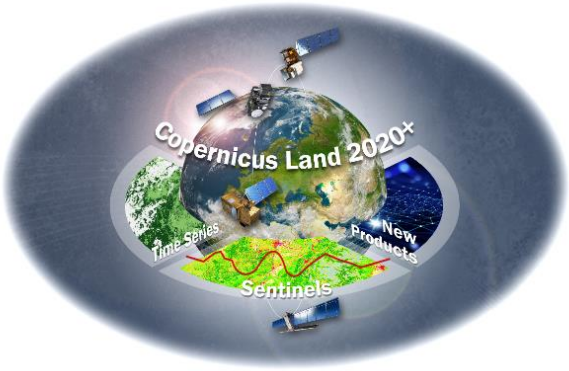
**Horizon 2020**

Space Call - Earth Observation: EO-3-2016: Evolution of Copernicus services

Grant Agreement No. 730008

# ECoLaSS

## Evolution of Copernicus Land Services based on Sentinel data




# D3.2

## "D21.1b – Service Evolution Requirements Report"

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## DISSEMINATION LEVEL

| DISSEMINATION LEVEL | | |
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| PU | Public | **X** |
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## APPLICABLE DOCUMENTS

| ID | DOCUMENT NAME / ISSUE DATE |
|---|---|
| AD01 | Horizon 2020 Work Programme 2016 – 2017, 5 iii. Leadership in Enabling and Industrial Technologies – Space. Call: EO-3-2016: Evolution of Copernicus services. Issued: 13.10.2015 |
| AD02 | Guidance Document: Research Needs Of Copernicus Operational Services. Final Version issued: 30.10.2015 |
| AD03 | Proposal: Evolution of Copernicus Land Services based on Sentinel data. Proposal acronym: ECoLaSS, Proposal number: 730008. Submitted: 03.03.2016 |
| AD04 | Grant Agreement – ECoLaSS. Grant Agreement number: 730008 – ECoLaSS – H2020-EO-2016/H2020-EO-2016, Issued: 18.10.2016 |
| AD05 | D1.1 – "D11.1a - Agendas and Minutes of Meetings", Issue: 4.0, Date Issued: 10.12.2019 |
| AD06 | D3.1 "D21.1a Service Evolution Requirements" Report, Issue 1.0. Issued: 09.08.2017 |

# EXECUTIVE SUMMARY

The Horizon 2020 (H2020) project "Evolution of Copernicus Land Services based on Sentinel data" (ECoLaSS) addressed the H2020 Work Programme 5 iii. Leadership in Enabling and Industrial technologies - Space, specifically the Topic EO-3-2016: Evolution of Copernicus services. ECoLaSS has been conducted from 2017–2019 and aimed at developing and prototypically demonstrating selected innovative products and methods as candidates for future next-generation operational Copernicus Land Monitoring Service (CLMS) products of the pan-European and Global Components. ECoLaSS assessed the operational readiness of such candidate products and finally suggests some of these for implementation. This shall enable the key CLMS stakeholders (i.e. mainly the Entrusted European Entities (EEE) EEA and JRC) to take informed decisions on potential procurement as (part of) the next generation of Copernicus Land services from 2020 onwards.

To achieve this goal, ECoLaSS made full use of dense time series of High-Resolution (HR) Sentinel-2 optical and Sentinel-1 Synthetic Aperture Radar (SAR) data, complemented by Medium-Resolution (MR) optical data if needed and feasible. Rapidly evolving scientific developments as well as user requirements were continuously analysed in a close stakeholder interaction process, targeting a future pan-European roll-out of new/improved CLMS products, and assessing the potential transferability to global applications.

This Deliverable "**D21.1b – Service Evolution Requirements Report**" analyses the service evolution requirements of Copernicus Land services, for mid-term (2018) and long-term (2020+) evolution. These requirements were collected by conducting a number of phone and face-to-face interviews with key representatives of European institutions as well as key national users and stakeholders that are in charge of implementing or coordinating CLMS activities. This report considers recent developments regarding Copernicus Land services as well as future plans, and extends the information gathered in the interviews with additional sources such as relevant reports, studies and presentations from recent workshops on the topic, recent operational CLMS related procurement procedures, etc.

The results of the analyses undertaken in the present report show that basically all activities planned and undertaken by ECoLaSS largely concured with the perception and core requirements of the key users and stakeholders in terms of future Copernicus Land service evolution, and several of the ECoLaSS developments have been migrating to operational implementation during the project's lifetime.

The ECoLaSS project focused on the pan-European and Global CLMS component aspects, as these are partially closely related, and had to take the needs of the respective key user and stakeholder community properly into account. Most of the requirements for evolution of existing services and for next-generation new services have been initially collected for the pan-European CLMS products, i.e., the High Resolution Layers (HRLs) in terms of improvements in thematic information content and timeliness, and CORINE Land Cover (CLC) in terms of developments towards CLC+. Requirements for the Global Component were collected mainly from key representatives of the EC's Joint Research Centre (JRC) and further available documentation/reports. There is generally substantial interest about the use of the High Resolution Layers, particularly when equivalent information is not available at national level, but it should be stressed that some users indicated that there is still a lack of awareness about the HRLs as well as about other CLMS products, which is still hampering their uptake and use.

Furthermore, national users showed particularly high interest in products of the Local Copernicus Component, which is clearly related to the higher spatial resolution of the products, better fulfilling the information needs on a regional level and also perhaps because these products are thematically closer to those already available locally. There is a generally an increasing and high interest in Copernicus (Sentinel) satellite data for conducting own analyses independently from Copernicus services and products, which was repeatedly mentioned by several users.

In terms of improved product specifications, the requirement for shorter update frequencies (e.g. annual incremental updates) was mentioned several times. Concerning new services, a pan-European

Agricultural Service (HRL Crops) as well as a HR Phenology Layer were the most frequently recorded responses. A further outcome is a trend towards the desire for more generic or cross-cutting services and products.

While it was observed that technical issues and limitations of the CLMS products' (satellite and other) input data, as well as the actual methods for generation of the products are not of major concern to the users, it was also found that (depending on the individual user) the knowledge of specifications of the existing products and capacities is in general rather limited. Requests for obtaining more information on the products and metadata were voiced several times. Additionally, a general requirement for an easier and more standardized access to data, products and documentation, on a unified state-of-the-art access portal, was repeatedly stated, including the desire for a multi-layer online visualization and/or evaluation tool for the products.

It should be noted that at the beginning of the ECoLaSS project in early 2017, there had been a perception among some key users and stakeholders, that scientific testing and selection processes had not always been applied rigorously for all past HRL products, and some unconsolidated products were released. Therefore, the ECoLaSS project with its approach of systematic user requirements assessment and stakeholder interaction, new products design and testing, prototypical demonstration and benchmarking, has been widely appreciated. In that sense, a continued close interaction between users, R&D projects and service providers (as has been the case in ECoLaSS) is seen as very useful, especially in order to make the best out of the exciting upcoming CLMS products and services.

Particularly in project phase 2, several relevant CLMS related ITTs and procurement processes have been carefully observed and evaluated, particularly during 2019. This report summarises the final and complete findings of this extended analysis. Due to the various relevant developments in the second half of 2019, it has been decided to capture these developments until the project end in order to provide a most complete account of CLMS related user requirements by Dec. 2019, providing the most up-to-date basis for potential uptake of the work by others, after the end of the ECoLaSS project.

The non-public Annexes 1+2 additionally provide detailed records of all conducted stakeholder/user interviews, allowing to further analyse individual, specific requirements as needed, at a later stage.

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# Abbreviations

| | |
|---|---|
| AdV | Arbeitsgemeinschaft der Vermessungsverwaltungen (German Association of Land Surveying Authorities |
| AFIGEO | Association Française pour l'Information Géographique) French Association for Geographical Information) |
| AG | Aktiengesellschaft (stock company) |
| BfN | Bundesamt für Naturschutz (German Federal Agency for Nature Conservation) |
| BKG | Bundesamt für Kartographie und Geodäsie (German Federal Agency for Cartography and Geodesy) |
| BMUB | Bundesministeriums für Umwelt, Naturschutz, Bau und Reaktorsicherheit (German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety) |
| BMVI | Bundesministerium für Verkehr und digitale Infrastruktur (German Federal Ministry of Transport and Digital Infrastructure) |
| BMVIT | Bundesministerium für Verkehr, Innovation und Technologie (Austrian Ministry for Transport, Innovation and Technology) |
| BMZ | Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (German Federal Ministry for Economic Cooperation and Develoipment) |
| C3S | Copernicus Climate Change Service |
| CAEN | Croatian Agenca for Environment and Nature |
| CAP | Common Agricultural Policy |
| CCM | Copernicus Contributing Mission |
| CDDA/s | Common Database on Designated Area/s |
| CEIA | Czech Environmental Information Agency |
| CEMS | Copernicus Emergency Management Service |
| CGDD | Comissariat Général au Développement Durable (French General Office for Sustainable Development) |
| CGS | Collaborative Ground Segment |
| CLC | CORINE Land Cover |
| CLC+ | CORINE Land Cover plus (with improved specifications) |
| CLCC | CORINE Land Cover Change |
| CLMS | Copernicus Land Monitoring Service |
| CNES | Centre National d'Études Spatiales (French Space Agency) |
| CNIG | Conseil National de l'Information Géographique (French National Council for Geographic Information) |
| CO | Confidential |
| CODE-DE | Copernicus Data and Exploitation Platform – Deutschland |
| CORINE | Coordination of Information on the Environment |
| CSV | Comma-separated values |
| CZ | Czech Republic |
| DEM | Digital Elevation Model |
| DESTATIS | Deutsches Statistisches Bundesamt (German Federal Statistical Office) |
| DG/s | Directorate-General/s |
| DG AGRI | Directorate-General for Agriculture and Rural Development |
| DG CLIMA | Directorate General for Climate Action |
| DG DEVCO | Directorate-General for International Cooperation and Development |
| DG GROW | Directorate General for Internal Market, Industry, Entrepreneurship and SMEs |

| | |
|---|---|
| DG ENV | Directorate-General for Environment |
| DG REGIO | Directorate General for Regional and Urban Policy |
| DIAS (CDIAS) | (Copernicus) Data and Information Access Service |
| DK | Denmark |
| DLR | Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Center) |
| DRI | Direction de la Recherche et de l 'Innovation (French Innovation and Research Directorate) |
| DWD | Deutscher Wetterdienst (German Weather Service) |
| EAA | Environmental Agency Austria (Umweltbundesamt Österreich) |
| EAGLE | EIONET Action Group on Land Monitoring in Europe |
| EARSC | European Association of Remote Sensing Companies |
| EARSeL | European Association of Remote Sensing Laboratories |
| EC | European Commission |
| ECoLaSS | Evolution of Copernicus Land Services based on Sentinel data (H2020 project) |
| ECV | Essential Climate Variable |
| EE | Estonia |
| EEA | European Environment Agency |
| EEA-39 | The 33 member countries of the EEA (i.e., the EU-28 member states together with Iceland, Liechtenstein, Norway, Switzerland and Turkey), plus 6 cooperating West Balkan countries (i.e., Albania, Bosnia and Herzegovina, the former Yugoslav Republic of Macedonia, Montenegro, Serbia as well as Kosovo) |
| EEEs | European Entrusted Entities |
| EFDAC | European Forest Data Centre |
| EFFIS | European Forest Fire Information System |
| EGMS | European Ground Motion Service |
| EIONET | European Environment Information and Observation Network |
| EIS | Environmental Information System |
| ELF | European Location Framework |
| ELI | Earth and Life Institute |
| EMS | Emergency Management Service |
| ENFIN | European Network of Forest Inventories |
| EO | Earth Observation |
| EOC | Earth Observation Centre |
| EPA/s | Environmental Protection Agency/s |
| ES | Spain |
| ESA | European Space Agency |
| ESM | European Settlement Map |
| ETC | European Topic Centre |
| ETC/ULS | European Topic Centre on Urban, Land and Soil Systems |
| ETS | Emissions Trading System |
| EU | European Union |
| EU-28 | the 28 member states of the European Union |
| EUROGI | European Umbrella Organisation for Geographic Information |
| EVI | Enhanced Vegetation Index |
| FAO | Food and Agriculture Organization (of the UN) |
| FISE | Forest Information System for Europe |

| | |
|---|---|
| FOR | Forest (HRL) |
| FP6 | 7th EC Framework Programme for Research and Technological Development |
| FP7 | 6th EC Framework Programme for Research and Technological Development |
| FS Unit | Food Security Unit, JRC |
| GAF | GAF AG (a service provider) |
| GAFA | Google, Apple, Facebook and Amazon |
| GBOV | Ground-based Observations |
| GEO | Group on Earth Observations |
| GEOGLAM | GEO Global Agricultural Monitoring |
| GEOSS | Global Earth Observation System of Systems |
| GFOI | Global Forest Observations Initiative |
| GFZ | Deutsches GeoForschungsZentrum (German Research Centre for Geosciences) |
| GHG | Greenhouse Gas |
| GHSL | Global Human Settlement Layer |
| GIS | Geographic Information System |
| GIO | GMES Initial Operations |
| GIS | Geographic Information System |
| GIZ | Deutsche Gesellschaft für Internationale Zusammenarbeit (German Corporation for International Cooperation) |
| GmbH | Gesellschaft mit beschränkter Haftung (limited liability company) |
| GMES | Global Monitoring for Environment and Security (former name of Copernicus) |
| GHG | Greenhouse Gas |
| GRA | Grassland (HRL) |
| GSAA | Geospatial Aid Application |
| GUF | Global Urban Footprint |
| GUI | Graphical User Interface |
| H2020 | Horizon 2020 (the 8th Framework Programme for Research and Technological Development of the EC) |
| HR | High Resolution |
| HRL/s | High Resolution Layer/s |
| HR VPP | High Resolution Vegetation Phenology and Productivity |
| IACS | Integrated Agricultural Control System |
| IGN | Institut National de l'Information Géographique et Forestière (National Institute of Geographic and Forest Information) |
| IMD | Degree of Imperviousness |
| IMP | Imperviousness (HRL) |
| INSPIRE | INfrastructure for SPatial InfoRmation in Europe |
| InVeKoS | Integriertes Verwaltungs- und Kontrollsystem (English: Integrated Administration and Control System – IACS) |
| IPCC | Intergovernmental Panel on Climate Change |
| IRS | Indian Remote Sensing Satellite |
| ISRSE | International Symposium on Remote Sensing of Environment |
| ITT | Invitation to Tender |
| JKI | Julius Kühn-Institut |
| JR | Joanneum Research GmbH (a service provider) |
| JRC | Joint Research Centre of the EC |

| | |
|---|---|
| KO | Kick-Off |
| LABO | Bund-Länder Arbeitsgemeinschaft Bodenschutz (German Federal Working Group on Soil Protection) |
| LBM-DE | Landbedeckungsmodell Deutschland |
| LISA | Land Information System Austria |
| LC | Land Cover |
| LCC | Land Cover Change |
| LC/LU | Land Cover/Land Use |
| LPIS | Land Parcel Identification System |
| LU | Land Use |
| LUCAS | Land Use/Cover Area frame Survey |
| LULC | Land Use/Land Cover |
| LULUCF | Land Use, Land Use Change and Forestry |
| MAES | Mapping and Assessment of Ecosystems and their Services |
| MEPA | Malta Environment and Planning Authority |
| MMU | Minimum Mapping Unit |
| MR | Medium Resolution |
| MS/s | Member State/s |
| N2000 | Natura 2000 |
| NA | Not Applicable / No Answer |
| NASA | National Aeronautics and Space Administration |
| NFI/s | National Forest Inventory/-ies |
| NFP | National Focal Point |
| NGOs | Non-Governmental Organisation/s |
| NGR | Natural and Semi-natural Grassland (HRL 2012) |
| NRC | National Reference Centre |
| NRC-EIS | EIONET National Reference Centres (NRCs) on Environmental Information Systems |
| NRT | Near Real Time |
| NSS | Natural systems and sustainability programme, EEA |
| NSS3 | Land systems group, EEA |
| PEPS | Plateforme d'Exploitation des Produits Sentinel (Sentinel Products Exploitation Platform) |
| PPI | Plant Phenology Index |
| PU | Public (Dissemination Level) |
| PWB | Permanent Water Bodies (HRL 2012) |
| QGIS | Quantum GIS |
| R&D | Research & Development |
| REA | Research Executive Agency (of the EC) |
| REDD+ | Reducing Emissions from Deforestation and Forest Degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries |
| RZ | Riparian Zones |
| S-1 / S1 | Sentinel-1 |
| S-2 / S2 | Sentinel-2 |
| S-3 / S3 | Sentinel-3 |

| | |
|---|---|
| S2GM | Sentinel-2 Global Mosaic |
| SAR | Synthetic Aperture Radar |
| SAS | Société par actions simplifiée |
| SDG/s | Sustainable Development Goal/s |
| SEIS | European Shared Environmental Information System |
| SIRS | Systèmes d'Information à Référence Spatiale SAS (a service provider) |
| SOER | State of Environment Report |
| SOeS | Service de l'Observation et des Statistiques (French Observation and Statistical Service) |
| SPOT | Satellite Pour l'Observation de la Terre |
| SRTI | Space Research and Technologies Institute |
| SWF | Small Woody Features (HRL 2015) |
| TCD | Tree Cover Density |
| TI | Thünen-Institut |
| UA | Urban Atlas |
| UBA | Umweltbundesamt Deutschland (German Environment Agency) |
| UCL | Université Catholique de Louvain (Catholic University of Leuven), Belgium |
| UFZ | Helmholtz-Zentrum für Umweltforschung (Helmholtz Centre for Environmental Research) |
| UN | United Nations |
| UNECE | United Nations Economic Commission for Europe |
| USGS | United States Geological Survey |
| VHR | Very High Resolution |
| VITO | Vlaamse Instelling Voor Technologisch Onderzoek (Flemish Institute for Technological Research) |
| WaW | Water/Wetness (HRL 2015) |
| WENR | Wageningen Environmental Research |
| WET | Wetlands (HRL 2012) |
| WFS | Web Feature Service |
| WMS | Web Map Service |
| WP | Work Package |
| ZKI | Zentrum Für Kriseninformation (Centre for Crisis Information) |

# 1 Introduction

The Horizon 2020 (H2020) project, "Evolution of Copernicus Land Services based on Sentinel data" (ECoLaSS) addresses the H2020 Work Programme 5 iii. Leadership in Enabling and Industrial technologies - Space, specifically the Topic EO-3-2016: Evolution of Copernicus services. ECoLaSS is being conducted from 2017–2019 and aims at developing and prototypically demonstrating selected innovative products and methods as candidates for future next-generation operational Copernicus Land Monitoring Service (CLMS) products of the pan-European and Global Land Components. ECoLaSS assesses the operational readiness of such candidate products and eventually suggests some of these for implementation. This shall enable the key CLMS stakeholders (i.e. mainly the Entrusted European Entities (EEE) EEA and JRC) to take informed decisions on potential procurement as (part of) of the next generation of Copernicus Land services from 2020 onwards.

To achieve this goal, ECoLaSS makes full use of dense time series of High-Resolution (HR) Sentinel-2 optical and Sentinel-1 Synthetic Aperture Radar (SAR) data, complemented by Medium-Resolution (MR) Sentinel3 optical data if needed and feasible. Rapidly evolving scientific developments as well as user requirements are continuously analysed in in a close stakeholder interaction process, targeting a future pan-European roll-out of new/improved Copernicus Land Monitoring Service products, and assessing the potential transferability to global applications.

This Deliverable D3.2: "D21.1b – Service Evolution Requirements Report" is the second issue of the main Deliverable of Work Package (WP) 3: "WP 21 – Assessment of Service Evolution Requirements", as part of Task 2: "Consolidation of Copernicus Land Evolution Requirement". The main objective of this Task is to collect, update and consolidate the functional and technical evolution requirements of existing and upcoming services for the Copernicus Land Monitoring Service (CLMS) beyond 2020, both of the Continental and Global CLMS Component.

The assessment of service evolution requirements as outcome of WP 21 forms the basis for all the work within the ECoLaSS project, i.e. the planned methodological developments (Task 3), the prototype demonstrations (Task 4), as well as the stakeholder consultation, the identification of candidates for future operational roll-out and the assessment of their integration potential in future (2020+) Copernicus Land services (Task 5). Additionally, the results of WP 21 constitute an important input to the assessment of evolution requirements of future/improved Copernicus Land services in terms of EO and other data needs (WP 22) as well as infrastructure needs (WP 23). The dependencies and interconnections of WP 21 with the relevant other WPs/Tasks of the ECoLaSS project are visualised in Figure 1:

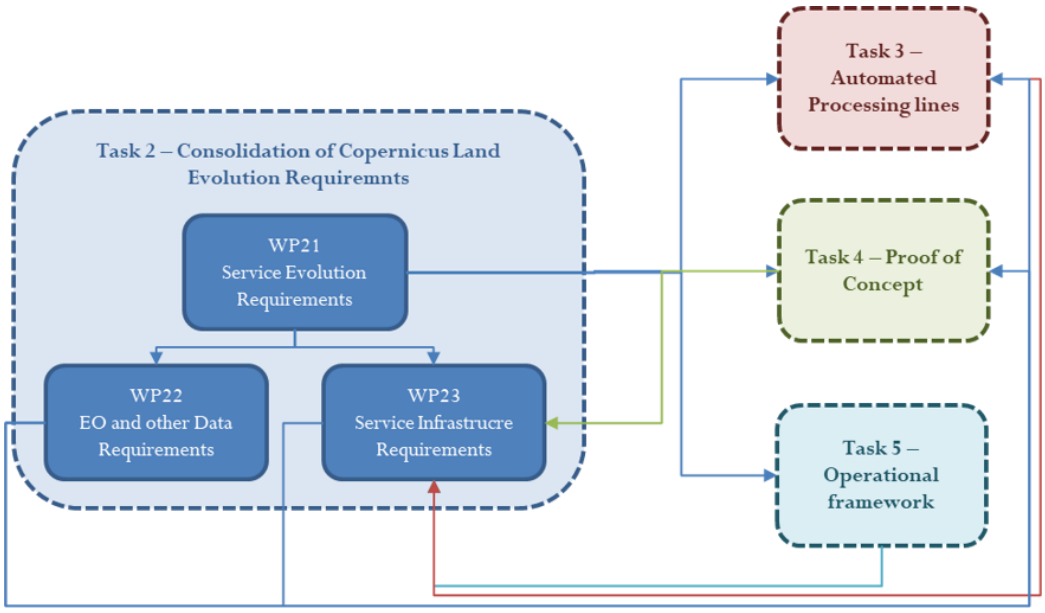


**Figure 1: Schematic dependencies and information flows between the main ECoLaSS implementation Tasks**

The ECoLaSS project follows a two-phased approach of two times 18 months duration. This deliverable "**D21.1b – Service Evolution Requirements Report (Issue 2)**" comprises the project's comprehensive final collection and synthesis of the overarching requirements for the evolution of the Copernicus Land services. Since the development of requirements on both, the Copernicus institutions' side and the technological side (i.e. DIAS infrastructure providers, service providers, ESA, etc. ) has been exceptional in 2019, it has been decided to capture these developments until project end in order to provide a complete account of requirements by the end of the project in Dec. 2019. Anyway, the WP 21 has continuously served all subsequent WPs' developments and Deliverables throughout the project.

The entirety of requirements were collected throughout the first and second phase of the ECoLaSS project by various means:

i. by conducting a number of phone and face-to-face interviews with key representatives of the main European stakeholders as well as with representatives of national users and stakeholders that implement or coordinate Copernicus activities.
ii. Besides that, two webinars were held in order to present the project and collect further updates of user requirements. These were collected with a refined questionnaire, distributed together with the webinar invitation.
iii. Additional sources, such as recent reports, ITTs and service procurement procedures, relevant conference and workshop presentations on the topic, as well as other user requirements collections and studies, have been systematically reviewed and incorporated into this assessment.

Evolution requirements have been considered from the beginning of the project (Jan. 2016), discriminating between short- and mid-term (up to the reference year 2018) and future long-term (2020+) Copernicus Land Monitoring Service needs.

Although the Local Component is not part of the developments envisaged in ECoLaSS, respective such requirements voiced in view of the Local Component have also been documented in this report, in addition to the pan-European and Global component, as they were received.

While this Deliverable is public in general, the complete interview protocols as documented in the Annexes 1 and 2 thereto, are provided as confidential separate document, taking into account confidentiality and data protection aspects. The EC services as well as the EEEs for Copernicus Land have unrestricted access, and further individual access may be granted upon request.

Chapter 2 of this document outlines both, the status and state of the art of the current products of the Copernicus pan-European and Global Component Land services (section 2.1), and the ECoLaSS approach taken for the user requirements analysis through interviews, webinars and assessment of relevant reports (section 2.2). Chapter 3 provides a synthesis of the collected service evolution requirements along policy frameworks and drivers (section 3.1), an assessment of the current and future use of Copernicus products and their strengths and limitations (section 3.2), as well as technical specifications for next-generation improved and novel CLMS products (section 3.3). Finally, chapter 4 contains a summary of the main findings and conclusions.

The detailed questionnaires of the user requirements analysis are contained in Annexe 1 and Annexe 2.

***Please note:*** *This Deliverable is not to be understood by any means as an official reference whatsoever describing the future development of Copernicus Land Monitoring Service components and products. It merely constitutes the present H2020 research project's output, being based mainly on an as-complete-as-feasible, but inevitably non-exhaustive review of service developments and requirements and a selection of interviews and questionnaires with/from key representatives of EEEs and the most relevant user communities, collecting their requirements, and aiming to confirm or adjust some of the products and services that are envisaged for development and demonstration as part of ECoLaSS. It does neither*

*represent an official position of the European Commission nor of the EEEs or the participating Copernicus user organisations.*

# 2 Status and Approach

This chapter provides first a comprehensive analysis of the current status and state of the art of the Copernicus Land Monitoring Service's pan-European and Global Component products and their respective development over the course of the project duration (section 2.1), which constitutes the non-static, but evolving basis for developments as undertaken by ECoLaSS. This is followed by a detailed methodological description of the assessment approach pursued by ECoLaSS for collecting the relevant user requirements, by means of interviews, webinars and assessments of relevant reports, studies, recently issued CLMS-related ITTs and service procurement processes, as well as other relevant studies and material (section 2.2).

## 2.1 Status of existing Copernicus Services

With its initial operations started in the frame of the GMES/Copernicus Initial Operations (GIO) phase in late 2011, the Copernicus Land Monitoring Service (CLMS) is today providing a multitude of operational services and information as part of the CLMS local component (also called 'Hotspot Monitoring'), the pan-European (= continental) component and the global component, supported by reference data and an additional dedicated Copernicus in-situ data component. All produced and validated Copernicus Land products are available as online viewing, WMS and download services on the Copernicus Land portal at: http://land.copernicus.eu/. In the following, the status of the pan-European (section 2.1.1) and the global (section 2.1.2) CLMS components is explained in more detail, since both are the thematic focus of ECoLaSS. Due to its relevance for the CLMS services, further status information on the in-situ component is added (section 2.1.3).

### 2.1.1 Pan-European Land Component

The pan-European and the Local CLMS components are coordinated by the European Environment Agency (EEA). During the GMES/Copernicus Initial Operations (GIO) phase**,** the pan-European Land component addressed mainly a set of five thematic so-called High-Resolution Layers (HRLs): Imperviousness, Forest, Natural Grassland, Wetland and Water Bodies, for the reference year 2012, as well as an update of the CORINE Land Cover (CLC) product for the year 2012. In parallel to the HRL production, European-wide NDVI datasets were calculated, and HR and VHR Image Mosaics created.

From September 2016 onwards, the production of the HRLs for the 2015 reference year had started, with the ECoLaSS consortium partners GAF and SIRS being involved in all five layers, among them GAF as Lead for the HRL Forest and HRL Grassland, and SIRS as Lead for the HRL Small Woody Features, and both being involved in minor roles also in all other Layers. All HRLs 2015 already made partially use of time series analysis of Sentinel and other CCM satellite data. Except for the HRL Small Woody Features, all HRLs 2015 had been finalised by mid-2018, whereas last corrections and partial re-deliveries lasted until end-2018.

Accelerating the implementation speed of the consecutive 3-yearly update cycles, the HRL 2018 implementation contracts have were signed already in December 2018. Both GAF and SIRS are again participating to these operational implementations, with GAF contracted for leading the HRLs Forest and Grassland 2018, and SIRS being production partner for the HRLs Imperviousness and Forest. Production of the HRLs 2018 considers already several key developments tested and/or anticipated by ECoLaSS, such as a much improved EO data pre-processing, applying fully integrated Sentinel-2/-1 based time series analyses, the evolution from 20m to 10m spatial resolution, use of temporal features, sophisticated change product concepts, and fully cloud-based processing environments. The HRLs Forest and Grassland 2018 will be produced fully on the Mundi DIAS (https://mundiwebservices.com/), which is considered a test of feasibility and practical fitness-for-purpose of the DIAS concept under operational and heavy-load production conditions.

The starting point for ECoLaSS had been that, based on the experiences from the GMES Initial Operations (GIO) stage between 2011 and 2014, **major bottlenecks** had been identified by the EEA, which were at that time considered the most relevant obstacles to be overcome for the future evolution of the Copernicus Land Monitoring Service components on pan-European level (see also Dufourmont 2015; Langanke & Dufourmont 2015):

- Acquisition of EO data for HR Layer production disconnected from service provision with: **a)** no continuous satellite image acquisition system (only two HR image coverages), **b)** lack of timely availability of initial contiguous image coverages, **c)** very long range of image acquisition (4 years, from 2011 to 2014) for complete coverage (EEA-39)
- Complex workflow involving several (regionally split up) service providers, and iterations with EEA-39 member states with a negative impact on:
    - timeliness of final product delivery, maturity level of HR Layers, lack of detailed product specifications
    - Geographic discrepancies and time series inconsistencies with different methods applied, requiring better harmonisation of HRLs both from a spatial and temporal perspective.

It should be noted here that by the time of the final update of this report, all the above points can be considered solved meanwhile, through the much improved EO data provision capacity of the Sentinel satellites, and the changed production setup in connection with the significant technological evolution such as cloud-processing facilities. Anyway, the Guidance Document related to the H2020 Call of the present project [AD02] had foreseen a range of evolution topics for the pan-European component which had looked much further into the future, i.e. towards 2020+. The ECoLaSS team had selected some of them to be addressed within ECoLaSS, pre-dominantly focussing on the evolution potential for the existing and potential future HRLs, which are mostly still valid.

Meanwhile, some further topics have emerged as part of the pan-European CLMS component, which are briefly mentioned here, and discussed for their relevance:

- In late December 2018, the EEA published an ITT for a Near Real Time (NRT) pan-European Snow and Ice Monitoring[1] based on Sentinel-2 data (and later followed up by another, complementary ITT, making additional use of Sentinel-1 data) which is being implemented since May 2019 by a specialised consortium (without ECoLaSS partner involvement). This subject is quite special and does not have too much thematic overlap with the more land cover/land use related topics being assessed in ECoLaSS, however there are several operational setup aspects which may be considered relevant for any future CLMS services and will therefore be considered in this report.
- In April 2019, another ITT for pan-European monitoring of High-Resolution Vegetation Phenology and Productivity Parameters (HR VPP)[2] was published by the EEA. A record amount of 9 tenders was submitted, amongst them two with ECoLaSS partner lead or involvement. The related award decision took as long as early December 2019 to be published; the implementation will be done without ECoLaSS partner involvement. The HR VPP tasks will comprise an NRT processing of various Vegetation Indices from Sentinel-2 (and Landsat-8) data across the EEA-39 area, and an annual retrieval of Phenology & Productivity parameters from seasonal trajectories of the Vegetation Indices. There may be thematic commonalities and complementarities particularly with the ECoLaSS prototypes developed in WP 41, to be assessed once the successful bid and the

[1] Open Call for Tenders EEA/DIS/R0/18/014 "Pan European High Resolution Snow and Ice Monitoring of the Copernicus Land Monitoring Service — Production of Basic Products"; Issued 21.12.2018. URL: https://etendering.ted.europa.eu/cft/cft-display.html?cftId=4317

[2] Open Call for Tenders EEA/DIS/R0/19/007 "High Resolution Vegetation Phenology and Productivity Monitoring – Biophysical Parameters – Copernicus Land Monitoring Services"; Issued: 08.04.2019. URL: https://etendering.ted.europa.eu/cft/cft-display.html?cftId=4710

related implementation concepts will become known. In any case, it appears that the HR VPP products may become an important input to next-generation pan-European CLMS services. Even more than in case of the Snow and Ice Monitoring service, several foreseen operational setup aspects seem to point already towards a future, much more complex operational setup of future services – details of which are discussed in this report.

- In July 2019, the CLC+ Backbone ITT has been published, asking for a pan-European industrial implementation of the first part of the next generation of CORINE Land Cover (CLC) products. Many innovative technologies, which have been explored by ECoLaSS, will have to be applied, such as high-quality cloud-based massive image pre-processing, land cover classification and characterisation based on temporal features both from Sentinel-2 and Sentinel-1 time series, etc. Further elements are related to a pan-European segmentation of stable "landscape elements" from HR and VHR optical satellite imagery, making use of so-called "hardbones" (stable linear features such as traffic and river networks) in combination with segmented "softbones" (i.e. finer-resolution polygons) at a 0.5 ha MMU. The CLC+ will incorporate elements and aspects both of the local and the pan-European CLMS components and is expected to complement these products. The implementation of the CLC+ Backbone has been entrusted in late Dec. 2019 by the EEA to a large pan-European consortium led by one of the ECoLaSS partners.

Several further new pan-European CLMS component topics, part of which are also investigated by ECoLaSS, are imminently upcoming or scheduled for the next 1-2 years[3], such as:

- Subsequent to the CLC+ Backbone, which will constitute only the first element of a series of CLC+ related products, further associated products will be procured by the EEA, such as the CLC+ Core Database (incorporating various additional data e.g. from Member States), the CLC+ Instances (derived LC/LU datasets for specific purposes) and the CLC+ Legacy (providing continuity of the time series of the "traditional" CLC with 25 ha MMU).
- An update of the HRL Small Woody Features (presumably still for the reference year 2018) is currently being investigated by the EEA together with the EC DG Agri, investigating optimisation potential to extend the service specification towards supporting the new CAP requirements.
- a new High Resolution Layer (HRL) Crops (expected in 2020), comprising a crop masks and discriminating major groups of crop types, supporting amongst others reporting on Land Use, Land Use Change and Forestry (LULUCF);
- a so-called "HRL Grassland Enrichment", which is expected to add further information on management practises (e.g. intensity of grassland use) to the existing HRL Grassland for the reference year 2018 or 2021 (expected in 2020);
- a further thematic characterisation of the HRL Water & Wetness through a similar associated further thematic "Enrichment", presumably targeting to derive Wetlands and Water Quality aspects.

Other known upcoming topics associated to the Local Land Component are not further discussed here.

### 2.1.2 Global Land Component

The CLMS Global Land component, coordinated by the EC's Joint Research Centre (JRC), is providing a range of services, comprising a series of biophysical variables on the status and evolution of the land surface, a Hot Spot monitoring component outside the EU territory, a dedicated service for "Ground-Based Observations for Validation" (GBOV), and recently a Sentinel-2 Global Mosaic (S2GM) service:

[3] as detailed in EEA (2018) and (non-public) information presented in the recent Copernicus User Fora and the most recent Copernicus Work Programme

- The biophysical products are designed to monitor vegetation state, water cycle, energy budget, and the terrestrial cryosphere, currently based on medium to low spatial resolution satellite sensors. During the first operational phase (2013 to 2015), the portfolio comprised products with a temporal coverage starting from 1998 to present, a temporal resolution of typically 10 days and a spatial resolution of 1 km to 0.1° (i.e. approx. 10 km) (Cherlet 2015). For the current phase from 2016 onwards, further products (e.g. moderate resolution land cover, Greenness evolution, etc.) were added to the list of the Global Land services and the spatial resolution of some of the products was increased from 1 km to 333 m / 100 m (based on Proba-V) and 300 m (based on S-3). A 100m global land cover/land use product has been published in May 2019. In mid-October 2019, an ITT for continuation of this product suite from 2020 onwards has been published by the JRC, targeting, in 4 separate Lots, the continued production of biophysical variables of the Biosphere (Vegetation and Energy) domain as well as of the Hydrosphere and Cryosphere thematic domain. Further aspects addressed were targeting operation and evolution of a 'Data Distribution and User Interface' and an independent review and validation.
- The CLMS Global Land's Hot Spot monitoring component had been established for providing detailed land cover/land use and change information on specific areas of interest outside the EU territory (predominantly Africa), for the European Union's environmental policy monitoring. It is based on HR/VHR satellite data based mapping and answers to ad-hoc requests, focusing particularly on the domain of the sustainable management of natural resources and protected areas.
- Furthermore, a dedicated service for "Ground-Based Observations for Validation" (GBOV) of Copernicus Global Land Products was introduced, which provides multiple years of high quality in-situ measurements (predominantly in N-America, and few in Europe and Australia) to validate seven core land products.
- The Sentinel-2 Global Mosaic (S2GM) component provides a interactive, global-coverage service for compilation of Sentinel2 L2A spectral surface reflectance temporal composites through an on-the-fly user-defined production service.

The Hot Spot monitoring and the GBOV components are of less relevance in the context of ECoLaSS.

Further relevant thematic LC/LU and characteristics mapping/monitoring services with high automation level on global scale are expected to be procured in the course of 2020 and the following years by the JRC and ESA. Details are not yet known, and neither whether such services would fall into the perimeter of Copernicus, however they appear to be potentially thematically relevant for the investigated domain of services and products.

### 2.1.3 Copernicus in-situ Component

Beyond the pan-European and Global Land components of the CLMS, some latest developments in the EEA-coordinated Copernicus in-situ component are also of relevance for the assessments and developments undertaken in ECoLaSS, such as:

- There has been an ESA procurement process since late 2018 for a new version of a Copernicus programme-level DEM, primarily serving the Sentinel data processing needs of ESA, but also the Copernicus service components, the respective EEEs and EU entities/bodies for their purposes, particularly in Europe. This new product is supposed to largely replace the current EU-DEM, which is known to have various limitations in quality and spatial resolution and covers only the EEA-39 area. The new Copernicus DEM has been contracted in the second half of 2019, and first deliveries to the CLMS core service producing entities have already been made in Dec. 2019. This new DEM provides worldwide height information at 90m and 30m spatial aggregation, and an additional 10m DEM over Europe, all derived consistently and with high precision from the same original EO data source. Particularly the 10m DEM will prove to be a tremendous improvement

for supporting future services of both the pan-European and the local CLMS components, although probably still not serving all needs (particularly of new services) completely. Access and use restrictions may apply to the 10m European dataset beyond the core service production, to be confirmed.

- Additionally, there are preparations ongoing for a Copernicus European Ground Motion Service (EGMS) for the whole of the EEA-39, to be based on SAR interferometry. In anticipation of that, the EEA had issued two ITTs for supporting services in the form of preparatory studies[4] and an expert advisory board, in February 2019. These activities are expected to prepare the terms and conditions for a later operational EGMS service ITT to be issued by the EEA presumably in spring 2020. The operational service is expected to commence in 2020 and provide regular pan-European information layers on terrain movements caused by tectonics, subsidence, ground water over-exploitation, etc. It is not yet entirely foreseeable whether this new service may provide added value to a next generation of thematic CLMS services.

## 2.2 Approach for User Requirements Analysis

This section outlines the approach for the user requirements analysis taken in this report by means of direct user/stakeholder interviews (section 2.2.1) and multi-participant webinars (section 2.2.2). It further presents the questionnaires that were developed to perform the interviews and collect feedback from the webinars (section 2.2.3), and provides an overview of further sources of information which have been evaluated, such as reports, recent ITTs and procurement procedures and stakeholder presentations of relevance (section 2.2.4).

### 2.2.1 User/Stakeholder Interviews

The user/stakeholder analysis was conducted by performing various phone- and physical face-to-face interviews with key representatives of the most relevant European institutions as well as with a selection of key national users/stakeholders, which have a mandate for national CLMS implementation or coordination.

Since these CLMS users and stakeholders all have different roles and mandates, different types and levels of involvement in Copernicus Land and consequently different levels of knowledge and expertise about the existing and currently produced CLMS products, it was decided to preferably perform guided oral interviews (rather than, e.g., more “anonymous” online questionnaires). These guided interviews have allowed for some flexibility in the interview process, in that they were more open than fully pre-structured interviews, which tend to focus on closed questions. It was found that guided interviews better allowed the interviewee to make suggestions and the interviewer to adapt the questions to the context. Thus, this allowed the interviewer to provide explanations and guidance during the interviews, and it also enabled intermediate questions and flexibility.

The interviews were carried out by the consortium partners GAF, SIRS, UCL and Joanneum Research. Despite the form of guided interviews, standard (empty) interview questionnaires were sent to all participants in advance, to allow them to familiarise with the matters, and the interviews were performed +/- along the structure of the questionnaire, with as much flexibility as deemed appropriate in the course of the interviews. From notes taken simultaneously by at least one additional ECoLaSS team member, interview protocols were compiled (see Annexe 1) and sent to the interviewees afterwards for updates, amendments and approval.

[4] Open Call for Tenders EEA/DIS/R0/19/004 “Copernicus European Ground Motion Service – Supporting Services”; Issued 08.02.2019. URL: https://etendering.ted.europa.eu/cft/cft-display.html?cftId=4441

A first round of user interviews was one of the first activities at the beginning of the project, comprising primarily qualitative questions, with possibilities for open responses. The second round featured only few further additional dedicated interviews during the second project phase (e.g. so far not addressed EC Directorates General), but focused rather on addressing additional stakeholder groups to better represent the national domain, by means of webinars on specific topics of interest (see section 2.2.2).

Table 1 and Table 2 provide an overview of key representatives of relevant European institutions as well as key national stakeholders and users with a relevant Copernicus mandate, which were interviewed primarily in the first round of assessment of the CLMS service evolution requirements. It should be stressed that the selection of interviewees was not meant to be exhaustive, but to select key representatives of EEEs and the most relevant user and stakeholder communities to confirm or adjust some of the products and services envisaged for development and demonstration as part of ECoLaSS. As indicated, this is meant to be a proxy of the extensive user consultation process taking place as part of the Copernicus programme. The filled interview protocols are given in Annex 1. Due to the sensitivity of part of the contained information, the Annex 1 is provided as a separate, restricted document.

**Table 1: Addressed European-level stakeholders interviewed in ECoLaSS Phase 1**

| ANNEX | ORGANISATION | CONTACT POINT | ROLE OF ORGANISATION IN COPERNICUS |
|---|---|---|---|
| 1.a | European Environment Agency (EEA) | Tobias Langanke | European Entrusted Entity (EEE) for Copernicus implementation |
| 1.b | EC DG Joint Research Centre (JRC) | Michael Cherlet | European Entrusted Entity (EEE) for Copernicus implementation |
| 1.c | EC DG Joint Research Centre (JRC) | Guido Lemoine, Olivier Léo | European Entrusted Entity (EEE) for Copernicus implementation |
| 1.d | EC DG Environment (DG ENV) (dedicated meeting 02 Mar 2018, Brussels) | Frank Vassen, Hugo de Groof | Key European stakeholder and user |
| 1.e | EC DG Environment (DG ENV) (dedicated meeting 05 July 2017, Brussels) | Peter Löffler | Key European stakeholder and user |
| 1.l | EC DG Regional and Urban Policy (DG REGIO) | Hugo Poelman | Key European stakeholder and user |
| 1.m | EC DG for Climate Action (DG CLIMA) (dedicated meeting 07 Dec. 2017, Brussels) | René Colditz | Key European stakeholder and user |
| 1.n | EC DG for Agriculture (dedicated meeting 01 Mar. 2018, Brussels) | Mohammed El-Aydam | Key European stakeholder and user |

**Table 2: Selected key national stakeholders/users interviewed in ECoLaSS Phase 1**

| ANNEX | ORGANISATION | CONTACT POINT | ROLE OF ORGANISATION IN COPERNICUS | COUNTRY |
|---|---|---|---|---|
| 1.f | UBA Germany | Christian Schweitzer | key national coordinating Copernicus entity and user | Germany |
| 1.g | BKG Germany | Ralf Gehrke | key national coordinating Copernicus entity and user | Germany |
| 1.h | DLR Raumfahrtmanagement | Michael Bock | key national coordinating Copernicus entity and user | Germany |
| 1.i | Environment Agency Austria (EAA) | Andreas Littkopf | key national coordinating Copernicus entity and user | Austria |
| 1.j | CGDD (DRI+SOES) | Vincent Pircher, Benoit David, Frédérique Janvier | representatives of national user | France |
| 1.k | CNIG, AFIGEO (workshop) | Pascal Lory | Group of national users | France |

### 2.2.2 User/Stakeholder Webinars

Unlike in the first project phase with more dedicated user/stakeholder requirements assessments through phone or face-to-face interviews, the assessments of the second project phase focused additionally on webinars, which were designed to address many different stakeholders at the same time from both the EIONET NRCs Land Cover and several DGs.

The general concept of the webinars was twofold: first, the audience was introduced to the project in general, along the four consecutive main project tasks: Service Requirements Assessment, Methods Development, Prototype Demonstration, and Operationalisation. In a second step, the hosts explained the newly designed and (compared to the old one) shortened questionnaire for feedback collection, focussing more precisely on the improvement of already existing and the development of new products within the CLMS (rather than asking open questions and allowing unrestricted 'wish lists').

The webinars were recorded and the videos uploaded to YouTube, with restricted access to protect the privacy of the participants. One great advantage of webinars is the possibility to use a chat function for asking questions. During the recording of the presentations, the participants were encouraged to do so. After the presentation, the collected questions were answered anonymously. Every stakeholder invited to one of the webinars received the link to the respective video and thereby was able to get all the information needed in order to efficiently fill out the previously obtained questionnaire, even if the specific person was not able to attend the webinar.

The first webinar took place on 18 October 2018. It was designed for the EIONET National Reference Centres (NRCs) for land cover/land use. Out of the 39 countries, the NRCs who finally handed in a filled out questionnaire are listed in Table 3.

**Table 3: EIONET NRCs for land cover/land use within the second round of the ECoLaSS User/Stakeholder Requirements Assessment**

| ANNEX | ORGANISATION | CONTACT POINT | ROLE OF ORGANISATION IN COPERNICUS |
|---|---|---|---|
| 2a | Space Research and Technologies Institute at the Bulgarian Academy of Sciences, Bulgaria | Ventzeslav Dimitrov | EIONET National Reference Centre for land cover/land use |
| 2b | Czech Environmental Information Agency, Czech Republic | Lenka Rejentová | EIONET National Reference Centre for land cover/land use |
| 2c | Federal Agency for Cartography and Geodesy (BKG), Germany | Friederike Emig | EIONET National Reference Centre for land cover/land use |
| 2d | Croatian Agency for Environment and Nature (CAEN), Croatia | Branimir Pavlinec, Bojan Karaica, Tamara Kirin | EIONET National Reference Centre for land cover/land use |
| 2e | Environmental Protection Agency (EPA), Ireland | Gavin Smith | EIONET National Reference Centre for land cover/land use |
| 2f | Malta Environment and Planning Authority (MEPA), Malta | Stephen Conchin | EIONET National Reference Centre for land cover/land use |
| 2g | Wageningen Environmental Research (WENR), Netherlands | Gerard Hazeu | EIONET National Reference Centre for land cover/land use |

The second webinar took place on 7th December 2018 and was tailored towards various representatives of the EC DGs (DG ENV, DG REGIO, DG CLIMA, DG AGRI, DG JRC) and key national stakeholders (DLR, BKG, EAA Austria), out of which the following ones finally handed in filled out questionnaires:

**Table 4: Participating DGs and key national stakeholders within the second round of the User/Stakeholder Requirements Assessment**

| ANNEX | ORGANISATION | CONTACT POINT | ROLE OF ORGANISATION IN COPERNICUS |
|---|---|---|---|
| 2h | DG Regional and Urban Policy (DG REGIO) | Hugo Poelman | Key European stakeholder and user |
| 2i | DG Climate Action (DG CLIMA) | René Colditz | Key European stakeholder and user |
| 2j | Environment Agency of Austria (EAA) | Andreas Littkopf | EIONET National Reference Centre for land cover/land use |

The filled-out questionnaires are provided in Annex 2 to this report. Due to the sensitivity of part of the contained information, the Annex 2 is provided together with the Annex 1 as a separate, restricted document.

### 2.2.3 Questionnaire Templates

The template for the stakeholder interview questionnaire that was used for all user and stakeholder interviews within project phase 1 is the following:

---

**1. Description of your Organisation**

Organisation:

Department/Unit:

Contact person:

Interviewer (if applicable):

| |
|---|
| Please describe the overall mission/mandate and policy objectives of your organisation and state which department/unit is responsible for following up on Copernicus Land Services. |

**2. Policy Framework**

**2.1 Role in Copernicus Land**

| |
|---|
| Please describe the role of your organisation in relation to the CURRENT implementation/use of Copernicus Land Monitoring Services. [5] |

| |
|---|
| Please describe the involvement of your organization for FUTURE (2020+) Copernicus Land Service implementation/use. |

**2.2 Policy-related Events/Milestones**

| |
|---|
| What are the policy related events/milestones/reports for the work of your organisation within the next 5 years, with relevance to Copernicus Land Services? |

**2.3 Policy Drivers**

| |
|---|
| (a) Highlight the main environmental regional/national and international environmental policies that your organisation implements or provides implementation support for (either directly or indirectly);<br>(b) Explain how these policies drive your geographical information needs in relation to Copernicus Land Monitoring Services. |

[5] http:\\land.copernicus.eu

### 2.4 Use of Copernicus Land Products

(a) Which Copernicus Land Service products are used in your organisation, and in which context?

(b) Where do you see the strengths and most valuable information in these products, and why?

(c) Which current shortcomings do you experience? (e.g., frequency, quality, thematic content…)

### 2.5 End Users & Applications:

#### 2.5.1 Product Users

(a) Which kind of users are the users of the CURRENT Copernicus Land products (as far as you are aware of)? (include also national stakeholders, the private sector as well as research organizations…)

(b) Can you predict possible new kinds of users in 2020+?

#### 2.5.2 End-use Applications

(a) What are the main end-use APPLICATIONS of the CURRENT Copernicus Land products (as far as you are aware of)?

(b) What are your thoughts on the situation in 2020+? (e.g., derived statistics for xyz report)

## 3. Technical Specifications for Copernicus Land Service Evolution:

### 3.1 Evolution of Existing Products

#### 3.1.1 Products for Service Evolution

(a) Based on the current Copernicus Land product specifications, for which existing products do you consider an improvement/evolution as necessary? (you may address more than one product)

(b) Please state the reasons why?

#### 3.1.2 Evolution of Key Specifications

Please provide desired specifications for the products under evolution (question 3.1.1): (e.g., MMU, spatial resolution, change monitoring, update frequency, nomenclature, thematic accuracy, data format, projection, attributes, quality information, INSPIRE metadata, access mechanism)

### 3.2 New Services/Products

#### 3.2.1 Definition of New Services

Which new Copernicus Land products do you envisage?

(a) Mid-term (until ~2018 Update)

(b) Long-term (2020+)

### 3.2.2 Key Specifications for New Services

| |
|---|
| Please provide your idea of specifications for these new products (question 3.2.1): (e.g., nomenclature, spatial and temporal resolution, etc.) |

### 3.2.3 Cross-cutting Services

| |
|---|
| (a) Do you see the need for new cross-cutting Copernicus Services?<br>(b) If yes, which? |

## 3.3 Implementation of Improved (see 3.1) and New Services & Products (see 3.2)

### 3.3.1 Implementation Schedule

| |
|---|
| What is your required schedule and plan for implementation of improved or new services/products into the operational Copernicus Land Monitoring Service portfolio? |

### 3.3.2 Infrastructure

| |
|---|
| Do you have any specific requirements in terms of service provision via online platforms, data and information access services? |

For the second project phase, the questionnaire has been changed (see as follows), taking into account recommendations for simplification made by the EEA, e.g. working with standardised pre-defined answer categories and tick-boxes. This was considered advisable, as many of the stakeholders are regularly "flooded" by surveys and questionnaires for various purposes, and in order to obtain a good feedback rate, a fill-in time as short as possible was targeted. Therefore, the template has been particularly shortened and restructured, compared to the questionnaire used in phase 1. Nevertheless, it is still focussing on the evolution potential of existing and new CLMS products as well as of the service infrastructure in general:

---

Organisation:

Department/Unit:

Contact person:

**1. Evolution of Existing Products**

**1.1 Based on the current Copernicus Land product specifications[6], for which existing PRODUCTS do you consider an improvement/evolution as necessary, and why? (you may address more than one product)**

PAN-EUROPEAN COMPONENT

☐ HRL Imperviousness
☐ HRL Forest
☐ HRL Grassland
☐ HRL Water and Wetness
☐ CORINE Land Cover
☐ Image Mosaics
☐ EU-DEM
☐ EU-Hydro

Reasons:

LOCAL COMPONENT

☐ Urban Atlas
☐ Riparian Zones
☐ Natura 2000

Reasons:

GLOBAL COMPONENT

☐ Vegetation Products (if specific ones state below under "Reasons")
☐ Water Products (if specific ones state below under "Reasons")
☐ Energy Products (if specific ones state below under "Reasons")
☐ Cryosphere Products (if specific ones state below under "Reasons")

Reasons:

---

[6] http://land.copernicus.eu

### 1.2 Please specify your desired SPECIFICATION upgrades for existing products:

| | Product 1 [enter product] | Product 2 [enter product] | Product 3 [enter product] | Product 4 [enter product] | Product 5 [enter product] |
|---|---|---|---|---|---|
| MMU | | | | | |
| spatial resolution | | | | | |
| change monitoring | | | | | |
| update frequency | | | | | |
| nomenclature | | | | | |
| thematic accuracy | | | | | |
| data format | | | | | |
| projection | | | | | |
| attributes | | | | | |
| quality information | | | | | |
| INSPIRE metadata | | | | | |
| access mechanism | | | | | |

Others:

Comments:

### 2. Definition of New Services/Products (beyond 1.1)

### 2.1 Which new Copernicus Land products do you envisage?

### 2.2 Please provide your idea of SPECIFICATIONS for these new products:

| | Product 1 [enter product] | Product 2 [enter product] | Product 3 [enter product] |
|---|---|---|---|
| MMU | | | |
| spatial resolution | | | |
| change monitoring | | | |
| update frequency | | | |
| nomenclature | | | |
| thematic accuracy | | | |
| data format | | | |
| projection | | | |
| attributes | | | |
| quality information | | | |
| INSPIRE metadata | | | |
| access mechanism | | | |

### 3. Infrastructure

**Do you have any specific requirements in terms of service provision via online platforms, data and information access services?**

☐ Data Access and download:
☐ Documentation:
☐ Usability and visualization:
☐ Others:

### 2.2.4 Relevant Reports, Work Programmes, recent ITTs/procurements and pertinent Conference/Workshop Presentations

The information gathered in the interviews (section 2.2.1) and webinars (section 2.2.2) is complemented in this report by additional information from various other sources of relevance. Such material supporting the collection and synoptic analysis of service evolution requirements was particularly compiled from: (i) reports originating from previous or parallel studies and contracts related to the evolution of Copernicus Land services (such as e.g. by the ETC/ULS, NEXTSPACE, etc.); (ii) relevant work programmes; (iii) recent relevant CLMS ITTs and service procurement procedures, and (iv) presentations at relevant meetings, conferences and workshops on the topic of the CLMS. These comprise e.g.:

- Future potential Agricultural Service: The Joint Research Centre (JRC) emphasised the concept note entitled "Towards Future Copernicus Service Components in support to Agriculture" which has been drafted by JRC in April 2016 (JRC, 2016).
- Climate change indicators: The German Environment Agency – Umweltbundesamt (UBA) emphasized a report on the contribution of remote sensing – in particular Copernicus data and services – to the development and assessment of selected indicators as part of the indicator set of the German national adaption strategy to climate change (Schönthaler et al., 2017). UBA is involved in the indicator development and assessment and supports the above-mentioned study.
- Copernicus Technical Documents: The representative of the Wageningen Environmental Research (WENR) recommended to take into account the NEXTSPACE User Study, that was published in mid-2018 (Nextspace Consortium, 2018).
- Copernicus Strategy in Germany: DLR emphasised the „Nationales GMES Maßnahmenprogramm" which is relevant to the Copernicus strategy in Germany (BMVBS, 2011). This national Copernicus action paper has meanwhile been followed up by the German government's Copernicus strategy paper "Die Copernicus Strategie der Bundesregierung" (BMVI 2017) and the national Copernicus work programme "Nationales Copernicus Arbeitsprogramm 2018" (BMVI 2018), through which various concrete measures for the exploration of the Copernicus data's and products' potential mainly in public administrations and (in few) downstream services are initiated.
- Copernicus Work Programmes: In regular (annual) intervals, the European Commission publishes yearly Work Programmes for the entire Copernicus, including the Space, Services and In-situ components. These Work Programmes detail the envisaged works, upcoming Calls for Tender and approximate contents and budget assignments of the upcoming Copernicus tasks, at least for one year ahead. The Work Programmes are drafted by the EC and the EEEs, and are being circulated, discussed and amended with/by the Copernicus User Forum and the Copernicus Committee before being openly published. These are probably the most comprehensive existing records of the (near) future Copernicus Plans, however with the drawback that they are made publically available typically only at a late stage, only at the beginning of the year concerned. Thus, the Copernicus Work Programmes up to the year 2019 (EC 2019, EC 2018, EC 2017) have been officially available and were taken into account by ECoLaSS.
- EEA Work Programmes: Additional to the Copernicus Work Programmes, also the EEA publishes own work programmes, which are not only related to Copernicus, but to the entirety of the EEA's activities. These have likewise been assessed by ECoLaSS. Over the years, there have been evolving formats, i.e.:
    - until 2014 published as 4-year aggregated 'Multi-Annual Work Programmes', i.e. 2009-2013 and 2014-2018 (EEA 2014)
    - until 2016 additionally published as 'Annual Work Programmes' (e.g. EEA 2016)
    - up to now published as 'Single Programming Documents', addressing the 3-year time span ahead (e.g. EEA 2018).

Further important information on the CLMS evolution requirements are provided by several studies on various topics which were undertaken by the European Topic Centre on Urban, Land and Soil Systems (ETC-ULS) under a contract by the EEA:

- HRL partial incremental updates: The ETC/ULS report "Task 17 – Analyse the possibilities for moving from 3 or 6 yearly snapshots into yearly partial incremental updates of land monitoring products, including the assessment of changes required in workflows" from 31.03.2016 (Hazeu et al., 2016) contains HRL product update considerations that had seemingly been already partially adopted for the HRL 2015 tender specifications. The report was recommended to be taken into account also by the WENR representative.
- Inclusion of SAR data: The ETC/ULS studies on "D1 - Fine tuning of technical specifications – Task II.6.2 – Define a methodology to ingest SAR based information in the HRLs on land cover characteristics over areas prone to cloud cover" from 30.11.2015 (Surek et al., 2015a), and "D2 - Summary report by case studies about potential use of SAR data – Task II.6.2 – Define a methodology to ingest SAR based information in the HRLs on land cover characteristics over areas prone to cloud cover" from 30.11.2015 (Surek et al., 2015b), summarise methodologies and tools for the processing of SAR data and provide case studies. These methods were not adopted into the HRL 2015 tender specifications to a large extent, however, dense SAR time series are operationally applied for the HRL 2015 production of Lot 3 - Grassland, and Lot 4 - Water/Wetness.
- Phenology: A scoping paper on "Remote Sensing Phenology for Ecosystem Assessment" from 15.11.2016 (Roerink et al., 2016) had been drafted by the University of Wageningen in cooperation with EEA. It summarises state-of-the-art methodologies for phenology parameter derivation and assessment, using existing tools such as Timesat, HANTS etc. amongst other methodologies.
- Land Degradation: The ETC/ULS report "Task 182_9 Scoping Study on Land Degradation" from 29.09.2015 (Aksoy and Prokop, 2015) provides an overview about land degradation assessment, including the use of remote sensing indicators and a respective case study. Copernicus services or products are not specifically addressed in the report, but there could be a potentially interesting connection to future Copernicus Land services.

Furthermore, several new relevant ITTs have been published since the first issue of this report. These have been analysed for new "de facto" requirements introduced by the procuring entity:

- Near Real Time (NRT) pan-European Snow and Ice Monitoring (Dec. 2018)
- High-Resolution Vegetation Phenology and Productivity Parameters (April 2019)
- CORINE Land Cover+ (CLC+) Backbone (July 2019).
- Copernicus Land Portal (Nov. 2019)

Until recently, Copernicus and EEA Work Programmes had not been easily and timely accessible to the public. Therefore, also a range of publically available presentations of the main CLMS actors (i.e. EEEs, EC) on the evolution of the CLMS, held at previous Copernicus workshops and scientific conferences, have been collected and evaluated. Altogether, requirements have been analysed and considered from the following most relevant presentations (more recent ones are listed first):

- "2012 – 2018 DWH experience from a CLMS user perspective": H. Dufourmont, Copernicus Data Access and Contributing Missions Workshop, Brussels 02.04.2019 (Dufourmont 2019)
- "The User Perspective - Requirements and expectations from the Copernicus information services": C. Steenmans, CLMS Conference "Land monitoring at its crossroads – Towards Copernicus 2.0". Innsbruck (Austria) 08.-09.10.2018 (Steenmans 2018)

- "On the road: Serving the global land monitoring challenges": M. Cherlet, CLMS Conference "Land monitoring at its crossroads – Towards Copernicus 2.0". Innsbruck (Austria) 08.-09.10.2018 (Cherlet 2018)
- "CLMS products and services: the offer to EU policies": H. Dufourmont, CLMS Conference "Land monitoring at its crossroads – Towards Copernicus 2.0". Innsbruck (Austria) 08.-09.10.2018 (Dufourmont 2018)
- "Copernicus Programme": M. Massart, WorldCover 2017 Conference, Frascati, ESA/ESRIN, 14-16 March 2017 (Massart, 2017).
- "Sentinel-based Evolution of Copernicus Land Services on Continental and Global Scale": L. Moser, WorldCover 2017 Conference, Frascati, ESA/ESRIN, 14-16 March 2017 (Moser et al., 2017).
- "Advances in Copernicus High-Resolution Land Monitoring": L. Moser, WorldCover 2017 Conference, Frascati, ESA/ESRIN, 14-16 March 2017 (Ramminger et al., 2017).
- "Update and feedback from pan-European Copernicus land monitoring service": T. Langanke, ECoLaSS Kick-Off Meeting, 20 January 2017 (Langanke, 2017).
- "Copernicus Programme Status & Product Intentions for 2018": Copernicus User Forum 13, 11 January 2017, Brussels, Belgium (Copernicus User Forum, 2017).
- "Copernicus Data and Information Access Service (DIAS)": ESA, Industry Information Day, ESA/ESRIN, Frascati, 20 December 2016 (ESA, 2016).
- "Copernicus Agriculture and Forestry Applications User Requirements Workshop": P. Löffler, Brussels, 30 June 2016 (Löffler, 2016).
- "Copernicus Land Monitoring Service": T. Langanke, Fachworkshop: Die Herausforderung: Deutschland Monitoring. Nationales Forum für Fernerkundung und Copernicus 2015, Berlin, 3-5 November 2015 (Langanke, 2015).
- "Land monitoring service evolution: short term evolution": T. Langanke and H. Dufourmont, New Horizons for European and global land monitoring, 20 October 2015 (Langanke and Dufourmont, 2015).
- "EC policy perspective on the role of land in the Copernicus programme": P. Breger and C. Bamps, New Horizons for European and global land monitoring, Copenhagen, 19 October 2015 (Breger and Bamps, 2015).
- "Copernicus Land Monitoring – Global Land": M. Cherlet, New Horizons for European and global land monitoring, Copenhagen, 19 October 2015 (Cherlet, 2015).
- "Pan-European land monitoring: results and challenges": H. Dufourmont, New Horizons for European and global land monitoring, Copenhagen, 19 October 2015 (Dufourmont, 2015).
- "Copernicus in our operations": C. Steenmans, 36th International Symposium on Remote Sensing of Environment (ISRSE), Berlin, 11-15 May 2015 (Steenmans, 2015).

## RECORD OF RELEVANT ATTENDED EVENTS

Additionally, broader stakeholder consultation has been carried out through participating in open conferences, symposia, scientific conferences and workshops with strong focus on ECoLaSS key topics, such as LC/LU, time series applications, big data processing techniques, DIAS, Copernicus evolution and continental to global scale Land applications and products. Targeted consultations were done at national and international Copernicus events, which often are more stakeholder and user focused anyway. Relevant attended events considered important for such user/stakeholder interaction where ECoLaSS consortium members participated are listed in Table 5 below:

**Table 5: Recent and upcoming (green) events of relevance for user/stakeholder interaction**

| EVENT | DATE | LOCATION | RELEVANT TOPICS |
|---|---|---|---|
| **2017** | | | |
| WorldCover 2017 Conference | 14-16 March 2017 | ESA, Frascati, Italy | LC/LU, Global CLMS Products |
| German National Copernicus User Forum | 14-16 March 2017 | Berlin, Germany | Copernicus (national) |
| CNES COSPACE Workshop on Vegetation | 28 March 2017 | Paris, France | Copernicus (national) |
| French national event with different stakeholders , such as National Council for Geographic Information (CNIG), French Mapping Agency (IGN) and French Association for Geographical Information (AFIGEO) | 30 March 2017 | Marne la Vallée France | Copernicus (national) |
| French Ministry of Solidary Ecological Transition | 13 April 2017 | France | Copernicus (national) |
| 37th International Symposium on Remote Sensing of Environment | 8-12 May 2017 | Tshwane, South Africa | LC/LU, including Global Land Service special session |
| French National Copernicus User Forum: workshop on the evolution of Copernicus Services | 14 June 2017 | Paris, France | Copernicus (national) |
| MultiTemp 2017 | 27-29 June 2017 | Bruges, Belgium | LC/LU, time series methods and monitoring applications |
| Annual General Meeting of the European Association of Remote Sensing Companies (EARSC) | 04-05 July 2017 | Brussels, Belgium | GEO and global Land products and evolution potential, ESA plans for Land services evolution |
| CCI+ Information Day | 06 July 2017 | Frascati, Italy | R&D plans for further evolution of land services, amongst others on bridging the gap between global and continental CLMS component |
| Intergeo: Tradefair for geoinformation professionals | 26-28 September 2017 | Berlin, Germany | Copernicus + EO downstream user community from public and private sector and academia |
| Eurogeographics/EEA/EC Workshop on “Land use/land cover products: challenges and opportunities” | 15 November 2017 | Brussels, Belgium | Exchange between national cartographic entities and Copernicus users/service providers |
| EEA Land Monitoring CLC+ Workshop | 16 November 2017 | Brussels, Belgium | Complete Copernicus stakeholder, user and service provider community, as well as national cartographic entities |
| Multiply – Sensagri – ECoLaSS Coordination Meeting with REA and DG GROW | 17 November 2017 | Brussels, Belgium | Coordination of CLMS-related R&D in H2020 |
| Coordination Meeting between ECoLaSS and the EEA | 14 December 2017 | Copenhagen, Denmark | Coordination of CLMS-related R&D by ECoLaSS |

| EVENT | DATE | LOCATION | RELEVANT TOPICS |
|---|---|---|---|
| **2018** | | | |
| EARSC – DG Connect Workshop | 25 January 2018 | Brussels, Belgium | e-Infrastructures, European Open Science Cloud; DIAS |
| Workshop on Crop Monitoring | 01 March 2018 | Berlin, Germany | European & national crop monitoring |
| Copernicus Anniversary Event "20 years Baveno Manifesto" | 20-21 June 2018 | Baveno, Italy | Future development of Copernicus, launch of the DIASes |
| EARSC Workshop on Data and Information Access Services (DIAS) | 26 June 2018 | Brussels, Belgium | European service provider community; DIAS providers |
| EARSC Workshop on the future of the European EO/Copernicus | 27 June 2018 | Brussels, Belgium | European service provider community; EEEs; DIAS |
| 3rd joint EARSeL LULC & NASA LCLUC Workshop on "Land-Use/Cover Change Drivers, Impacts and Sustainability within the Water-Energy-Food Nexus" | 07 July 2018 | Chania, Crete | EO-based research on land use change, with a focus on, amongst others, forest, watershed management, urban areas, arable lands, irrigation, droughts |
| INSPIRE Conference | 18-21 September 2018 | Antwerp, Belgium | Sentinel data use; next-generation Copernicus HRLs on Agriculture and Grassland |
| Intergeo 2018: Tradefair for geoinformation professionals | 16-18 October 2018 | Frankfurt, Germany | Copernicus + EO downstream user community from public and private sector and academia |
| Information Exchange meeting between CLMS-related H2020 projects and Copernicus EEEs | 15 November2018 | Brussels, Belgium | Coordination of CLMS-related R&D by H2020 projects; future development of the CLMS |
| German National Copernicus User Forum | 27-29 November 2018 | Berlin, Germany | Copernicus (national) |

| EVENT | DATE | LOCATION | RELEVANT TOPICS |
|---|---|---|---|
| **2019** | | | |
| ESA Big Data from Space conference | 19-21 February 2019 | Munich, Germany | Big data community (relevant topics: cloud processing techniques, data analytics, DIAS, Sentinel data processing, etc.) |
| Copernicus Data Access and Contributing Missions Workshop | 02 April 2019 | Brussels, Belgium | Data access and DIASes, Artificial Intelligence; Copernicus Contributing Missions evolution |
| Information Exchange meeting between CLMS-related H2020 projects and Copernicus EEEs | 09 April 2019 | Valladolid, Spain | ECoLaSS progress and CLMS H2020 projects collaboration |
| IACS Workshop | 10 April 2019 | Valladolid, Spain | IACS data and CAP |
| ESA Living Planet Symposium | 13-17 May 2019 | Milan, Italy | Broad variety of topics, including EO missions (Sentinels); state-of-the-art land monitoring (LC/LU, agriculture, forestry, phenology, …) |
| 1st EEA Workshop on Phenology and Drought Monitoring | 04-05 June 2019 | Copenhagen, Denmark | Mostly scientific, academic & institutional entities (and few industry players) assembling state of the art in phenology and drought monitoring |
| ExpandEO Event 2019 | 20-21 June 2019 | Brussels, Belgium | Several smaller workshops and events (e.g., EARSC annual meeting) with various EO, CLMS and DIAS related topics |
| ESA Phi-Week 2019 | 09-13 September 2019 | Frascati, Italy | Latest state of the art of remote sensing, image processing, Data Analytics and Artificial Intelligence |
| 25th MARS Conference | 26-28 November 2019 | Prague, Czech Republic | Monitoring agricultural resources; CAP Monitoring |

# 3 Service Evolution Requirements

Chapter 3 provides a synthesis of the outcomes of the user and stakeholder interviews, webinars, other consultations, and other information collections at conferences, from relevant reports, ITTs, etc. (cf. section 2.2). For traceability reasons, the collected requirements are structured along the questions in the interview questionnaires, although the sources of the information are manifold. The filled questionnaires are provided in Annex 1 and Annex 2 and are referred to throughout this document.

The service evolution requirements are grouped along three overarching topics: the policy framework, drivers and milestones (section 3.1), an analysis of the current use, strengths, shortcomings and further use potential of the existing services/products (section 3.2), and an assessment of the technical specifications suggested for novel services/products (section 3.3).

## 3.1 Policy Framework, Drivers and Milestones

The following sections summarise the user's and stakeholder's responses related to their current and future role in the CLMS (section 3.1.1), and policy related events/milestones as well as policy drivers related to the CLMS (section 3.1.2). This is collectively considered the prerequisite to understand the related requirements for further evolution of the CLMS services and products.

### 3.1.1 User/Stakeholder Role in Copernicus Land (Current and Future)

When assessing the CLMS evolution requirements, it is first important to understand which role(s) the interviewed stakeholders have in the context of Copernicus. The aim was to assemble and analyse as broad a coverage of different and representative CLMS mandates as possible in the frame of the ECoLaSS project. The current and future roles in the CLMS of the following organizations were recorded in the phone or face-to-face interviews:

**European key stakeholders,** which are entrusted with the implementation of the CLMS or act as key users:

- The European Environment Agency (EEA), interview partner: Tobias Langanke, of the Natural Systems and Sustainability programme (NSS), Land systems group (NSS3) / Coordinator of the High Resolution Layer (HRL) implementation as part of the pan-European CLMS (see Annex 1.a).

  The EEA acts as the European Commission's European Entrusted Entity (EEE) to implement the pan-European and Local Copernicus Land Monitoring Service components, as well as coordinate the cross-cutting Copernicus In-situ component. The EEA plays not only an important role as procurement agency for CLMS implementation, but plays also an important role as user of the CLMS products. Experience from the current CLMS product use is regularly captured, and requirements and ideas for future service evolution and new products are systematically collected from the thematic user groups within the EEA. This close integration is also structurally implemented through the close integration of Copernicus project managers in the NSS programme at EEA.

- The DG Joint Research Centre (JRC), interview partners: Michael Cherlet - Coordinator of the Copernicus Global Component, from the Knowledge Management for Sustainable Development & Food Security Unit - (see Annex 1.b) and Olivier Léo and Guido Lemoine from the Food Security Unit (see Annex 1.c).

  The JRC acts as the EC's EEE to implement the Global Copernicus Land Monitoring Service component, as well as the Copernicus Emergency Management Service (CEMS). The JRC Food Security (FS) Unit acts as user of some of the Copernicus Land products, and has strong interest in the development of a future pan-European Agricultural Service. In April 2016, the JRC FS Unit drafted a Concept Note: "Towards future Copernicus Service Components in support to

agriculture?" (JRC, 2016), which was updated following a series of consultations with Member States and the development of pilot studies initiated by Member States (CZ, DK, ES and EE).

- The DG Environment (DG ENV), interview partners: Frank Vassen, from Unit D3 – Nature conservation; Directorate „Natural Capital" (see Annex 1.d), who had been, amongst others, involved in the CLMS local component's Natura 2000 product definition, and Peter Löffler from Unit D1 – Land Use & Management, Directorate D „Natural Capital" (see Annex 1.e), responsible for all Forest topics in Unit D1 and for the Forest Information System for Europe (FISE).

  DG ENV acts as European key stakeholder and user of Copernicus Land Monitoring Service products and is interested in future developments of the pan-European CLMS, with specific focus on the HRL GRA (Unit D3) and HRL FOR (Unit D1).

- The DG for Agriculture and Rural Development (DG AGRI), interview partners Mohamed El Aydam, Barthélemy Lanos, Piotr Wojda and Louis Mahy, from Unit Unit G4 – Arable Crops and Olive Oil. DG AGRI has the political mandate for agricultural Monitoring in the EU, comprising IACS, LPIS and CAP Monitoring. DG AGRI is mainly interested in getting further tailored agricultural monitoring services from Copernicus, including a dedicated HRL Crops (mask & types) and further enriched HRL Grassland products. In that sense, DG AGRI could become a key user of Copernicus in the near future. Furthermore, DG AGRI has been supporting making LPIS data more openly and widely available under the INSPIRE Directive, see details in Annex 1.n.

- The DG Climate Action (DG CLIMA), interview partner: René Colditz, from Unit C3: Land Use and Finance for Innovation (see Annex 1.m and Annex 2.i). DG CLIMA leads the EC's efforts to fight climate change at EU and international level. Its mission is to formulate and implement climate policies and strategies, take a leading role in the international climate negotiations, implement the EU's Emissions Trading System (EU ETS), monitor EU Member States' emissions and promote low-carbon technologies and adaptation measures. In the context of its mandate, DG CLIMA is mostly interested in the CLMS pan-European component's HR Layers, which appear to have high potential for supporting IPCC class nomenclature compliant reporting on LULUCF, particularly if/when complemented by a dedicated HRL Crops in the future.

- The DG Regional and Urban Policy (DG REGIO), participating member: Hugo Poelman, from Unit B1: Policy Development and Economic Analysis (see Annex 2.h). DG REGIO is one of the main users of the Urban Atlas and generally uses CLMS products for further GIS analysis focusing on proximity and accessibility to urban areas, enhanced spatial localisation of population, and localisation of urban green infrastructures and urban service provision. The outcomes of these analyses, i.e. regional, territorial and urban indicators, are supporting the EU cohesion policy.

**National key users and stakeholders** responsible for national Copernicus implementation/coordination:

- The German Environment Agency (Umweltbundesamt – UBA, Germany), interview partner: Christian Schweitzer, from the Environmental Information Systems and Services; Unit 1.5 – Environmental Information Systems and Services (see Annex 1.f).

  UBA Germany provides the deputy thematic coordinator for the Copernicus Land Monitoring Service in Germany. The Agency is a member of the Copernicus Relays network. It has further roles in Copernicus Land, such as being the EEA-EIONET National Focal Point (NFP) and National Reference Centre (NRC) for air quality as well as for Environmental Information Systems (EIS) which is responsible for CORINE Land Cover (CLC) updates. It is the general EIONET contact point towards EEA for the CLMS pan-European and local components. Projects and feasibility studies are conducted, focussing on Copernicus data application (e.g. for several thematic fields such as land sealing (imperviousness) or land cover and land use mapping, air quality). There is an

increasing recognition that financing further Copernicus related projects and feasibility studies through the „Ressortforschungsplan" of the German Federal Ministry for Environment, Nature Conservation, Building and Nuclear Safety (BMUB) is necessary to foster further national Copernicus uptake. Additionally, UBA Germany has participated to an initial assessment of the CLC+ Backbone concept.

- The German Federal Agency for Cartography and Geodesy (Bundesamt für Kartographie und Geodäsie – BKG), interview partner: Ralf Gehrke, from the Unit GI 7 Development and Remote Sensing (see Annex 1.g).

  BKG is involved in Copernicus Land Monitoring Service related endeavours on national level through the German national thematic coordinator for the CLMS, Mr. Hovenbitzer, and is a member of the Copernicus Relays network since February 2017, and a delegate to the Copernicus User Forum. BKG participates in the national CLC activities as subcontractor to the UBA. The Agency is conducting pilot projects which are investigating the use of Copernicus satellite data, aiming to support the sustainable broad uptake of CLMS products in Germany. Among these are: *LBM-DE:* Landbedeckungsmodell Deutschland (BKG product); *CopKoordLand:* Support for the technical coordinator for Copernicus Land service and quality assessment of HRL and UA; as well as some research projects (*Landbedeckung mit Radardaten*: Sentinel-1 SAR data for land cover classification; *LaVerDi*: Sentinel-2 time series for change detection and SDG indicators; *Funkie*: testing datasets for natural hazard monitoring; and further more. Moreover, BKG is the designated agency for continuing the services of the ZKI (Zentrum für Kriseninformation – Centre for Crisis Information) currently still run by the DLR. This service is a kind of national pendent, and partially duplicating, the Copernicus Emergency Management Service (CEMS)`s Rapid Mapping Service.

- The German Aerospace Center – Deutsches Zentrum für Luft- und Raumfahrt (DLR) Raumfahrtmanagement (Space Administration), interview partner: Michael Bock, from the Earth Observation Department (see Annex 1.h).

  The DLR is the executive agency for the implementation of Copernicus in Germany, entrusted by the German Federal Ministry of Transport and Digital Infrastructure (BMVI). The DLR Space Administration provides interfaces for Copernicus Land to users via national thematic Copernicus service coordinators and contact points ("Fachkoordinatoren"), which are BKG and UBA in case of the CLMS. DLR represents Germany in the Copernicus User Forum und the Copernicus Committee, together with the thematic Copernicus coordinators. DLR is also co-organisor of the National Copernicus Forums and info days. DLR's activities regarding Copernicus data cover informing, coordinating and integrating, qualifying and providing support and making data available. It is in charge of the national Copernicus website „Copernicus in Deutschland" (Copernicus in Germany)[7]. The DLR is also responsible for implementation of the German national Collaborative Ground Segment (CGS), called CODE-DE. One other Currently, discussions with the BMVI are ongoing related to the continuation of the national Copernicus Strategy and implementation programme.

- The Environment Agency Austria (EAA) (Umweltbundesamt – UBA, Austria), interview partner: Andreas Littkopf, from the Soil and Land Management Department. EAA is the Austrian EIONET National Reference Centre (NRC) for Land Cover (see Annex 1.i and Annex 2.j).

  The Agency leads the European Topic Centre on Urban Land and Soil Systems and is directly supporting the Copernicus team at the European Environment Agency (EEA). Long-term cooperation with EEA is expected also to continue beyond 2020 e.g. in the frame of (future)

[7] www.d-copernicus.de

European Topic Centres. The EAA advocates Copernicus services being used for national applications and further developments related to land and biodiversity monitoring.

- The General Office for Sustainable Development of the French Environment, Energy and Sea Ministry - Commissariat Général du Développement Durable (CGDD) du Ministère de l'Environnement, de l'Énergie et de la Mer - , interview partners: Mr Vincent Pircher from CGDD/ Direction de la Recherche et de l 'Innovation (DRI), French representative at the Copernicus User Forum); Mr Benoit David from CGDD/DRI, Satellite National Plan and Mrs Frédérique Janvier who is the French EIONET NRC representative on Land Cover (see Annex 1.j).

  CGDD/DRI represents the French position to the Copernicus User Forum and Committee and is in charge of liaising with French stakeholders. Its main Coperniucs related role is to provide feedback from French institutional needs. CGDD/SOeS is the French EIONET NRC and oversees the implementation of CLC for France as well as other Copernicus land products. It also develops statistical indicators based on Copernicus and other geospatial products for the French government. Regarding future activities, CGDD/DRI will provide input to future requirements from French institutions as part of the Copernicus Committee and User Forum whilst SOeS will provide more technical input/feedback as part of the EIONET NRC meetings/activities and will address the national expression of need for environmental statistics, and the needs of other end users.

- The National Council for Geographic Information (CNIG)/ French Mapping Agency (IGN) and French Association for Geographical Information (AFIGEO). Interview partner: Pascal Lory, user interface for Copernicus Land Monitoring Services (see Annex 1.k).

  CNIG and AFIGEO are two organisations focusing on the development of Geographical Information in France. A had been organised involving French institutions and service providers, making use of Copernicus data, to present their solutions. This information was gathered at an information day organised by the French CNIG/IGN and AFIGEO on 30 March 2017 to foster exchanges between the Copernicus programme and the needs of end-users. Producers of in situ data (i.e. mainly IGN) also presented their vision regarding the complementarity between Copernicus and national infrastructure. The main activities towards these users are: Awareness of the Copernicus services offer, improvement of the relationship between these services and users' expectations, identification of service opportunities for private sector, support of the users to position themselves in the added value chain, coordination of geographic information actors in France, recommendations to the Copernicus point of contact for France, recommendations at European level (European Commission, ESA, EEA, etc.), notably concerning favourable development conditions for service companies.

In the second round of the user/stakeholder requirements assessment, the recommendations made by the project's reviewer, to involve the **National Reference Centres (NRCs)** for Land Cover in a wider and more systematic manner, were implemented. A dedicated webinar was held in October 2018 (cf. section 2.2.2), to which all NRCs Land Cover were invited via the EEA, and in which several (additional) NRCs participated. Within this webinar, the participants were asked for feedback in form of a filled-out questionnaire (cf.section 2.2.3), with which all the NRCs for Land Cover had been provided prior to the webinar. The following participants handed in their feedback:

- The Space Research and Technologies Institute (SRTI) of the Bulgarian Academy of Sciences, Bulgaria. Participating member: Ventzeslav Dimitrov, from the Department Remote Sensing Systems (see Annex 2.a).

- The Czech Environmental Information Agency (CEIA), Czech Republic. Participating member: Lenka Rejentová, from the Department of Geoinformatics and Remote Sensing (see Annex 2.b).

- The Federal Agency for Cartography and Geodesy (BKG), Germany. Participating member: Friederike Emig, from the Department GI 7 (Development and Remote Sensing) (see Annex 2.c).

- The Croatian Agency for Environment and Nature (CAEN), Croatia. Participating members: Branimir Pavlinec, Bojan Karaica, Tamara Kirin, from the Habitats department, Department of Environmental Monitoring and Development of Information Systems (see Annex 2.d).

- The Environmental Protection Agency (EPA), Ireland. Participating member: Gavin Smith, from the Analytics Team of the Department Evidence & Assessment, (see Annex 2.e).

- The Malta Environment and Planning Authority (MEPA), Malta. Participating member: Stephen Conchin, from the Information Resources Unit (see Annex 2.f).

- The Wageningen Environmental Research (WENR), Netherlands. Participating member: Gerard Hazeu, from the Spatial Knowledge Systems Department (see Annex 2.g).

Besides the above listed institutions, a close collaboration between ECoLaSS and "sister" H2020 Land projects led to additional user feedback from the involved institutions ITACYL and the University of Valencia (see Annexes 2.k and 2.l), which are project participant and project coordinator in the Sensagri project. Sensagri has the focus on prototypes for agricultural applications, exploiting the synergies of optical and SAR data. The resulting prototypes are complemented by a proof-of-concept for four agricultural monitoring services. All the project's outcomes aim at a potential future integration into the Copernicus service architecture.

### 3.1.2 Policy Drivers and Milestones

For understanding the requirements of the stakeholders and users, it is of high importance to understand which obligations these do have in terms of reporting to international, European and/or national policies. Typically, these policies drive the needs for data and products. The most important policies related to Copernicus Land services are listed here below, together with the main drivers and events related to them. European organisations such as the EEA, JRC or the various EC DGs, have a strong interaction, supporting several European international (environmental) policies, as follows:

**State of Environment Report (SOER)** (cf. Annex 1.a, Annex 1.i):

The EEA is in charge of producing the State of Environment Report (SOER), which also represents the most important EEA internal use of CLMS data. It addresses both the Common Agricultural Policy (CAP) and other environment related policies such as the Fishery and Cohesion policies. It is regularly issued in a 5-year cycle. The next SOER is upcoming in 2020, feeding also into the ongoing policy making cycles of the Common Agricultural Policy, the Common Fisheries Policy and the Cohesion Policy. It will thus be an important goal post to meet in terms of timely provision of the HRL's reference year 2018.

**EU Common Agricultural Policy (CAP)** (cf. Annex 1.a, Annex 1.c, Annex 1.i, Annex 1.n):

The European Union's Common Agricultural Policy (CAP) is one of the main leading policies of relevance for the Copernicus Land services. At international level, the "greening" legislation of the CAP is particularly relevant. For the so called post-2020 CAP, the concept of the policy has been simplified not only in terms of management, but also in terms of the controls considering the huge spatial coverage

and frequent monitoring capacities of the Sentinel sensors. On EU level, mainly the DG AGRI and the JRC drive this policy.

**European Forest Policies** (cf. Annex 1.a, Annex 1.c, Annex 1.e, Annex 1.i, Annex 1.m)

The European Forest Strategy, adopted in 2013, has a strong influence on the Copernicus Land services, both at international and national levels. Its monitoring and situation is reflected in EEA's SOER publication.

The EU agencies are also collecting the requirements from the Land Use, Land Use Change and Forestry (LULUCF) reporting (2021+) for more frequent monitoring of forest areas. DG ENV considers forested land as carbon sink; therefore, carbon stocks and flows shall be represented for forest in this reporting, suggesting the possibility of using Sentinel satellite data for this topic. DG CLIMA requires LULUCF reporting to use IPCC compliant LC/LU class definitions, which is at the moment not fully met e.g. through the HRLs.

The Forest Information System for Europe (FISE) is the focal point for data and information on forests and forestry in Europe. Its development follows the EU Forest Strategy. The DG ENV considers that the envisaged focus of FISE shall be on: forest base data (extent, distribution, forest types etc.); forest biomass indicators; forest biodiversity and forest carbon. FISE is expected to become a cross-cutting public service. Unit D1 of DG ENV is also in charge of producing the State of Europe's Forests Report.

Mid- to long-term climate change & forest health monitoring (by Sentinel and other data) would be also required by DG ENV to monitor leaf discoloration, defoliation, phenology changes and impacts of increasing extreme-weather events such as droughts, storms and heavy rainfall.

**EU Biodiversity Strategy to 2020** (cf. Annex 1.d, Annex 1.e, Annex 1.i)

This policy is based on 6 main targets focused on the Birds and Habitats Directives. Its aim is to maintain and restore ecosystems and their services; increase the contribution of agriculture and forestry to biodiversity; ensure the sustainable use of fisheries resources; combat invasive alien species and help avert global biodiversity loss. The DG ENV indicates that the 'Fitness check' of the Habitats and Birds Directives concluded that the directives are fit for purpose, but are insufficiently implemented. Conservation status of the forest habitats and species is unsatisfactory. 80% of assessments of protected forest habitats gave an unsatisfactory result. Sentinel satellite data and CLMS products could be of use in monitoring and improving the conservation status by providing substantial input to reduce the effort of biodiversity monitoring through in-situ observations.

**State of Nature Report** (cf. Annex 1.d):

The DG ENV produces the State of Nature Report. It is published every 6-years (such as 2019), primarily based on information reported by the Member States according to Article 12 of the Birds Directive and Article 17 of the Habitats Directive. In addition to the Member States' contributions, the utilisation of the (spatially extended) Copernicus Land Local Component "Natura 2000" product is planned by DG ENV, as well as doing an own evaluation of the European Natura 2000 site related land use changes/trends.[8]

**EU Food Security Policy** and **EU Development Policy** (cf. Annex 1.b, Annex 1.c):

[8] The DG Environment had issued a respective Open Call for Tenders (ENV.D.3/SER/2018/0037) in December 2018, cf. https://etendering.ted.europa.eu/cft/cft-display.html?cftId=4260

Both policies are dealt with under the DG DEVCO (European Commission Directorate-General for International Cooperation and Development) – (Annex 1.b, Annex 1.c):

There is an established collaboration between JRC and DG DEVCO for the hot spot monitoring service on protected areas, supporting as well the Food Security policy at international level. JRC is also supporting the monitoring of land grabbing.

**Sustainable Development Goals (SDGs)** (cf. Annex 1.a, Annex 1.b, Annex 1.k)

In addition to the above described, specifically European policies, the European stakeholders also participate to and support the Sustainable Development Goals (SDGs) of the United Nations (UN), contributing with indicators reporting and the Atlas of Desertification (produced by the JRC, cf. Annex 1.b), amongst other elements.

Some national Copernicus stakeholders also contribute to these goals as main policy drivers, which are currently (i) the provision of Sustainable Development Goals (SDGs) indicators, and (ii) for accompanying the "ecological transition" in some countries.

Other European policies which could be linked to Copernicus Land Monitoring service products and activities and to the use of Sentinel data, are:

**Bioenergy Policy/Renewable Energy Directive** (cf. Annex 1.e):

The Bioenergy Policy and the Renewable Energy Directive both deal with the (economic) forest use intensification for bioenergy. Particularly the implications of the globally growing intensification of biomass exploitation for bioenergy versus the targets of biodiversity conservation and the resulting potential reduction of the forest carbon sink are an area of conflict and a concern to DG ENV. A close coordination with DG ENERGY is considered important in that respect.

**Bioeconomy policy/"green growth":**

Detailed (and spatially explicit) information on the amount of biomass stored in the global forests as well as on short-, medium- and long-term changes is still unreliable and partly missing. Additional quantitative information on forest carbon content is required.

In addition to all the above described European and global policy drivers, the conclusions of several EU flagship policies will be drawn by the year 2020, for which substantial inputs from the CLMS are expected to be used (**7th Environment Action Programme, Europe 2020/Horizon 2020, EU Biodiversity Strategy to 2020**). The SOER is a good example of the potential role of Copernicus products being used for the formulation and impact assessment of policies within the EEA. It is expected that for the 2020 SOER, CLMS data will be used to a much larger extent as compared to the 2015 SOER, with an anticipated availability of the CLMS Local Component, HRLs and CLC data with recent update dates.

The interviewed EU stakeholders are supporting such policy making and impact assessment. They are going, as well, through consultations and collection of results of the Member States' own initiatives. Further reports are being produced in that respect. A number of other **EEA reports and publications** use CLMS data. These thematic reports are however only planned and known around 2 to 3 years in advance, so that it is difficult to predict exact policy drivers (and therefore CLMS data use). Past EEA reports that have used CLMS data were e.g. EEA report 31/2016 **Land Recycling** or report 11/2016 on **Urban sprawl**

**in Europe**. Further potentially relevant reports are e.g. on **Land resource efficiency**, on **Past land cover trends** and on **Environmental performance of cities**.

All European directives are relevant not only at international/EU level but also at national and local level. Therefore, national and regional level policies are also partially related and relevant to Copernicus Land services. Most of the countries have also their own specific policies, which are typically more specific than the European ones for their particular national situations, such as:

**National Strategies for Biodiversity Conservation** (cf. Annex 1.f, Annex 1.j):

In particular the following two national strategies were pointed out by national stakeholders:

UBA Germany reported that Germany has its own National Sustainability Strategy that helps Germany to report to the United Nations (UN). UBA is involved in consultations and discussions on this strategy (cf. Annex 1.f).

CGDD reported on the French National Strategy for Biodiversity. It has a "national state of the environment report" published in 2018, which is currently planned every four years (cf. Annex 1.j).

Some countries have their own national adaption strategies to Climate Change, such as Germany (cf. Annex 1.f). UBA Germany is involved in the indicator development and assessment, and supports a study assessing the potential of remote sensing data for further indicator development and monitoring.

## 3.2 Use of Copernicus Land Monitoring Products, End-users and Applications

The following sections present the users' and stakeholders' responses related to their current use of CLMS products (section 3.2.1), including the strengths and shortcomings of these products (section 3.2.2). This constituted the basis for identifying targeted needs for product improvements or new developments in ECoLaSS (as further described in chapter 4). Additionally, section 3.2.3 summarizes product end-users and end-use applications that are currently foreseeable by the addressed user community.

### 3.2.1 Current Use of Copernicus Land Products

This section summarizes the Copernicus Land Monitoring Service products that are currently used in the interviewed users' and stakeholders' organisations.

#### COPERNICUS LAND SERVICE PRODUCTS CURRENTLY USED IN STAKEHOLDER ORGANIZATIONS

EEA– Pan-European Component (cf. Annex 1.a):

- Current use mainly of CLC and derived land take indicator for a number of reports and tasks where changes and trends in land use and cover are relevant.
- Use of HRL Imperviousness data both for a published EEA indicator, and in work and reports on urban issues and on biodiversity issues.
- Explorative use of HRL Forest data and CLMS local component data, in particular Urban Atlas (UA) and Riparian Zones (RZ).

JRC – Global Component (cf. Annex 1.b):

- Global Atlas of Desertification is derived from some Copernicus Land products
- Several products used in the JRC's Food Security Unit and Forestry Unit.

JRC – Food Security Unit (cf. Annex 1.c):

- Current use of Copernicus Land products is limited. HRL Grassland was considered potentially of great interest, but thematic content and quality issues in the HRL Grassland 2012 product prevented using it to its potential. The refurbished HRL Grassland 2015 and 2018 may become relevant again.

DG ENV (cf. Annex 1.d):

- The local component Natura 2000 has be extended in close collaboration between EEA and DG ENV to cover all Natura 2000 sites with significant occurrences of grassland habitats in the current operational phase of Copernicus. The related extended site mapping has been concludes in Dec. 2019, and a new complete update for all addressed Natura 2000 areas for the reference year 2018 is in preparation[9]. This, in combination with regular update intervals and spatially explicit statistical evaluations of pressures exerted on the Natura 2000 sites is expected to significantly increase the product's use potential.
- There are currently limited own capacities in DG ENV to analyse remote sensing/Copernicus data or products, however external contracts are being made use of.

UBA (cf. Annex 1.f):

- Use and testing of CLC (used for several applications); HRL Imperviousness (IMP) (for calculation of imperviousness); Local Component Products: Urban Atlas (UA); and other Copernicus biodiversity topics like forest HRL products, Riparian Zones (RZ) and Natura2000 and others.
- Regarding HRL Forest (FOR): Feasibility study to detect tree species using Sentinel-2. In the future, tenders may be issued for the implementation of a tree species mapping. There is a further demand for a tree species map in Germany at Bundesamt für Naturschutz (BfN) and Thünen-Institut (TI) for the German State-of-Forest report ("Wald-Zustandsbericht").

BKG (cf. Annex 1.g):

- Products of Copernicus Land services may be used as complementary information source for various projects: HRL and UA in the project CopKoordLand, HRL/CLC in the project Cop4Stat.

DLR Raumfahrtmanagement (cf. Annex 1.h):

- DLR Raumfahrtmanagement does not use Copernicus products themselves, since in their coordinative function they rather provide funding for the development, implementation and use of Copernicus services to German public institutions and value adding industry.
- At the Earth Observation Center (EOC) of DLR Oberpfaffenhofen, Copernicus products may be used as well.

EAA (cf. Annex 1.i):

- The HRL Imperviousness is used for national monitoring of soil sealing and future spatial planning in terms of mitigating and limiting of soil sealing in Austria, as well as for wildlife migration corridors conservation and planning.
- Other land monitoring products are only used in a limited manner currently for European reporting. On basis of S-2 products it is expected that also usage on the national level will be possible.

CGDD (cf. Annex 1.j):

[9] The EEA published the related Open Call for Tenders (EEA/DIS/R0/19/001) in mid-Nov. 2019 (https://etendering.ted.europa.eu/cft/cft-display.html?cftId=5546). The resulting contract has not been awarded by the time of concluding this report (end Dec. 2019).

- CLC is the main source of data to provide various land cover indicators as part of the national strategy for biodiversity. Other sources are national ones or based on LUCAS (indicators for UN SDGs or the national ecological transition policy). However, the use of HRL IMD appears promising.

DG REGIO (cf. Annex 1.l):

- DG REGIO was the first user of the Urban Atlas (UA) 2006 and still one of the main users of UA.
- It does not make direct use of EO imagery but of the derived land cover products.

In summary, it seems that the current use and uptake of Copernicus Land Monitoring Service products is quite different from entity to entity, both at European and national level. This appears to be more correlated to the different policies' information needs than to European or national level. One further common component may be also the entities' heritage and record of Copernicus "exposure".

### 3.2.2 Strengths and Shortcomings of Current Copernicus Land Products

This section summarizes the strengths and shortcoming of the CLMS products, as collected from the users and stakeholders as well as various other information sources. This collection constituted the basis for identified service update/evolution needs (as documented in section 3.3), and for the development work undertaken in the ECoLaSS Tasks 3, 4 and 5 (cf. Figure 1).

**STRENGTHS AND MOST VALUABLE INFORMATION OF THE CLMS PRODUCTS:**

The following key strengths of the products were highlighted (Annex 1.a, Annex 1.f, Annex 1.g, Annex 1.h, Annex 1.i, Annex 1.j, Annex 1.m). Some of these remarks have been mentioned by several stakeholders:

- Full spatial EEA-39 coverage
- Much improved cloud gap mitigation
- Consistent reference time step
- Good spatial resolution / MMU
- Regular update cycle / change monitoring
- Consistent pan-European information
- Thematic information layers which are partially not available in Member States, such as continuous-scale information Layers (IMD, TCD)
- Free and open availability
- Proven and documented quality
- HRLs are receiving very good feedbacks. HRL IMD appears particularly interesting in terms of quality, precision and complementarity with existing datasets
- Urban Atlas and Riparian Zones products also receive good feedback regarding MMU

**SHORTCOMINGS THAT ARE EXPERIENCED:**

The following shortcomings were recorded (Annex 1.a, Annex 1.d, Annex 1.f, Annex 1.g, Annex 1.h, Annex 1.i, Annex 1.j, Annex 1.m, Annex 1.n, Annex 2.a, Annex 2.b, Annex 2.c, Annex 2.d, Annex 2.e, Annex 2.f, Annex 2.g, Annex 2.h, Annex 2.i, Annex 2.j, Annex 2.k). Some of these remarks have been mentioned by several stakeholders:

- Thematic gaps in the European CLMS portfolio, i.e. primarily:
  - an agricultural service (HRL Crops), comprising crop area and (main) crop types, as well as monitoring agricultural activity such as ploughing, harvesting, cutting, etc.;

- phenology related spatially explicit information on vegetation growing season characteristics (start, end, peak, length, etc.), disturbances, droughts, etc.;
- grassland use intensity, discrimination of permanent vs. temporary grassland;
- monitoring of snow and ice cover.

With the recently contracted information layers on HR Vegetation Phenology and Productivity, some of these shortcomings will be addressed. Besides that, an agricultural service as part of the HRLs as well as a grassland use intensity product are currently still in the debate. Both have an obvious critical dependence on in-situ data.

- Quality gap: The HRLs 2012 on Natural Grassland and Wetland were potentially of great interest, but thematic content-related quality issues had been identified both by the ETC-ULS and several Member States, which prevented using them to their potential. Therefore, both products were discontinued in their initial forms.

  As a consequence, new HRLs have been conceptualised, which have been successfully derived with good quality for the reference year 2015, and are just being updated for the reference year 2018.

- Temporal gap: frequency of product updates of the pan-European Component (e.g. HRLs) of 3 years is considered insufficient for several applications, and repetition cycles of 1 year would be welcomed by many users.

- Thematic class nomenclatures: It was considered, that for international reporting on climate policies, compliance of CLMS products to IPCC LC/LU classes would be required. Notably the absence of an HRL Crops was perceived as a blockage.

- Furthermore, there is a tendency to request a stricter separation of land cover and land use aspects in CLMS products, following the recommendations of the EAGLE group and the respective hierarchical EAGLE land cover class nomenclature. A first realisation of this concept is upcoming in the CLC+ Backbone product.

- Continuous-scale information products were requested for more CLMS products beyond the current IMD and TCD products.

- Historical reference years: Some users requested a (significant) retrospective extension of the HRL time series to historic reference years (e.g. using Landsat/IRS/SPOT/other archive data), in order to extend the possibilities for change analysis and enhance the scope for policy evaluation and reporting.

- Duration until product provision is perceived as too long (service procurement, data processing, product generation, QC until publication)

- Communication gap: Need for more transparency/communication: website/portal, description of products, metadata, and production processes behind the data (discussed e.g. at the WorldCover conference in ESRIN/Frascati, March 2017).

- The spatial resolution (20m) of several products, e.g. EU-DEM, HRLs, and CLC is considered not sufficient for some users. 10m HR Layers would be appreciated, as well as for the DEM.

  Within the currently ongoing updates of the HRLs for 2018, the spatial resolution has been increased from 20 to 10m. The new Copernicus DEM will provide a 10m resolution high-quality product for Europe. Also the latest update of the CLC of 2018 is based on 10m resolution data (Sentinel-2) although resulting still in a 25 ha MMU.

- On the other hand, to some users, the lack of consistency of the spatial resolutions between the different products of the pan-European component, is a concern.

- CORINE Land Cover (CLC): especially in the context of CLC, it was mentioned that the MMU is too coarse, plus it should be consistent in both CLC and CLCC. Besides that, a more spatially detailed

classification would be appreciated. Furthermore, the temporal resolution is of 6 years is considered not suitable for specific applications (e.g. in the context to agriculture).

- Imperviousness (IMP): the initial insufficient quality and time series consistency of the first product releases and the related need for a re-calibration of the previous IMP products as part of the 2015 update has been partially perceived as confusing.
- There is a perception among some users that scientific testing and selection processes were not applied consistently for all past HRL products, and some unconsolidated products were released (particularly in view of some HRLs 2012). Therefore, the ECoLaSS project with its approach of user requirements assessment and stakeholder interaction, new products design and testing, prototypically demonstrating and benchmarking, involving different service providers and institutes, has been widely appreciated.
- Quality control, validation and consolidation of products: Some of the products did not totally fulfil quality requirements, but it was remarked that some of these requirements were set somewhat arbitrarily. There has been a lack of detailed product specifications for some HRLs in the past. A good quality control and validation before the release of products is considered mandatory.
- Additional use: Some national users remarked that there seems currently not much additional use potential provided by the CLMS products to the national level programmes.
- The increasing evident convergence process of the spatial resolutions of the CLMS pan-European and global components, triggered by the availability of the Sentinel data is perceived by some stakeholders to require an intensified coordination and a more transparent communication of respective strategies to the users and the public.
- Awareness and knowledge about Copernicus products needs to be generally improved through more dedicated communication and user uptake initiatives.
- A more capable Copernicus Land portal was multiply requested, allowing better data exploration, visualization, combination and access functionalities.
- European Image Mosaics (VHR and HR): These do currently not exhibit the desired quality and ease of access.

Though not being focus of ECoLaSS, Local Component requirements have been recorded as well (among others in Annex 2.a, Annex 2.b, Annex 2.d, Annex 2.e, Annex 2.f, Annex 2.h, Annex 2.i):

- Temporal gap of Local Component products: More timely information on Natura 2000 - e.g. from the past year – would be desirable. The limitations caused by the data situation of current Europe-wide VHR image coverages, as well as individual quality constraints of the 2012/2015/2018 VHR image coverages are recognised.
- Some users have voiced that parcel-based information would be required for some applications. CLMS local component products do not completely fulfil the need, but are somewhat close to the required scale.
- Extension of the local components to other areas/sites had been recommended by several users, such as including coastal habitats, urban agglomerations of < 50.000 inhabitants and more 3D models into the Urban Atlas, or water courses of lower Strahler categories in the Riparian Zones, or extension of the Natura 2000 sites to all relevant grassland rich habitats.

  Actually, most of these voiced shortcomings are currently incorporated in the latest updates. Regarding the Urban Atlas, the threshold of urban agglomerations has not been changed. However, since several urban regions have grown to >50.000 inhabitants, they will now be part of the product so that the overall mapped area is more than in the 2012 reference year. The Riparian Zones have been extended for the reference year 2012 to comprises now Strahler levels

2-9 instead of formerly 3-8, and a consistent update for the reference year 2018 is currently ongoing. The spatial extent of the Natura 2000 sites has been extended to a significantly larger area for the reference year 2012, and the consistent update for 2018 is just in the process of being re-contracted (see Footnote 9).

- The thematic and geometric accuracy as well as the spatial resolution of the Urban Atlas should be enhanced.
- The thematic focus of the Natura2000 sites should be extended to other habitats, that are not related to grassland.

### 3.2.3 Further Use Potential of Copernicus Land Monitoring Products and Applications:

After an analysis of the current users and uses of the Copernicus Land products, a view into their potential future is reflected in this section, as collected from several of the interviewed stakeholders and the information collected by al other means.

**Current users** are mainly European Institutions (such as EEA, JRC or DG ENV…); service industry (mainly for downstream services); research and academia; countries' national agencies and regional administrations and NGOs. On the level of Member States, current use is more common at national than at regional or local level, as current specifications are not always in line with needs at this level.

In some regional environmental agencies, CLMS data are nevertheless reviewed and thought about, but have not yet been used, as there is a lack of capacities and personnel. Workshops take place on national and regional level to overcome obstacles on the user side, such as awareness, data access and documentation of the products. Also the EC and the EEEs have increased their user uptake endeavours significantly in the past years. Regional users are expected to further increase their interest in Copernicus Land products substantially.

**Possible future** additional users could be environmental industries, NGO's or further national agencies working with geodata. Moreover, interest within the R&D/academia community should be further raised, particularly for applications on continental scale. One example of a recent scientific paper using Copernicus High Resolution Layer Imperviousness Degree data is presented by Lefebvre et al. (2016).

New potential users are as well very interested in the Copernicus Sentinel satellite data. Depending on the degree of their own capacities, some users prefer Copernicus Sentinel data over the actual Copernicus products, for performing their own analyses.

Regarding the **use/application of Copernicus Land data**, the biggest potential is seen in the synergistic use of products and the combination of Copernicus products with other data, e.g. a combination of status layers, change layers and additional data (e.g. Imperviousness combined with population data to get per-capita figures). This would enable a wider spectrum of product uses and applications.

Some future applications of Copernicus Land Products are seen in the fields of:

- Statistics
- Agriculture
- Biodiversity, environment and ecosystem services
- Coastal Zones, particularly Land-Marine transitional areas and ecosystems
- Forest
- Grassland
- Freshwater ecosystems

Statistics from different Copernicus Land products would be very interesting for the biodiversity related users. For example, for the Sustainable Development Goals (SDG), the use of LUCAS data, CORINE-related indicators or Imperviousness-based indicators are explored, amongst others.

For agricultural activities, the current number of users for existing Copernicus Land products is limited, but could be boosted with a future availability of a HRL Crops. Another use case would be for Member States' institutions in charge of the CAP implementation and controls as well as farmers themselves, especially for CAP impact monitoring. The main current use could be in the identification of pastures. In addition, HRL Grassland and Riparian Zones & Natura 2000 LC/LU products are used for cross-checking of LUCAS data. Further added-value potential is in the area of agricultural statistics (e.g. there are no agricultural data covering all areas). Potential use post-2020 could be much wider. CAP-related use of Copernicus satellite data (Sentinels) would in general be welcome, although in terms of spatial resolution the presently available Sentinels can only to a limited extent contribute to CAP Monitoring. The Small Woody Features (SWF) product could be potentially of use, particularly if extended in thematic scope for the 2018 reference year, as is currently being discussed between the EEA and DG AGRI.

A stronger promotion of the Natura 2000 product towards the general public and academia has been requested by some interviewed users. Policy relevant questions might be of relevance for academic users as well. An ability to go further back into the past with time series is seen as an asset and could possibly attract further users, such as national Natura 2000 site managers. Also monitoring of biodiversity could be improved through longer time series: historically, forest cover has been going up in Europe during the last decades, but all major European reports on conservation status and biodiversity suggest that there are problems.

Forest monitoring products are highly demanded. Currently, main activities in this area are oriented to forest damage assessment, mapping of tree species composition, monitoring of forest area changes, and regional forest administration purposes. Potential future forest related tasks could be on-demand monitoring of potentially illegal forest logging; spatially explicit and more frequent (e.g. annual) monitoring of forest cover and forest type changes; distinguishing between intensive/extensive forest uses; monitoring of tree cover density development; forest cover and timber stock monitoring. It should be noted that most European Member States have well developed NFIs, and even though the value of HRL FOR is recognised at that level, there is significant room for improved use of these data at national level.

Imperviousness: there are few other equivalent data for monitoring urban sprawl, even though the temporal consistency appears problematic. The quality of the HRL Imperviousness should get further substantially improved with the 2018 update and the evolution to 10m spatial resolution.

Grassland and Wetland products are currently being improved as well to a 10m spatial resolution and making use of fully integrated Sentinel-1 and Sentinel-2 time series with the 2018 HRL production. Various uses are expected from European to regional levels as products become available. Additional HRL Grassland users could be attracted as well through an open/public online viewer, providing new ways of data representation for investigation of LU/LC changes and continuous representation of grassland variations. This and other improvements are expected to be implemented with the update of the CLMS portal in 2020.

## 3.3 Technical specifications for Copernicus Land Service Evolution

The requirements for improved/new technical specifications of Copernicus Land services & products are mainly based on recognised existing gaps or shortcomings (cf. section 3.2.2) in the current CLMS portfolio, and on the stakeholders' respective needs. The analysis is split into (i) products and specifications for improving existing services (section 3.3.1), in contrast to (ii) products and specifications

for new services (section 3.3.2), and (iii) infrastructure for implementation of improved and new services & products (section 3.3.4).

### 3.3.1 Evolution of Existing Services/Products

The following sections provide an overview of the collected general requirements for evolution of existing services (section 3.3.1.1), and, separately, respective technical specifications (section 3.3.1.2).

#### 3.3.1.1 Products for Service Evolution

This section provides an overview of voiced requirements for evolution of already existing Copernicus Land services and products. ECoLaSS targets the Copernicus Land pan-European and Global Land Components. Despite the Local Component is not part of the developments envisaged in ECoLaSS, requirements for the Local Component which the stakeholders brought forward were documented in addition.

The current status is that the pan-European Copernicus Land products are in an operational state and target diverse user groups and applications, whereas the Global Land products are used more by the scientific user community, as well as by institutional and (inter-)governmental agencies.

**PAN-EUROPEAN COMPONENT**

The Pan-European **HRL 2018/HRL 2020+** evolution was mentioned by almost all key Copernicus users and stakeholders that were interviewed. In Annex 1.a and Langanke (2017) it was stated, that the specifications of the 2018 update presumably would be similar to the ones of the HRLs 2015 (AD02; Ramminger et al. 2017), but potentially more frequent update options would be included further in the future. However, the final specifications of the HRLs 2018 ITT slightly differ from the specifications of the 2015 products (e.g. in spatial resolution, additional layers, further quality metrics). Among the five HRLs 2015 (Imperviousness, Forest, Grassland, Water/Wetness, and Small Woody Features), the former four layers were pointed out specifically within the first round of requirements assessment for further evolution:

- HRL Grassland (GRA) was multiply voiced, from users with particular interest in natural habitat types relevant for biodiversity, or agricultural focus (Annex 1.a; Annex 1.c; Annex 1.d; Annex 1.e; Annex 1.i), anticipating the migration to full 10m spatial resolution of the Sentinels, and potentially adding of a Grassland use intensity / mowing frequency discrimination component.
- HRL Forest (FOR) was specifically pointed out as promising layer for various applications, considering also future higher resolution products from Sentinel data and more frequent update cycles (Annex 1.a; Annex 1.d; Annex 1.e, Annex 1.m).
- HRL Imperviousness (IMP) was pointed out repeatedly (Annex 1.a; Annex 1.f; Annex 1.g).
- HRL Water/Wetness (WaW) was mentioned regarding the importance of mapping wetlands for biodiversity or soil protection (Annex 1.a; Annex 1.f).

A concern was raised about the partial co-existence of the HRLs with other, global products of more scientific origin, e.g., HRL FOR or Global Forest Initiative; HRL IMP or Global Urban Footprint (DLR) or Global Settlement Map (JRC) (Annex 1.h). Quality advantages of the HRLs which have been stated e.g. in the frame of the Copernicus Validation project, as well as the independent, regular and sustainable European monitoring capacity in close conjunction with political decision-making on environmental issues should be highlighted and promoted in that respect.

A general concern regarding the CLMS products (particularly the HRLs) available on pan-European and global level is the coordination of the further evolution and convergence process in terms of spatial scales and resolutions as well as thematic definitions of respective products. Discussions between the EEA and the JRC seem to be ongoing for that purpose. So far, it has been agreed that it is necessary to define a basic set of land cover classes for both, pan-European and global level, on the base of which more detailed classes can be defined.

The pan-European **CORINE Land Cover CLC 2018/CLC+ in 2020+** was repeatedly stated as having significant evolution potential. Particularly national users showed strong interest (Annex 1.a; Annex 1.f; Annex 1.g; Annex 1.h; Annex 2.k; Copernicus User Forum, 2017). The CLC 2018 as part of the pan-European component and with an MMU of 25 ha is scheduled to be improved towards 0.5 ha in CLC+, which – in terms of spatial resolution and vector data nature – will be tending in fact more towards the Local ('Hotspot') Component's characteristics. The CLC production for the reference year 2018 has been still carried out in the "traditional" way. In parallel, testing of CLC+ for some countries as part of the CLC 2018 contracts has been performed by several Member States on a voluntary basis as part of the production cycle 2018. The full implementation of CLC+ will be established from 2020 onwards under a framework service contract of the EEA with an industrial consortium, which has been concluded in December 2019.

**GLOBAL COMPONENT**

Currently, the Global Component's **Biophysical Variables** systematic monitoring is mostly based on PROBA-V (Cherlet, 2015; CLMS 2017) and are at present being adjusted to incorporate Sentinel-3 as well as take the opportunity to revisit workflows, resolve interdependencies and adopt a more modular approach. Several new Cryosphere and Water products have been processed and made available. Calibration between sensors and the development of a long time series has also been a priority (Annex 1.b; Copernicus User Forum, 2017).

The implementation of the **Hot Spot Monitoring of the Global Component** has been initiated by DG DEVCO in 2016 and is currently ongoing under coordination of the JRC. So far, the programme has been focusing primarily on African protected areas, with one exception in the Caribbean. An extension of the activities is planned for 2020 to support forest monitoring (REDD+), GEO activities (GEOGLAM and GFOI) and EU supported rural development projects, with a spatial coverage not limited to Africa.

**LOCAL COMPONENT**

The Local Component is not the focus of developments in ECoLaSS, however the (non-exhaustive) information received from stakeholders during the interviews, webinars and the questionnaires is summarised in this report, in order to preserve the gathered information. Specifically, a need for further evolution of the **Natura 2000** product as part of the Local Component was mentioned by DG ENV (Annex 1.d), in terms of spatial extension to further grassland-rich areas. Further mainly national users and stakeholders that are currently using the Natura 2000 product or see use potential thereof (Annex 1.c; Annex 1.f; Annex 1.i) could become interested in the future, which will likely be connected to geo-information needs on higher spatial resolution/scale for national and regional-level applications.

Besides the Natura 2000 product, further improvements were also considered necessary for the **Urban Atlas** (Annex 1.l; Annex 2.b; Annex 2.d; Annex 2.e; Annex 2.f; Annex 2.h; Annex 2.j).

Beyond the three existing products Urban Atlas (reference years 2006, 2012, 2018 update ongoing), Natura 2000 (reference years 2006, 2012, 2018 in the procurement process) and Riparian Zones (reference years 2012, 2018 update ongoing), the new Coastal Zones product (reference years 2012, 2018) has just been initiated in 2019.

#### 3.3.1.2 Evolution of Key Specifications

This section provides suggested specifications for evolution of the existing Copernicus Land services, as stated in section 2.3.1.1.

**PAN-EUROPEAN COMPONENT**

In terms of evolution of key specifications, a general comment was on the trade-off that will have to be made between targeting very specific thematic issues vs. more generic, multi-purpose, multi-user products such as tree cover density (TCD) or biophysical products (Annex 1.a). This goes alongside the

widely accepted definition of downstream services vs. core services. Common specifications for all pan-European products are:

- the coverage of the EEA-39 area,
- the use of HR Sentinel data, as well as
- the expected increasing use of VHR data.

Most of the requirements for future specification evolution target the **HRLs in general**, as follows:

- Update frequency and temporal interval: Higher temporal resolution/more frequent updates, depending on dynamics of individual HRL product-related land cover changes (Langanke, 2017; Annex 1.a). In some cases 3-yearly status layers were considered sufficient (Annex 1.i), but in other cases yearly status layer updates would be desired (Annex 1.d; Annex 1.h; Annex 1.m, Annex 1.n, Annex 2.b). Regular updates solely regarding changes (rather than updating the full European surface) were mentioned (Annex 1.h), or were recommended as yearly incremental updates (Annex 1.h; Langanke, 2017; Dufourmont and Langanke, 2015) – e.g. in terms of annual main LC class changes (such as changes in impervious area or tree cover) between the 3-yearly status layers, or as developments towards dynamic HRL products (Annex 1.h), or a yearly alert by change detection only (Annex 1.i).

  The GRA and WET/WaW services were specifically mentioned related to more frequent update frequencies or dynamic products (Annex 1.g; Annex 1.j).

- Shortened production time: Increased timeliness of availability of the products (Annex 1.g; Annex 1.j). It is recognised however that there are limitations related to EO data needs of entire growing seasons as well as service procurement and technical production requirements that will have to be taken into account.

- Time series (multi-sensor) input data: The change from largely mono-temporal classifications to time series and multi-sensor analysis was already (partially) implemented with the HRL 2015 production and shall be further fostered, including SAR data where possible (Langanke, 2017); Increased product quality is expected through the use of time series data as input, particularly for the HRLs 2018 (Annex 1.g).

- Higher spatial resolution: The spatial resolution of 20m for the HRLs 2015 was described as appropriate for European applications (Annex 1.h); however developments towards higher spatial resolution – taking into account technical/sensor constraints – were multiply mentioned (Annex 1.d; Annex 2.a; Annex 2.b), in case product quality and time series consistency can be maintained (Annex 1.h). This increase in spatial resolution was already initiated with the HRL 2018, where a spatial resolution of 10m is one of the technical specifications. National users would desire a spatial resolution that regularly allows retrieving objects with a 0.25 ha or 0.5 ha Minimum Mapping Unit (Annex 1.h; Annex 1.i).

- Continuously scaled products: Some users request moving towards more continuously scaled products in the future, such as the current Imperviousness Density (IMD) or Tree Cover Density (TCD) (Annex 1.a), in order to further supplement categorical HRL products with additional, continuous information on Land cover characteristics.

- Generic products: Towards more generic products – such as biophysical parameters, phenology or snow monitoring – also on pan-European scale (Annex 1.a).

- Legend information: Should be technically consistent and be provided in several formats (ArcGIS, QGIS, CSV) (Annex 1.f).

- Quality & Consolidation: All existing products should be consolidated, properly designed and tested, quality controlled and consistently provided in the next releases. A thorough (external) validation should be performed before product release (Annex 1.h). Provision of a “Flag-Layer”

and other quality layers would be of help, in order to provide pixel-based geo-located quality information to the users (Annex 1.h).

- Accuracy requirements: Current requirements of ~85/90% accuracy should be maintained (Annex 1.h; Annex 1.i, Annex 2.a), as well when applying automated updates based on time series (Annex 1.h), which is acknowledged to be a challenge. Furthermore, it was reconfirmed to include the quality information in the metadata (Annex 2.a).
- Historical time series: Going back to the past with longer time series of HR optical satellite data (e.g., SPOT/IRS/Landsat etc.) to derive long-term trends of changes. Relevance for Grassland was specifically mentioned (Annex 1.d); Operationalization of full time series analysis (calibration between different historical image sources) would be desired (Langanke (KO), 2017). It is understood that archive image data are only available with reduced temporal frequency (as compared to Sentinel-2), and that the spatial resolution is in some cases lower (e.g., 30m in the case of Landsat), which may necessitate a stronger temporal integration of years into historic reference year, and accordingly larger reference year time steps.
- Ensuring backward compatibility of HRL time series: compatibility could be established by transformation possibilities, especially in view of time series for change monitoring (Langanke, 2017). Also the evolving spatial resolution needs to be considered, particularly for the change products.
- Harmonisation & product information: A better harmonisation and streamlining between the global and pan-European components has been a perceived necessity. This should lead to a situation where users are fully clear about the differences and commonalities of the respective products and the respective evolutions to be expected (Annex 1.a).
- New data model: from mapping & classification to separate land cover and land use components and attribution: e.g. along the EAGLE data model, or the national example of the Land Information System Austria (LISA) approach – which is based on public domain software such as QGIS plugins (Annex 1.i). The EAGLE model will be operationally implemented for the first time with the CLC+ Backbone product from 2020 onwards.
- Well documented methods and workflows: Provision of detailed product specifications (Annex 1.j); where possible with freely available open source scripts/tools (Langanke, 2017).
- Cartographic visualisation: a more sophisticated product presentation and visualisation in an online viewer and/or enhanced CLMS portal with improved exploration and data manipulation functionalities would be of high value for users (Annex 1.a; Annex 1.d; Annex 1.f; Annex 1.g; Annex 1.h), see also section 2.3.2.3 on “Cross-cutting Services” and on 2.3.3 “Infrastructure”.

Specific evolution requirements related to the **HRL Grassland** specifications have been additionally raised (Annex 1.d; Annex 1.c; and Annex 1.i):

- Phenology/Seasonal Information: Seasonal instead of static information has be requested in many occasions. Particularly Phenology parameters, e.g. the timing and frequency of (i) changes or (ii) cutting/grazing would be of relevance (Annex 1.d).
- Use Intensity: Grassland information should include the management practice, such as intensive/extensive use (Annex 1.c).
- Update frequency and temporal interval: In terms of temporal changes/losses, a yearly update that would allow to quantify areas and changes, including a cartographic visualization would be desired (Annex 1.d; Annex 2.i).
- Longer time series: not only reaching into the future (starting with the Sentinels ~2015) – but going back to the past. A yearly change would not necessarily be required, but a trend/tendency

towards pan-European/regional changes/losses would be of value (Annex 1.d), e.g. going back to 1990 or even further.

- Nomenclature (Annex 1.d; Annex 2.i):
  - Separation between grassland and cropland (+ change/conversion);
  - Separation between (i) species-rich (extensively used) and therefore relevant for biodiversity and (ii) species-poor (intensively used) and managed grassland (+change/conversion);
  - A differentiation amongst different types of species-rich grassland habitats, based on land use type, altitude and latitude, hydrology, geology and soil quality (although it is recognised that this probably is an unreachable objective unless in a dedicated downstream service);
  - IPCC conformity – which requires at least adding a HRL Crops to the family of HRLs;
- Identification of pressures on grassland areas in terms of:
  - intensification (i.e. increased fertilisation and earlier/more frequent mowing or grazing) (Annex 2.g);
  - extensification (i.e. the opposite trend);
  - abandonment (e.g. shrub encroachment due to lack of grazing or mowing management);
  - transformation (i.e. into cropland or other non-grassland land uses, e.g. infrastructure).
- In-situ data: There would be an identified improvement potential through the use of LPIS data which are currently mostly not openly available (Annex 1.i, Annex 1.n), which is limiting achievable product contents/details.
- Combinations: Use of different parameter combinations to derive intensive/extensive management of grassland/forest, for large-area trends in the EU (Annex 1.e).

Desired specific evolution requests for the **HRL Forest** specifications comprise: Tree species (shifts between extensive and intensive management, loss of habitats); Texture (tree rows, shapes) (Annex 1.e; Löffler, 2016), or identification of plantation forests vs. other types (Annex 1.d). As an accompanying measure under the forest theme, a general (improvement of) cooperation with *National Forest Inventories (NFIs)* and/or the European Network of Forest Inventories (ENFIN) for product validation purposes was recommended (Annex 1.e), which is already piloted or carried out in some European regions (e.g. Sweden, Baden Württemberg in Germany). Satellite-based spatially explicit monitoring products (from Copernicus) could (at least in parts) be validated by the NFIs through their ground measurement data, even if the respective data sources as such are not made available publically or for the service (Annex 1.e). However, the typically only 10-yearly NFI observation intervals are a limiting factor. Further technical specifications desired by the users/stakeholders are yearly updates of both status and change layers (Annex 2.i).

Regarding the **HRL IMP**, it was stated that in view of the European Settlement Map (ESM) produced by JRC and available for the year 2012, a comparable HRL product with 10m spatial resolution and 3-year update (or better; Annex 2.h; NEXTSPACE User Study, 2018) frequency would be interesting in case it becomes operational/will be regularly updated (Annex 1.g). Purely as per its definition, the ESM actually could be a subset (building identification) of the HRL IMD (all sealed surfaces). The inclusion of a "Built-Up area" product in the HRL Imperviousness 2018 specifications can probably be understood in that sense. One further observation was that the improvement of the HRL IMP product to better match with statistical data in industrial and traffic areas would be appreciated (Annex 1.f), and that the legend information should be consistent/transferable to CLC and MAES (Annex 1.f).

The **HRLs Water/Wetness 2015** and **Wetlands 2012** are of interest in terms of service evolution as well (Annex 1.d; Annex 1.f). Potential enlargement of the product's scope might be towards 'real' wetland identification, biodiversity and soil protection in the future. Further parameters such as water quality (pesticides, hot spot areas) or flood mapping were pointed out (Annex 1.g).

The **CORINE Land Cover** specifications are moving towards higher spatial resolution with **CLC+**: from 25 to 0.5 ha MMU (Annex 1.a; Copernicus User Forum, 2017, CLC+ ITT) which would address the desired specifications of several users (Annex 2.c; Annex 2.e; Annex 2.g; Annex 2.i; Annex 2.j; Annex 2.k). The new CLC+ nomenclature is foreseen to be closely aligned to the EAGLE concept (as requested by some users, cf. e.g. Annex 2.e; Annex 2.g), so that CLC+ will feature the first implementation of the EAGLE matrix model on an operational level (Langanke, 2017; Copernicus User Forum, 2017; Dufourmont and Langanke, 2015), while allowing the continuation of a CLC Legacy product.

The challenging aspect was raised that CLC+ shall be harmonized with the Local Component products, and duplication of work with respect to Local Component products shall be avoided (Annex 1.a). The question was raised if the HRLs and the CLC+ product should complement each other, should be produced in parallel, and if the two products contain partially the same information (Annex 1.h). Preferentially, the whole portfolio should be complementary, easy to understand, and usable in combination (Annex 1.a). The opinions on update frequency differ from 6 years (as in case of CLC) over 3 years (Annex 2.c; Annex 2.e; Annex 2.g) to annual updates (Annex 2.i). In terms of thematic accuracy, the expectation is between 85% and >90% overall accuracy (Annex 2.e). It would be appreciated if the results of the accuracy assessment were published per country (Annex 2.e).

Regarding the pan-European **Image Mosaics** it was suggested to include NIR/SWIR spectral bands in the future (Annex 2.a).

#### GLOBAL COMPONENT

In terms of specifications for the Global Component – **Biophysical variables,** the current portfolio of the Global Component is foreseen to remain stable (Annex 1.b), but be extended to additional data sources. Processing chains have been adapted from PROBA-V to Sentinel-3, and calibration between sensors and the development of a long time series is also regarded a priority.

#### LOCAL COMPONENT

In **general**, future Local Component products are expected to ensure that no duplications with a future CLC+ will occur (see above), that geometry and thematic consistency between products is realised and more detailed classes/different classes will be established (Annex 1.a).

For the upcoming updates of the **Urban Atlas** it is partially wished to increase the update frequency (Annex 2.f).

Ideally, more timely information of the **Natura 2000** product (e.g. from the past year) would be desirable (Annex 1.d). The limitations caused by the data situation of current Europe-wide VHR image coverages – as well as quality constraints of VHR image coverages are recognised.

### 3.3.2 Definition of New Services/Products

This sections provides an overview of the collected technical specifications for desired/envisaged new services and products. The most frequently requested new service were a pan-European Agricultural (HRL Crops) product, followed by a pan-European HR Phenology Layer.

**PAN-EUROPEAN COMPONENT:**

There was a consensus on the most needed new service being an **Agricultural Service** (Annex 1.a; Annex 1.c; Annex 1.d; Annex 1.f; Annex 1.g; Annex 1.j; JRC, 2016; Langanke, 2017) which shall include crop area and types status and monitoring within the pan-European Component. In Annex 1.a it is further noted that there are multiple possible policy contexts related to a future Agricultural Service, which were expected to strongly influence the definition of the future service(s): Greening the CAP, LULUCF reporting for the Climate Change and Energy Union (forest/carbon fluxes, biofuel crops, grassland etc…), SDG indicators, or Land accounting - ecosystem services monitoring (more details in section 2.1.2).

Case studies based on Sentinel data exist that have monitored a large number of crop types. They are, however, altogether highly dependent on dense field data, and might not work in case of limited in-situ data availability and in countries with small field sizes and diverse agricultural practices, or be not feasible for a continental scale implementation (Annex 1.a). In that context, LPIS or IACS/InVeKoS data would be very useful (Annex 1.f, Annex 2.i), but are currently restricted in their accessibility (Annex 1.f). Specifically a connection with the Integrated Agricultural Control System (IACS) would be of value, i.e. for setting up a digital dossier of a farm, and collect information at farm level through GSAA (Geospatial Aid Application). The IACS is at the core of CAP implementation in Europe, and JRC provides methods and technical guidance in support of this implementation (Annex 1.c).

There have been many related controversial discussions by the relevant stakeholders over these topics over the past years, but finally, the latest Copernicus Work Programme foresees a new High Resolution Layer (HRL) Crops, comprising a crop masks and discriminating major groups of crop types. This is expected to be operationally implemented from 2020 onwards (although not clear yet, whether for the reference year 2018 or 2021) and support, amongst others, reporting on Land Use, Land Use Change and Forestry (LULUCF). It should be mentioned that there are also further-reaching user requirements, requesting e.g. estimations of biomass & yield (Annex 1.g).

A further multiple need has been voiced for a **Phenology product** as a potentially new pan-European layer (Annex 1.a; Annex 1.i; Annex 1.j; Copernicus User Forum, 2017). The plans from EEA for an implementation have been realised in early 2019 with the ITT for the HR Vegetation Phenology and Productivity that was closed end of May. Previous in-house studies at EEA and at JRC (Annex 1.a) led to the published specifications such as a specific set of vegetation indices to be derived as well as phenological and productivity parameters. The need for a plant phenology index (PPI) has been raised, using medium to high resolution data (Annex 1.i). The procurement process has only concluded in Dec. 2019, and operational implementation is expected to start in the course of 2020.

Regarding a HR pan-European **Snow and Ice Monitoring Service** (Annex 1.a; Dufourmont and Langanke, 2015; Breger and Bamps, 2015), the specifications of this Sentinel-2 based operational service were published as part of the respective first ITT in December 2018. In April 2019, a respective service contract has been signed. This will be complemented by another, Sentinel-1 based monitoring component, which has being tendered by the EEA in late 2019.

Further potential pan-European products of interest, which to date have not been planned as a Copernicus Land service or Layer, have been mentioned once or twice:

There have been some general requests to provide more support to the monitoring of **natural habitats**, although there is a recognition that satellite imagery may only provide part of the information required

(Annex 1.d; Annex 1.i; Annex 1.j; Annex 2.d). No such service seems to be planned at the moment. Also a **Soil Layer** was mentioned once (Annex 1.h), as well as one on **Essential Climate Variables** (Annex 1.j).

**GLOBAL COMPONENT:**

The focus is expected to be on stabilisation of the **current product portfolio** and implementation to full operations, including transitions to the full use of Sentinel instruments (Copernicus User Forum, 2017).

The emphasis will be on additional Analysis Ready Data Layers, building on initial global mosaics, which will potentially result in new thematic products, e.g. on **Forest, Water**, or **Imperviousness (human settlement mapping (GHSL))** which are potentially foreseen for the Global Component evolution. These thematic products will follow a similar approach as the pan-European HRLs and could be developed by JRC and rolled out to operational service provision once consolidated (Annex 1.b; Copernicus User Forum, 2017), as part of the Global Component. The common denominator is that the products should be based on high spatial resolution data from Sentinel-2, for which there are some thematic precursor projects existing: The current GHSL product (GHSL, 2017) produced by JRC is the most advanced product; the recently produced Water product (Pekel et al., 2016; Global Surface Water Explorer, 2017) is based on the Landsat archive processed with Google Earth Engine; for the Forest product a similar approach as for the Water product is planned.

A Copernicus Emergency Management Service (EMS) **Drought Observatory** was communicated as future service, with potential **synergies with the Copernicus Land service** (e.g.: ECVs, water surface) or the Copernicus Climate Change service. Monitoring and forecasting of droughts shall be performed in terms of **European** and **global** early warning. The service will be based on satellite data, hydro-meteorological modelling and in-situ observations. Satellite data play a key role for monitoring vegetation stress, soil moisture and land surface temperatures. The combination of different indicators is expected to provide decision support to policy makers and different economic sectors (Copernicus User Forum, 2017).

An upcoming evolution of the existing **Hot Spot Monitoring** of the Global Component is described in section 3.3.1.1, as it is considered a thematic extension rather than a fully new service element.

**LOCAL COMPONENT**

Interest in a new **Coastal Zones** product was raised several times (Annex 1.a; Annex 1.d; Annex 1.e; Copernicus User Forum, 2017). This new service is foreseen to provide a link between the Copernicus Land and Marine Services. An initial workshop was already conducted in December 2016, followed by a second workshop (http://workshop.copernicus.eu/coastal) on 29 June 2017 (Annex 1.a). The Coastal Zone service has become part of the Local Component (Annex 1.a; Copernicus User Forum, 2017; Dufourmont and Langanke, 2015; Breger and Bamps, 2015) meanwhile, as in December 2018 the ITT for operational service provision had been published. It will produce VHR land cover/land use information for the reference years 2012 and 2018 within a 10 km buffer zone along the EEA-39 coastline. The production started in March 2019 and is foreseen to be finished in December 2020.

### 3.3.3 Cross-cutting Services

Although not scope of the development work undertaken in ECoLaSS, this section on cross-cutting services summarises the requirements captured from stakeholders in terms of future generic cross-cutting services. These comprise the users' wishes to:

- share common transverse activities across the Local, pan-European and Reference Data/in-situ Components (such as the ongoing GIO/Copernicus Land Monitoring Service for Validation of products of the Continental and Local Components including in-situ Data);

- provide a link to the Copernicus In-situ Component (such as the ongoing services supporting the EEA's implementation of the cross-cutting activities for coordination of the Copernicus in-situ component);
- strengthen the link to the user community (such as the ongoing EC/DG GROW User Uptake initiatives), the Copernicus Relays and Copernicus Academies;
- provide overarching generic technical support/visualisation/data processing services.

Amongst others, **Harmonization of Local, pan-European and Global Component** product boundaries was mentioned as a way forward in terms of cross-cutting activities between the different CLMS Components (Annex 1.a).

A dedicated cross-cutting service addressing a gap in the **visualization, presentation and communication** of Copernicus Land data was proposed by some users (Annex 1.d; Annex 1.a; Annex 1.f; Annex 1.g; Annex 1.h). Particularly DG ENV emphasised that there should be a focus on provision of information in a way which is understandable and immediately usable for multiple users (cf. Annex 1.d), i.e.:

- A cartographic visualization tool/viewer including zoomable information layers and enabling the overlay of different products on top of each other would enhance and simplify the use of Copernicus products (Annex 1.d; Annex 1.h). Non-intuitive data visualisation/presentation is an obstacle for many uses (not the data formats itself). Additionally, a better GUI, cartographic presentation and visualization would improve the usability (Annex 1.f).
- More customised presentation and visualization in terms of obtainable statistical analyses, diagrams and dashboards would be of value for users, also without downloading the products. According to some users, online visualization and deduction of statistics is actually seen more important than data download, and might enable the use of Copernicus data also for users that usually do not work with geographic data formats (Annex 1.d). E.g. in current public forest reporting systems, there is a large amount of information displayed as tables, numbers, data, figures etc. Coherent thematic maps would make a big difference for comprehensive visualization of forest information (Annex 1.e).
- In case a large number of thematic CLMS products from time series will be available in the future, a timeline visualization tool/viewer, showing the timing and frequency of existing products would be an asset (as applied for the German Collaborative Ground Segment CODE-DE, see section 2.3.3) (Annex 1.g).
- Visual identity should be coherent, and complexity should be optimized for ease of use by policy makers (e.g., thematic maps, figures and tables) (Annex 1.e).
- A user-targeted thematic support was requested on how to use the CLMS products, explaining targeted, meaningful combinations of different Copernicus Land products, i.e. thematic "utilisation support" to end users through definition and testing of end-use applications (Annex 1.d). This requirement has meanwhile been largely addressed through establishment of the network of Copernicus Relays and Copernicus Academies, as well as through the setup of a central Copernicus Support Office by the EC.

As a summary of the above, product/service conceptualization and description should – from the beginning – also consider applicability/usability of the service/s, as well as cartographic/statistical value-adding options (Annex 1.d). With the upcoming comprehensive update of the Copernicus Land portal, most of the above points may actually be addressed.

Another suggestion made by some users relates to "**human sensors**" (Annex 1.g). This crowd-based concept related to in-situ data collection by the use of smartphones, to take pictures for e.g. validation purposes, possibly for a little payment, by sending humans to specific points of interest. Eventually data in movement (streets, traffic...) could be additionally captured. It is acknowledged that crowd-sourcing activities might be more suitable for research projects, and that there are restrictions towards

operational products, e.g. related to reliability, product delivery, completeness, data protection aspects, etc.

The **EAGLE data model** as new (object-based) model in connection with public domain software for attribution was generally mentioned multiple times from mainly national stakeholders and users, mostly in connection with CLC+ future developments (Annex 1.a; Annex 1.f; Annex 1.g; Annex 1.h; Annex 1.i). This object oriented data model is considered a potential means for overcoming currently existing inconsistencies between various products' nomenclatures, both on Copernicus, national and international level.

### 3.3.4 Infrastructure

In terms of implementation requirements for the next-generation CLMS, the infrastructure requirements for product production, storage and data dissemination are summarised in this section.

The need for a **common access point** to CLMS services and products was repeatedly pointed out during the stakeholder interviews. Currently, Copernicus Land service products are provided through the **Copernicus Land portal** (CLMS, 2017a). EEA reported that ideally, the look and feel, and the provision of services for all the Copernicus services should be further streamlined and harmonized. It is envisaged to avoid separate and different registration procedures, and to implement consistent naming of products and availability of downloads and Web Map Services (WMS) and viewers, in a consistent way across all services (Annex 1.a; Annex 2.e; Annex 2.f).

On the other hand, it was mentioned that the usability of the current portal depends on the experience of the user – and for some users it is difficult to get CLMS data from the portal (Annex 1.f). The access on the Land Service portal is described however as being more intuitive than for e.g. the Atmosphere and Marine Service portals (Annex 1.f). For some users it would be of use if there were more options regarding the data format (e.g. vector data) (Annex 2.h).

EEA plans to continue to improve documentation (which was also mentioned as a topic to be improved, especially towards technical specifications (Annex 2.a) and validation details (Annex 2.d; Annex 2.e)) and level of professional presentation on the current Copernicus Land platform, but major changes are likely to be implemented as part of the upcoming comprehensive Copernicus Land portal update in 2020.

The **Copernicus Data and Information Access Service(s) – (C)DIAS** were multiply mentioned by European and national stakeholders (Annex 1.a; Annex 1.b; Annex 1.c; Annex 1.f). For some applications, it was mentioned that the role of the DIASes will potentially be essential for both public and private value adding services in the future (e.g. Annex 1.c). Prototypes of the DIASes had been implemented previously in the frame of several national Copernicus **Collaborative Ground Segments (CGS)**. For example, the Copernicus Data and Exploitation Platform – Deutschland (CODE-DE) (CODE-DE, 2017) was referred to by German national stakeholders (Annex 1.f; Annex 1.g). CODE-DE provides a unified access point/entry point as a start, and a similar implementation on a European level would be desirable (Annex 1.f).

Various requirements for a future service infrastructure were discussed, with the common goal to simplify the Sentinel data and Copernicus product access, make it consistent throughout products, and therefore, more user-friendly. Access via Web Map Service/Web Feature Service (WMS/WFS) has been recommended (Annex 1.g; Annex 2.a) (see section 2.3.2). A central and easy access via a portal without searching through menus was another recommendation (Annex 1.h), preferrably provided via online platforms, such as DIAS or the Copernicus Open Access Hub (previously known as Sentinels Scientific Data Hub) in case of Sentinel data (Annex 1.i). It was argued that for all the various products a common, consistent access portal would probably not be feasible, considering all the different product characteristics and user communities, but a common entry point would greatly facilitate data access (Annex 1.f). One idea was to connect the provision of satellite data and Copernicus products, eventually including Copernicus Contributing Missions (CCMs), in the same portal (Annex 1.h). Nevertheless, there

are still concerns on user side about which platform should be used out of the currently available ones and how it will be guaranteed that the respective platform is successful (Annex 2.e).

The five DIASes which have been launched in summer 2018, and have been developed significantly since, have the potential to each fulfil all the above requirements under one umbrella, and time will have to prove how far this will go. Also a potential specialisation of individual DIASes may occur. At the moment, it is impossible to predict, which of the five DIASes will in the end turn out to be best suited for supporting future CLMS data processing, storage and dissemination requirements.

# 4 Summary and Outlook

In order to contribute to a comprehensive assessment of the CLMS evolution requirements and to identify focus areas for the development of relevant improved/new products and service demonstrations, two rounds of user requirements analysis have been carried out by ECoLaSS. In project phase 1, requirements collections were conducted via phone and face-to-face interviews with relevant users and stakeholders, as well as by collecting requirements from relevant workshops, presentations and reports/studies. The interview partners were representatives of key European institutions as well as important national users and stakeholders, which are in charge of implementing or coordinating national Copernicus activities. The temporal perspective ranged from mid-term (2018) to long-term (2020+) evolution needs of the CLMS service and product portfolio. In project phase 2, the focus of the assessment was extended to national stakeholders, i.e. primarily the EIONET NRCs Land Cover and further EC DGs. Relevant CLMS related ITTs and procurement processes were carefully observed and followed, particularly during 2019. This report summarises the final and complete findings of this extended analysis. Due to the various relevant developments in the second half of 2019, it has been decided to capture the latest status until end of the project (end Dec. 2019) in this report, to provide the most up-to-date basis for potential take-up of the work by others, after the end of the ECoLaSS project.

In summary, the ECoLaSS project focused on the pan-European and Global CLMS Component aspects and therefore had to take the needs from the respective user and stakeholder community properly into account. The highest need for evolution of existing services and for next-generation new services was recognised for the pan-European Copernicus products, i.e. for the High Resolution Layers (HRLs): towards qualitative and timely improvements, and for CORINE Land Cover (CLC): towards significantly higher information content and spatial detail through CLC+. Requirements for the Global CLMS Component were collected mainly from key representatives of the Joint Research Centre's relevant thematic units, and further available documentation. The highest interest in products of the Local CLMS Component was typically shown by national (and sub-national) users, since the higher spatial resolution of the products is generally better fulfilling the needs on a national and regional level. Besides the extensive portfolio of CLMS products, there is a generally also high interest in Copernicus (Sentinel) satellite data themselves for own investigation purposes, which was repeatedly raised by several users.

Detailed analyses of respective new/updated product specifications have been provided in section 3.3, and are therefore not repeated in detail here. Nevertheless, there are a few key aspects to be highlighted: In terms of future service specifications, a general requirement for shorter update frequencies (i.e. through incremental updates) were mentioned throughout. Concerning new services, a particular need for a pan-European Agricultural Service (such as a HRL Crops), a further Grassland characterization (e.g. in terms of management intensity), an evolution of CORINE Land Cover towards CLC+ as well as a HR Phenology Layer and Coastal Zones monitoring were the most frequently recorded responses. Meanwhile, the latter three have become or are about to become part of the operational CLMS portfolio. A certain trend is further recognised towards more generic products and services being requested.

While on the one hand it was observed that, technical issues and limitations of the CLMS products' (satellite and other) input data, as well as the actual methods for generation of the products are not of major concern to the users, on the other hand it was also found that (depending on the individual user) the knowledge of specifications of the existing products is in general still rather limited. Requests for establishing mechanisms enabling to obtain more information on the products and metadata were brought up several times. Additionally, a general requirement for an easier and standardized access to data, products and documentation, on a unified access portal, was repeatedly stated, including the desire for a multi-layer online visualization and/or evaluation tool for the products. The users are generally willing to use the DIASes but they experience a lack of information on the exact capabilities and relative advantages of each platform, so that they could better decide which platform to use.

More frequent and incremental updates are already a key aspect of the developments addressed in ECoLaSS. A detailed analysis on the most suitable update time steps for the HRLs, which was voiced by

several users/stakeholders, has been conducted within the *WP 35: Time Series Consistency for HRL Product (incremental) Updates*. The first results of the development of an Agricultural Service prototype have been described in the specific *WP 44: Crop Area and Crop Status/Parameters Monitoring*. Taking into account the technical specifications voiced especially in the first round of this requirements assessment, the consortium has been refining the second round of prototypes, which have been finished in December 2019. A range of further new products/services has been addressed in the frame of *WP 45: New LC/LU products*, where not only a CLC-related prototype has been created, but also a layer combining the HRLs 2015 with a HR Crop prototype Layer as developed by ECoLaSS, in order to analyse the Layers' consistency, which was also one of the concerns on user's/stakeholder's side, with convincing results. Retrieval of phenological parameters has been among the key methods developed in *WP 41: Time-series derived Indicators & Variables*, which has been partly in line with the recently awarded new CLMS operational service for the HR Vegetation Phenology and Productivity.

Improvements of existing CLMS products such as HRL Grassland have been addressed as a core topic in *WP 43: Improved Permanent Grassland Identification.* In the second project phase, the number of investigated prototype Layers has been extended beyond an improved status layer on Grassland, i.e. additional focus has been put on demonstrating a Grassland Use Intensity product, which had been widely requested as a significant improvement of the service.

The results of the analyses undertaken in the present report show that basically all activities planned and undertaken by ECoLaSS largely concurred with the perception and core requirements of the key users and stakeholders in terms of future Copernicus Land service evolution, and several of the ECoLaSS developments have been migrating to operational implementation during the project's lifetime. The rich pool of further recommendations collected from the users and key stakeholders was thoroughly analysed, and constituted the basis for integrating some further aspects into the ECoLaSS developments in Tasks 3 and 4 as far as feasible.

The present report is further deemed a valuable source of reference also for other activities and developments beyond the scope and possibilities of the ECoLaSS project.

It should be noted that at the beginning of the ECoLaSS project in early 2017, there had been a perception among some key users and stakeholders, that scientific testing and selection processes had not always been applied rigorously for all past HRL products, and some unconsolidated products were released (particularly in view of some HRLs 2012). Therefore, the ECoLaSS project with its approach of systematic user requirements assessment and stakeholder interaction, new products design and testing, prototypical demonstration and benchmarking, has been widely appreciated. In that sense, a continued close interaction between users, R&D projects and service providers (as has been the case in ECoLaSS) is seen as very useful, especially in order to make the best out of the exciting upcoming CLMS products and services.

The following non-public Annexes 1+2 additionally provide detailed records of all conducted stakeholder/ user interviews, allowing to further analyse individual, specific requirements as needed, at a later stage.

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