with assigned classes ☐ other* *if other, please specify here:

Code	Topic	Value
10.6	Accuracy statement	Quality statement: ☐ not checked ☐ checked* *if checked, then please specify here: *i.e. by providing confusion matrix*
10.7	Other information	*Other relevant information: literature links, graphical processing workflows etc*
11	**Additional information**	
11.1	Crop calendar	*If relevant, crop calendar, vegetation stages and practices. A list of practices, possibly including the ones considered as non-monitorable with a selected signal/sensor.*
11.2	Payment schemes	*If relevant, please provide more information about related payment schemes as indicated in point 2.1*
11.3	Other	*Please specify.* *Add more rows according to the need.*

Source: GTCAP

4 Conclusions

The CbM template was developed to facilitate systematic and structured documentation of agricultural land monitoring systems relying on EO-based signal processing. With more than 50 Paying Agencies in EU Member States, there is a strong case for transparent and structured documentation to facilitate information exchange. Although focused on the agricultural use case, this template may also be adopted to document other land monitoring systems. A systematic description covering all the key system elements may also help the system designers to improve or optimize the information flow, or learn from other systems, if the completed templates are shared. The modular design of the template allows for selective usage of sections, if needed.

Although the current version of this document relies mostly on data provided by the Copernicus Sentinel-1 and Sentinel-2, it can be easily extended to include documentation from other data sources (i.e. geotagged photos, machinery tracks etc) and monitoring solutions.

Future development work may consider adding these elements and publish an updated version of this template. The developed template considers the latest standardization efforts of the GI community and is equally applicable any other land monitoring domain (environment, climate, territorial development).

References

Breger, P., 2017. The Copernicus full, free and open data policy. https://www.ecmwf.int/node/17104

Devos W., Sima A. and Milenov P. *Conceptual basis of checks by monitoring*, JRC127678, Publications Office of the European Union, Ispra, 2021a, https://marswiki.jrc.ec.europa.eu/wikicap/images/8/87/JRC127678_final.pdf

Devos W., Milenov P., Zielinski R., Vajsova B. *Checks by Monitoring Quality Assurance Framework. ANNEX IV Ground data, version 1.2.,* JRC 119733, Publications Office of the European Union, Ispra, 2021b,https://marswiki.jrc.ec.europa.eu/wikicap/images/c/cb/1_2_Annex_IV_Groud_data.pdf

Devos W., Lemoine G., Milenov P., Fasbender D., Loudjani P., Wirnhardt C., Sima A., Griffiths P., 2018. Second discussion document on the introduction of monitoring to substitute OTSC: rules for processing application for the 2018-2019. EUR 29369 EN. Publications Office of the European Union, Ispra, 2018, doi: 10.2760/344612

ISO 19144-2:2012, Geographic information - Classification systems — Part 2: Land Cover Meta Language (LCML), 2012, https://www.iso.org/standard/44342.html

ISO 19156:2011, Geographic information — Observations and measurements, 2011, https://www.iso.org/standard/32574.html

Milenov P., Vajsova, B., Voican G., Acquafresca L., Anastasakis K., Lemoine G., Assessing the Validity of the Feature of Interest in the context of the CAP Checks by Monitoring, Ispra, 2021, JRC123711

List of abbreviations and definitions

CAP	Common agricultural policy
CbM	Checks by monitoring
EO	Earth observation
FOI	Feature of interest
GSAA	Geospatial aid application
LCML	Land Cover Meta Language
LUML	Land Use Meta Language
LPIS	Land parcel identification system
NA	Not available
OGC	Open Geospatial Consortium
PA	Paying agency
QA	Quality assurance
UoD	University of discourse
ISO	International Organization for Standardization
NUTS	Nomenclature of territorial units for statistics
LAU	Land administration unit

List of figures

List of tables

Annex: Example documentation of mowing detection on temporal grassland using sections 1 to 7 of the template.

Code	Topic	Value
1	**Generic information**	
1.1	Project name	CbM
1.2	Template version	v.1.0
1.3	Name and contact details of person providing the information	Name surname: Institution: Contact details: e-mail:
1.4	MS/PA code	EU_Country
1.5	Date of entry	01.07.2021
1.6	Template ID	EU_Country CbM__2022
1.7	Very short description of the activity/practice/scheme being the subject of monitoring	mowing detection on temporal grassland
1.8	Keywords	mowing, grassland
2	**User information needs – requirements**	
2.1	Related payment scheme	*Free text insert here: e.g. (SPS, BPS, SFS, VCS, GRE,)* BPS
2.2	Minimum set of eligibility criteria	*Free text with information derived from national rules, including validity, compliance, and non-compliance rules.* Req1: At least one mowing/grazing in the time frame of 1.04-30.09
2.3	Period(s) when the requirement is to be observed (time frame)	Req1: 01/04 - 30/09
2.4	Temporal reference of the scheme	Possible answers: ☐ Agronomic year ☒ Calendar year ☐ No data
2.5	Specific crop type associated	Clover, Grass-Clover Mix, Lucerne, Arable Pasture, Forage Grass, Other Field Fodder Crops
2.6	Specific land cover type associated	**A** arable land (use this category for temporal grassland) N natural grassland G permanent grassland

Code	Topic	Value
		HV herbaceous vegetation
2.7	Geographic extent	Based on NUTS/LAU: ☒ Full country ☐ Region-specific* ☐ Not indicated **add specifics here:*
3	**Selected practices (only the ones relevant for monitoring)** *Please repeat section 3.2 for every activity or event listed in 3.1*	
3.1	Practices/activities/events affecting the physical state or triggering change of state of the agricultural land cover- that should be picked up by markers	Potential sequences of activities and events (in practice): ACT2-EV1-ACT2-EV1-ACT1 Where: ACT1 – mowing, (including activities: topping, mowing for hay and mowing for silage) ACT2 – grazing EV1- vegetation regrowth Re-occurring of mowing is possible approx. after 28 days, depending on local characteristics and weather conditions.
3.2a	Activity/event name	mowing
3.2a.1	Duration (temporal granularity)	Possible answers: ☒ Days ☐ Weeks ☐ Months ☐ Years
3.2a.2	Spatial propagation	Possible answers: ☒ Instantaneous ☐ Gradual ☒ Intermittent
3.2a.3	Timing (time frame)	Indicate a period when activity is likely to happen: [01.05] – [30.08]
3.2a.4	Temporal units	Possible answers: ☒ Calendar time ☐ Thermal time
3.2a.5	Observed aspects of phenomena affected by the given activity/event	Material: biotic Feature/Element Characteristic: Herbaceous Vegetation Portion of a mix: No

Code	Topic	Value
		Stratum: 1 (ground level)
3.2a.6	Related characteristics/properties affected by the given activity/event	**Element:** Herbaceous Vegetation **Phenological stage:** all stages **Height range:** 10cm-60cm **Ground cover**: close Note: Mowing date is decided individually by the farmer (e.g. with consideration of the weather), so can happen at every phenological stage, thus different grass height.
3.2a.7	Pre-conditions in time	Expected manifestations: For mowing (silage/hay): Fresh grass, 10-60cm emerging or at full natural development Close vegetation cover For topping: Fresh grass, 10-60cm when emerging or full development Close vegetation cover
3.2a.8	Mid-conditions in time	Temporal change from pre- to mid- conditions is abrupt. In a case of: **Topping**: grass is chopped/partitioned and left on the field. • Expected manifestations: presence of dry/dead vegetation, mixed with a fresh vegetation underneath, both covering the soil, • Close vegetation cover. **Grass mowed for silage** – residuals removed shortly after mowing or within 24-48 hours after being mown (if baling is foreseen). • Expected manifestations: absence of grass or very short grass, • Open vegetation cover, • Optional presence of dry/dead vegetation covering the soil for the first two days after the cutting event. **Grass mowed for hay** - residuals are baled within several days after being mowed. In between the grass is left to dry on the ground and is subject of tedding and raking. Expected manifestations: presence of dry/dead vegetation covering the soil for several days.
3.2a.9	Post-conditions in time	Temporal change from mid- to post- conditions is gradual. Absence of grass or very short grass (<10 cm). Open vegetation cover Underlying soil can be visible

Code	Topic	Value
		Re-occurring of mowing is possible approx. after 30-45 days, depending on local practices and weather conditions.
3.2b	Activity/event name	grazing
3.2b.1	Duration (temporal granularity)	Possible answers: ☐ Days ☒ Weeks ☒ Months ☐ Years
3.2b.2	Spatial propagation	Possible answers: ☐ Instantaneous ☒ Gradual ☒ Intermittent
3.2b.3	Timing (time frame)	Indicate a period when activity is likely to happen: [01.05] – [30.08]
3.2b.4	Temporal units	Possible answers: ☒ Calendar time ☐ Thermal time
3.2b.5	Observed aspects of phenomena affected by the given activity/event	Material: biotic Feature/Element Characteristic: Herbaceous Vegetation Portion of an intrinsic mix: No Stratum: 1 (ground level)
3.2b.6	Related characteristics/properties affected by the given activity/event	Element: Herbaceous Vegetation Phenological stage: all stages Height range: 10cm-60cm Ground cover: open to close Note: Grazing time is decided individually by the farmer (e.g. with consideration of the weather), so can happen at every phenological stage, thus different grass height.
3.2b.7	Pre-conditions in time	Expected manifestations: Fresh grass, 10-60cm emerging or at full natural development, Close vegetation cover
3.2b.8	Mid-conditions in time	Temporal change from pre- to mid- condition is gradual. In larger parcels animals may be fenced in a part of the field – impact on the spatial propagation. Expected manifestations: • fresh grass, 10-20cm, emerging or full development • Open to dense vegetation cover.

Code	Topic	Value			
3.2b.9	Post-conditions in time	Temporal change from mid- to post- condition is gradual. Absence of grass or very short grass (<10 cm). Open vegetation cover Underlying soil can be visible			
3.2c	Activity/event name	vegetation re-qrowth			
3.2c.1	Duration (temporal granularity)	Possible answers: ☐ Days ☒ Weeks ☒ Months ☐ Years			
3.2c.2	Spatial propagation	Possible answers: ☐ Instantaneous ☒ Gradual ☐ Intermittent			
3.2c.3	Timing (time frame)	Indicate a period when activity/event is likely to happen: [01.03] – [30.11]			
3.2c.4	Temporal units	Possible answers: ☒ Calendar time ☐ Thermal time			
3.2c.5	Observed aspects of phenomena affected by the given activity/event	Material: biotic Feature/Element Characteristic: Herbaceous Vegetation Portion of an intrinsic mix: No Stratum: 1 (ground level)			
3.2c.6	Related characteristics/properties affected by the given activity/event	Element: Herbaceous Vegetation Phenological stage: emerging Height range: 10cm-60cm Ground cover: open to closed Full plants regrowth happens within less than 45 days.			
3.2c.7	Pre-conditions	Absence of grass or very short grass (<10 cm). Open vegetation cover Underlying soil can be visible			
3.2c.8	Mid-conditions in time	Fresh grass, medium height Open to close vegetation cover			
3.2b.9	Post-conditions in time	Fresh grass, 10-60cm, full development Close vegetation cover			
3.3	Local (contextual) conditions to account for	No	Yes	No Data	Category

Code	Topic	Value			
	(a list of potential factors that do have an influence on the event or phenomenon behaviour in time)	☒	☐	☐	Climate (bio-geographic region) *e.g., crop emergence date may be influenced by persisting frost occurring for longer periods in a specific region. Provide all relevant information.*
		☒	☐	☐	Land form (level, sloping, steep) *e.g., areas prone to erosion would prevent the development of close and uniform vegetation cover*
		☒	☐	☐	Topography (relief/altitude) *e.g., high altitudes may be linked with shorter vegetation seasons, different emergence and harvest dates. Please provide all relevant information.*
		☒	☐	☐	Soil (type/texture) *e.g., certain soil types and characteristics could significantly affect the phenology and cover of vegetation.*
		☐	☒	☐	Water supply (rainfed, irrigated, post-flooding) The number of mowings may change depending on the precipitation.
3.4	*Local natural disturbances*	- potential drought [mid July-mid August]			
4	**FOI** *In case area or shape restrictions exist (4.1 and 4.2) please fill in this section multiple times to characterise the entire FOI population.*				
4a.1	FOI type ID	FOI_type_1			
4a.2	FOI geometry: area restrictions	For all FOIs greater than 200m2			
4a.3	FOI geometry: shape restrictions	Not specified			
4a.4	FOI geometry: type	Possible answers: ☒ Single polygon ☐ Multi-polygon			
4a.5	How was FOI created?	FOI is equal to GSAA No aggregation/splitting applied			
4a.6	Single agricultural land cover?	Possible answers:			

Code	Topic	Value
		☒ Yes ☐ No ☐ Other*: with the exception of single isolated trees
4a.7	Is single management practice verified for the FOI as a systematic check?	Possible answers: ☒ Yes ☐ No If YES, please specify how and when: Signal to noise ratio (SNR) the signal is computed after new image is available and the difference between consecutive observations are tested.
4a.8	Sub-FOI analyses foreseen? i.e. for partial mowing	Possible answers: ☒ Yes ☐ No
4a.9	Entire FOI used to derive signal statistics?	Possible answers: ☐ Yes ☒ No a negative buffer of 5m applied for each FOI, the selected pixels are fully enclosed in the geometry.
4a.10	Planned monitoring method	based on Sentinel-1 and Sentenel-2 data
4b.1	FOI type ID	FOI_type_2
4b.2	FOI geometry: area restrictions	For all FOIs smaller or equal to 200m2
4b.3	FOI geometry: shape restrictions	Not specified
4b.4	FOI geometry: type	Possible answers: ☒ Single polygon ☐ Multi-polygon
4b.5	How was FOI created?	FOI is equal to GSAA No aggregation/splitting applied
4b.6	Single agricultural land cover?	Possible answers: ☒ Yes ☐ No ☐ Other*: with the exception of single isolated trees

Code	Topic	Value
4b.7	Is single management practice verified for the FOI as a systematic check?	Possible answers: ☒ Yes ☐ No If YES, please specify how and when: Confirmation from the farmer
4b.8	Sub-FOI analyses foreseen? i.e. for partial mowing	Possible answers: ☐ Yes ☒ No
4b.9	Entire FOI used to derive signal statistics?	Possible answers: ☒ Yes ☐ No
4b.10	Planned monitoring method	geotagged photos
5	**Land cover characteristics** *(optional element, providing extra contextual information to the observable aspects of the land cover feature/phenomenon, described in 3.2.5 and 3.2.6)*	
5.1	Material	Possible answers: ☒ Biotic ☐ Abiotic
5.2	Outer Appearance Abiotic	*If other elements observable:* ☐ Natural Bare Surface - Rock, gravel, sand ☒ Natural Bare Surface - Bare soil ☐ Natural Bare Surface - Organic deposit ☐ Artificial Surface - Built- up (building, road) ☐ Artificial Surface - Non built-up (dumpsite, quarry) ☐ No data
5.3	Outer Appearance Biotic (Life form)	Possible answers: ☒ Woody – single trees ☒ Herbaceous ☐ Other (ex. Lichen, Mosses)
5.4	Phenology (Life cycle)	Possible answers: ☒ Perennial ☒ Annual ☐ Biennial ☐ Other
5.5	Floristic aspect	Possible answers:

Code	Topic	Value
		☒ Single plant specie ☒ Group of plant species Single plant specie: Clover, Lucerne, Other Field Fodder Crops Group of plant species: Grass-Clover Mix, Arable Pasture, Forage Grass, Other Field Fodder Crops non_statistically_derived_plant_group
5.6	Observable characteristics that are always present	Material: biotic Feature/Element Characteristic: Herbaceous Vegetation Stratum: 1 (ground level)
5.7	Horizontal distribution/pattern	Sparsely distributed single trees
5.8	Observable characteristic that is occasionally present	Feature/Element Characteristic: Trees with leaves Stratum: 3 Cover: sparse (single trees)
5.9	Vertical distribution (strata)	Stratum 1 Stratum 3 Optional
5.10	Inter-strata Relationship	No data, in most of the cases dense grass under single trees. There can be presence of trees, preventing the development of grass beneath.
6	**Signal** *In case of multiple signal used, this section should be filled in multiple times. In case image classification results are used this section is replaced by section 10. Other process inputs.*	
6.1	Signal ID	S1CoH6
6.2	Source	Possible answers: ☒ Sentinel 1 ☐ Sentinel 2 ☐ Thematic dataset (not classification) ☐ Other* *Please specify: *i.e: aerial, satellite based orthophoto GSD = Xm, geotagged photos (if relevant add here more information)*
6.3	Type	6 days coherence Sentinel-1
6.4	Statistical descriptor	median
6.5	Normalisation	No
6.6	Data de-noising	No

Code	Topic	Value
6.7	Resampling or missing data interpolation	Possible answers: ☐ Yes * ☒ No
6.8	Smoothing	Possible answers: ☐ Yes * ☒ No
6.9	Associated spatial primitive	Possible answers: ☒ FOI ☐ Image segment ☐ Image pixel/point
6.10	Associated FOI type	FOI_type_1
6.11	Signal constraints	At least two Sentinel-1 satellites available to reach 6 days revisit capacity (to derive 6-day coherence data)
7	**Markers** *Repeat sections: 7.1-7.12 for every marker used. In case image classification results are used this section is replaced by section 10. Other process inputs.*	
7.1	Marker name	Mowing_coherence_S1
7.2	Marker ID	M1_S1CoH6
7.3	Aspects of the real-world phenomenon addressed by the prototype marker:	Possible answers: ☐ Spatial ☒ Temporal ☐ Spatio-Temporal
7.4	Types	T3: an observation of a tell-tale event
7.5	Role of the marker	Possible answers: ☒ Manifestation scenario ☐ Absence scenario ☐ Other
7.6	Activity/event the marker is associated with	Mowing activity
7.7	User information need the marker is associated with	Req1
7.8	Marker core	Coherence values increase significantly after the mowing
7.8.1	Signal associated	S1CoH6

Code	Topic	Value
7.8.2	LC manifestation the marker is searching for	Grass is shortened
7.8.3	Signal behaviour	*Which particular signal behaviour is related to marker (i.e., drop of signal value after the activity happens on the field)* Possible answers: ☐ Decrease ☒ Increase ☐ Constant ☐ Other* Mowing implies change in the Coherence SAR (shortest temporal baseline 6 days) data i.e. increases the coherence values.
7.9	Marker parameters	Median signal increases
7.9.1	Related to signal value	>0.10
7.9.2	Related to time	The maximum change observed in 2-3 weeks after the activity occurring on the ground
7.9.3	Other constraints	Lower and relatively stable coherence values before mowing.
7.10	Period when the marker is activated	[01.04] – [15.10]
7.11	More information	*Any other information to add here:*
7.12	Marker output	Possible answers: Result: ☒ Found / not found ☐ Signal quality-based validity of observation ☒ Time stamp: Single date ☐ Time stamp: Period (from to) Please specify how the date/period is derived: linear interpolation ☐ Other: please specify here
7.13	Estimated sensitivity and selectivity (α and β)	α: no data β: no data

GETTING IN TOUCH WITH THE EU

In person

All over the European Union there are hundreds of Europe Direct centres. You can find the address of the centre nearest you online (european-union.europa.eu/contact-eu/meet-us_en).

On the phone or in writing

Europe Direct is a service that answers your questions about the European Union. You can contact this service:

— by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),

— at the following standard number: +32 22999696,

— via the following form: european-union.europa.eu/contact-eu/write-us_en.

FINDING INFORMATION ABOUT THE EU

Online

Information about the European Union in all the official languages of the EU is available on the Europa website (european-union.europa.eu).

EU publications

You can view or order EU publications at op.europa.eu/en/publications. Multiple copies of free publications can be obtained by contacting Europe Direct or your local documentation centre (european-union.europa.eu/contact-eu/meet-us_en).

EU law and related documents

For access to legal information from the EU, including all EU law since 1951 in all the official language versions, go to EUR-Lex (eur-lex.europa.eu).

Open data from the EU

The portal data.europa.eu provides access to open datasets from the EU institutions, bodies and agencies. These can be downloaded and reused for free, for both commercial and non-commercial purposes. The portal also provides access to a wealth of datasets from European countries.

The European Commission's science and knowledge service

Joint Research Centre

JRC Mission

As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.

EU Science Hub
joint-research-centre.ec.europa.eu

@EU_ScienceHub

EU Science Hub - Joint Research Centre

EU Science, Research and Innovation

EU Science Hub

EU Science