INTERNATIONAL WORKSHOP ON EARTH OBSERVATION FOR SEEA COMPLIANT NATURAL CAPITAL ACCOUNTING

Version 1

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esa

Content of the Presentation

- Intro - Development of the Roadmap
  - Objectives of the Roadmap
  - Process
  - Objectives of the session
- Discussions per account (30’ each)
  1. Extent accounting
  2. Condition accounts
  3. Services accounts
  4. Technicalities & Criteria for prioritization

➢ For the section on thematic accounts, we request written comments

Development of the Roadmap

Main objective of the project is to study the relevance of Earth observations for SEEA compliant natural capital accounting and to demonstrate the value of EO data for compiling SEEA EA accounts of terrestrial and freshwater ecosystems.

The Roadmap **assesses the adequacy of EO data from a technical, institutional, and economic perspective** to respond to the accounting needs of the Early Adopters, and identify areas that still need further development.

The roadmap is **not limited to the demonstrator accounts** but aims to define a broader research agenda to tackle the critical areas to integrate Earth Observation for ecosystem accounting.

It **serves as input** for the European Space Agency, as well as potential use by European Institutes, UNSD SEEA Ecosystem Accounting Technical Committee and Group of EarthObservation (GEO).

Tests to be conducted during the PEOPE EA project

- This would be done in a users' workshop, one in each country
- Based on the following criteria.

Indicator	Applicability across ecosystem types	Relevance to national priorities	Relevance for the Eurostat legal proposal	Possibility to assess uncertainty	Other indicators to be proposed by stakeholders
Ecosystem extent					
Artificial impervious area in coastal zone					
Forest condition					
Global climate regulation,					
Wood provisioning,					
Recreation infrastructure					

Process followed to develop the Roadmap

1. Parallel process
2. A draft Roadmap has been prepared by the Consortium
3. This draft Roadmap and its elements are being discussed in the symposium of May 2024
4. Written comments can be provided until 30 June 2024
5. A final roadmap will be prepared in August 2024.

Key questions for discussion (organized by account):

- Are the priorities for further developing EO data into account-ready datasets well identified?
- Are we missing priorities?
- How can ongoing programs and efforts be leveraged?
- Will there be a need to update the Roadmap based on learnings from the project?

New developments in the field

- Policy and institutional context
  - EU is preparing legislation to make SEEA EA accounts mandatory in the EU (24 out of 27 MS):
    - Extent (following EU extent typology);
    - Condition (9 condition indicators for 6 ecosystem types);
    - 7 Ecosystem services
  - Other international organisations exploring/testing use of SEEA EA as tool to analyse or report data – in combination with EO data (e.g., FAO, IFAD, OECD)
  - Many national statistical offices testing SEEA EA and reporting accounts
  - Continued interest from private sector

Table 1. Condition indicators included in the EU legal proposal.

Ecosystem type	indicator
settlements and other artificial areas	m^2 green areas per inhabitant
	Concentration of particulate matter with a diameter up to 2.5 µm or 10 µm to be reported in $\mu g/m^3$ as a national average for the reporting period
croplands	Soil organic carbon content in topsoil shall be reported in tonne/ha, as a national average for the reporting period
grasslands	Soil organic carbon content in topsoil shall be reported in tonne/ha, as a national average for the reporting period
croplands and grasslands together	Common farmland bird index shall be reported as a national aggregate index for the reporting period
forests and woodlands	Dead wood shall be reported in m^3/ha, as a national average for the reporting period
	Tree cover density shall be reported in %, as a national average for the reporting period
	Common forest bird index shall be reported as a national aggregate index for the reporting period
Coastal wetlands, beaches, and dunes	Artificial impervious area cover shall be reported in %, as a national average for the reporting period

Services included in EU legal proposal
- Crop provisioning
- Timber provisioning
- Global climate regulation
- Local climate regulation
- Pollination
- Air filtration
- Recreation

New developments in the field

- Technical progress and data availability
  - Jaxa has made ALOS PALSAR data available
  - CCI5 dataset of AGC released
  - NISAR and BIOMASS satellites will greatly enhance opportunities to map biomass and AGC
  - Discussions on CORINE land cover mapping program ongoing
  - New datasets on land cover (World Cover, 6 classes, 10m resolution;)
  - New open access databases being published and expanded (e.g. FAO WAPOR, OpenLandMap / OpenGeoHub)
  - VITO has published INCA version 2.0 with models for 9 ecosystem services in the EU, aligned with the guidelines being prepared in support of the EU legal proposal.

General considerations for the discussion

- Every continent / ecosystem type has specific challenges and priorities
  - Differences EU typology and IUCN Global Ecosystem Typology
- Connecting EO data to the accounts, and subsequently to the user is key;
- A suit of models are needed – some of these models are fairly complex; ARIES for EA is a helpful tool including in countries that lack their own capacity to develop accounts;
- EO data need to be made available preferably annually;
- EO data need to be provided with consistent methodologies, with explained accuracies;
- EO data need to be made available over a long-term.

➢ MORE considerations to be discussed in the session by account..

Extent accounts

Opportunities

- Many countries and organisations have done a lot of excellent work (at EU and country level). We need to capitalize for rapid progress.
- In Europe, the EU Biodiversity strategy to 2030 will enhance the speed and breadth of work in this field; this also needs to be explored by other jurisdictions. Giving access to the lessons learned to non-EU countries would help.
- The community aware of the benefits and requirements of ecosystem accounting is growing. This growing community can be leveraged to generate appropriate results exponentially
- Artificial Intelligence (AI) techniques enable and improve the delineation of ecosystems. Approaches need to be combined in a hybrid way with the many existing high quality global products.

Challenges

- Cross walking suggested international typologies with national ones is required but complicated. Ontologies are required;
- Accessing in situ data is required, but currently represent a major data gaps. Standardize in situ data to support the EO is limited;
- Satellite Earth observation (incl. Analysis Ready Data) are generally not immediately fit for the purpose for ecosystem accounting. We need Ecosystem Accounting Ready Data (EARD).
- The complexity of aiming for the IUCN GET-3 may be a barrier for entry-level ecosystem account compilers;
- Measuring the extent of ecosystems requires measuring its change over time. A challenge given the evolution of sensors;
- Measurements of EO spatial accuracy over time is an issue when compiling accounts.

Recommendations

1. Identify means and levers to invest further in compiling auxiliary and in situ data for validation and enhancement; is an international inventory (and repository) of validation data worth exploring?
2. Continue to share experiences (via #EO4EA) to better understand which methods and data sources work best for which ecosystem types and propose harmonization processes ;
3. Organise virtual workshops dedicated to ecosystem extent accounts to explore data models, data sources, platforms that are currently used, so that practitioners can access best practices. Produce and maintain an evergreen methodological guide following these workshops;
4. The need for EARD is shared by every ecosystem accountant. We should move from have national data cube to global ones. Create a Digital Earth Gaia?
5. Support GEO proposal to build a coordinated and collaborative Global Ecosystem Atlas

Conclusions of EO4EA 2022 workshop on ecosystem extent account (credit ESA)

Priorities identified in the RoadMap

Table 4. R&D priorities for extent accounts

Ecosystem type	R&D priority	Comments
All ecosystems	Use of (or generation of) value-added products as Essential Biodiversity Variables	
	Combining data from different types of sensors	
	Improve the availability (quantity and quality) of reference data for training and validation	Integration of local in-situ data is important, but also need to ensure the datasets are validated and outliers are to be removed
	Disentangle ecosystem condition factors to improve the delineation of ecosystems	
	Deal with difference in spatial scale amongst ecosystem types	Urban ecosystems require a resolution sub-10m, while forest ecosystems are to be characterized at 100m or above
	Handle robust detection of change and quantify their accuracies	Focus first on abrupt changes, thereafter, disentangle ecosystem condition to characterize gradual changes
	Deal with varying capacities amongst countries, and ensure that countries have ownership	
	Enable comparability across countries despite different typologies	
Tropical-subtropical forests		
Temperate-boreal forests and woodlands		
Shrubland and shrubby woodlands	Integrate fire regimes and water deficits	
Savannas and grasslands	Integrate fire and climate data to distinguish different savanna types (dry, moist, pyrrhic, trophic).	
Deserts and semi-deserts biomes	Integrate probability of fog information to distinguish cold and hot deserts	
Polar/alpine (cryogenic) biomes		
Intensive land-use biome	Integration of higher resolution EO datasets and use of object based segmentation	
Rivers and streams	Apply new multi-sensor methodologies to distinguish linear features	
Lakes		
Artificial wetlands		
Palustrine wetlands		
Shorelines		
Tidal biomes		

Questions for discussion

- Are we missing R&D priorities?
- What level of ecological disaggregation needed (intensive land use – cropland – perennial cropland – olive groves)
- How to align global typology (IUCN GET) with continental and national classification systems?
- How to build upon existing efforts?
- How to ensure long-term funding? should this be done globally?
- Who should coordinate?

Ecosystem type	R&D priority
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Condition accounts

Opportunities

- Continuous stream of EO data, large coverage, new upcoming features (e.g. Hyperspectral)
- Large experience to use EO/models to monitor health of ecosystems (e.g. RS-indices)
- Multidimensional integration, big data techniques
- Modelling approaches for ecological relevant variables

Challenges

- Frequency of temporal updates of key dataset, limited spatial details for some ET
- Different characteristics in time-series, complex pre-processing
- Sufficient & regularly updated in-situ points to generate accurate variables
- Limited cases / experiences in condition accounts, many variables
- Definition of reference conditions (undisturbed)

Recommendations

1. Identify (select) and Develop (methods) ‘default’ set of RS-ECT variables. Connect communities.
2. Define required ‘regularly updated’ datasets (EO/UAV & in-situ/IoT), incl. features and limitations
3. Provide ‘standardized’ tools to ease operationalization accounts (fit4purpose), regular updates of time-series
4. Speed-up efforts on biodiversity variables (in-situ, models and integration of EO – ML/AI)
5. Transparency: Statistical testing (validation) & handling of errors (propagate & uncertainty layers)
6. Study integration of accounts in decision and policy making (property landowners)

Conclusions of EO4EA 2022 workshop on ecosystem condition account (credit ESA)

Condition account priorities Roadmap

Table 5. R&D priorities for condition accounts

Ecosystem type	R&D priority	Comments
All ecosystems	Selection/definition of key indicator(s) per ecosystem condition typology per ecosystem type	Needs to be aligned with policy initiatives including GBF Deal with scalability for each Tier (global, national, regional, local)
Tropical-subtropical forests	Selection of a set of key indicators that may include level of past disturbance (e.g. logging history), fragmentation, productivity (NPP), fire occurrence, diversity of tree species, standing biomass.	Many indicators (e.g. NPP) are routinely derived from EO data already, others can be derived using established procedures (e.g. fragmentation). There is however a need to better understand the occurrence of peatlands in these ecosystems. Also, the analyses of standing biomass need to be enhanced, especially for high biomass, old growth forests.
Temperate-boreal forests and woodlands	Selection of a set of key indicators that may include level of past disturbance (e.g. logging history), fragmentation, productivity (NPP), fire occurrence, diversity of tree species, length of growing season	Many indicators (e.g. NPP) are routinely derived from EO data already, others can be derived using established procedures (e.g. fragmentation). There is however a need to better understand the occurrence of peatlands in these ecosystems.
Shrubland and shrubby woodlands	Selection of a set of key indicators that may include level of past disturbance (e.g. fire), productivity (NPP), diversity	
Savannas and grasslands	Selection of a set of key indicators that may include Rain-use efficiency (in semi-arid and sub-humid grasslands), soil cover (throughout the year), productivity (NPP), water stress (NDWI)	
Deserts and semi-deserts biomes	Selection of a set of key indicators that may include Rain-use efficiency, soil cover (throughout the year), productivity (NPP), water stress (NDWI)	
Polar/alpine (cryogenic) biomes	Selection of a set of key indicators that may include NPP, length of growing season, standing biomass.	There is a need to better understand the occurrence of peatlands in these ecosystems

Condition account priorities Roadmap - continued

<table>
<tr><td>Intensive land-use biome</td><td>A key challenge here is dealing with the often fragmented land use including mosaics of croplands, meadows and more natural patches of vegetation. Grouping these in a class ‘mosaic intensive land use’ is helpful and may be the only practical way forward, but it hides potential large differences within such a class. Hence, condition indicators for such a mosaic class need to indicate proportions of natural versus managed land, as well as indicators for productivity (NPP), water stress (NDWI) and potentially irrigation water use.</td><td></td></tr>
<tr><td>Urban ecosystems</td><td>Detection of green spaces, tree lines, and PM concentrations (with PM concentration being an input for the modelling of the air filtration service as well as an indicator for human health (but not necessarily linked to ecosystem in a country since PM emissions result from industry, traffic and domestic wood burning).</td><td></td></tr>
<tr><td>Rivers and streams</td><td rowspan="6">For wetlands, with the presence of vegetation, a range of indicators have been proposed that need further testing such as indicators for water stress (NDWI), productivity (NPP) and diversity of flora. To date, less thought has been given to identify condition indicators for water-ecosystems such as rivers, lakes, and coastal zones. It needs to be examined if indicators can be developed into account-ready indicators that indicate water levels/streamflows as well as water quality such as algae blooms.</td><td></td></tr>
<tr><td>Lakes</td><td></td></tr>
<tr><td>Artificial wetlands</td><td></td></tr>
<tr><td>Palustrine wetlands</td><td></td></tr>
<tr><td>Shorelines</td><td></td></tr>
<tr><td>Tidal biomes</td><td></td></tr>
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Condition account priorities - questions

- Are these the correct priorities?
- Are we missing priorities?
- Do they adequately represent priorities across the globe?
- How to obtain field data for calibration and validation?
- How to ensure consistency of models and account ready datasets?

Ecosystem services priorities

Opportunities

- Acknowledging substantial developments for EO data-based ecosystem services mapping, assessment and accounting (INCA tool, ARIES model, LANCE).
- EO data availability in suitable spatial, temporal and thematic resolution depends on continents/countries.

Challenges

- The development and operationalisation of many ecosystem services are still in their infancy.
- Large majority of ecosystem services (especially regulating and provisioning ES) can be analysed by EO data, but certain services (such as nature-based recreation) only partially.

Recommendations

- How can EO data help improving availability and comparability, particularly in developing countries?
- Potential to extend EO-based ES-related applications beyond environmental policies to economic decision-makers, insurance and finance sectors, if the right incentives (e.g. Payments for ES) are established.
- Improving engagement, communication and capacity building/training of users of EO-based accounts.

Conclusions of EO4EA 2022 workshop on ecosystem services account (credit ESA)

Services account priorities - Roadmap

Table 6. R&D priorities for ecosystem service accounts

Service	R&D priority
1. Provisioning services	
Crop	Maps of crops, annually updated, would be of high interest to support implementation of the European legal module on SEEA EA accounting.
Wood	At the point that AGB estimated become accurate enough to be interpreted in individual parcels, EO data can be used to estimate wood harvests, either through clearcut and/or selective harvesting.
Non-timber forest products	EO data could be used as a proxy for some services (wild animals, plants, etc.).
Livestock / grazed biomass	Rangeland productivity, seasonal or annually, would be required to link to livestock statistics. EO data can be used to estimate this productivity, although mowing is more easy to detect than grazing.
Aquaculture	To be further investigated if and how EO data can contribute.
....	
2. Regulating services	
Global climate regulation (carbon)	Integrating radar data, from the upcoming NISAR and BIOMASS satellites in order to enhance estimates of AGB including dealing with saturation effect
	Enhancing the models of SOC, root-shoot ratios, litter and deadwood in order to have wall-to-wall carbon stock maps
Rainfall maintenance	Enhancing models of the service based on EO data and AI algorithms to establish the functioning of this highly important but as yet not sufficiently understood service
	Integrating this service into SEEA EA accounts (since no case studies exit yet)
	Monetary valuation of the service (which requires complex modelling of the linkages between rainfall patterns and water use including for rainfed and irrigated cropping.
Water regulation	Modelling the effect of vegetation on water flows is time consuming and data intensive, requiring hydrological models such as SWAT. EO data cannot solve this issue, but EO data can be used in potential new AI driven models that aim to establish the water regulation service of forests. However, this is to date a not proven approach, and it is recommended to wait until further modelling efforts in this direction are published.
Flood control	EO data can assess the amount (length, density, width) of vegetation that is present in buffer zones along the coast (e.g., mangroves) or rivers (riparian forest). When this information is combined with bathymetry/elevation data, the flood control service can be derived. However, a challenge at present is that the globally available DEMs are relatively course, both horizontally and vertically). A more accurate global DEM would allow more accurate modelling of this service

Services account priorities Roadmap - continued

Service	R&D priority
Local climate regulation	EO data depicting small scale urban greenspaces including lines of trees
	Providing daily data on land surface temperature.
	Enhancing spatial models for the local climate regulation service.
Air filtration	Providing data on ground level PM2.5 concentration (as PM2.5 is a more accurate prediction of health effects than PM10), and relevant for health effects is the concentration to which people are exposed, i.e. at ground level.
	Better models of the filtration of PM2.5 by vegetation – based on wind speed, leaf area index, and resuspension of PM2.5 including calibration and validation of such models
Flood control	More accurate models, and approaches to scale up these models, of flood mitigating impacts of mangrove and riparian forests are required to facilitate incorporating this service in SEEA EA accounts. EO data is needed to understand the vegetation flood barriers itself (length, height, bathymetry/geomorphology) as well as human assets (houses, infrastructure, etc.) in the zone at risk from flooding.
Water regulation	A wide range of hydrological models is available, however scaling up from one watershed to the next is cumbersome. AI models may be developed that allow easier scaling up to analyze this service at national scale. Further testing of AI models is required.
Soil erosion and landslide mitigation	RUSLE is a basic simple approach, however more complex models that incorporate other types of erosion (landslides, gully, etc.) are also available. Several input factors as dynamic vegetation cover, but also erodibility can be derived from EO.
Coastal protection	Different models exist for various types of coastal ecosystems. The service is linked to flood control, but protection by vegetation is another important component. EO data can help detecting the vegetation type and their condition to protect coastal areas.
Pollination	Pollination models require maps of crops (so that crops requiring pollination can be identified spatially) and detailed maps of pollinator habitat including small landscape elements.
Pest and disease control	EO and climatic data can help by improving the predictions about where potential agriculture pests and diseases may be a threat. Spatial modelling techniques with EO data can also help to create special maps with risk surveillance and assessments that can be used also for vector-borne diseases.
Freshwater aquaculture services	Aquaculture can be monitored with Sentinel-1 (e.g., effect of oil pollution in terms of smoothing waves) and Sentinel-2 (e.g., color differences to detect algae blooms) or combined to mapping aquaculture facilities.
Nursery and habitat maintenance services	Ecosystem contributions necessary for sustaining populations of species that economic units ultimately use or enjoy can be expressed as the presence of suitable ecological conditions (habitats) and of species and hence evaluate the risks to which these habitats and species are exposed (hotspots at risk). EO can contribute to measure migration patterns, fragmentation, diversity, etc., which has to be complemented by other species information (e.g. genetic).

Services account priorities Roadmap - continued

Service	R&D priority
3. Cultural services	
Recreation-related	EO in combination with social media can provide spatiotemporal contributions to cultural ecosystem services
Visual amenity	EO data can measure the greenness and other landscape elements of importance, both in urban and rural areas
….	

Services account priorities - questions

- Are these the correct priorities?
- Are we missing priorities?
- Do they adequately represent priorities across the globe?
- How to obtain field data for calibration and validation?
- How to ensure (long-term) consistency of models and account ready datasets?

Technicalities & institutional

Key data management considerations

Consideration	Explanation
Interoperability	Ability of different data systems and platforms (e.g. ARIES and OpenEO) to communicate and exchange data in a consistent and meaningful way through machine2machine communication
Standardized	Set of uniform rules, formats and procedures to ensure data is consistent, accurate and easily accessible
Uncertainties	Possible deviation of the final result, the range of uncertainty indicates a confidence measure
Cost-efficient	Easy to use and low cost (price to be determined, e.g., 1 cent per km^2)
Flexibility	Integration of national or regional and non-EO datasets
Redundancy	Always on availability to the data and models
Security	Ability to replace standard datasets with national or regional datasets in a protected way, such these datasets cannot be accessed by others
…	

Key institutional considerations

Consideration	Explanation
Accuracy	Different types of accuracy apply, including spatial accuracy and thematic accuracy. Important is also to understand the accuracy of the produced maps and accounting tables derived from the maps.
Timeliness	In the EU legal framework, accounts need to be published, the latest the end of the year after the reporting year (the first reporting year will be 2026, accounts to be submitted to the EU by the end of 2027. This means that maps should be available with a time delay of at most around 6 months to allow time for account compilation and further processing.
Authoritative source	There should be quality assurance processes and the organization publishing the maps should be recognized as an authoritative data source. Potentially a technical advisory committee could support the process.
Clearly defined and transparent analytical procedures	The EO products should be developed with clear and transparent procedures; where changes are made in models or data sources, if possible, time series should also be adjusted to allow for consistent accounting over time.
Indicators aligned with SEEA EA	The SEEE EA has provided specific definitions and indicators for ecosystem services, and for seven of these (see chapter 2) these indicators have been worked out in more detail in the EU Guidance Notes published by Eurostat. These indicators should be considered when developing EO products to ensure easy uptake for account compilation.
Sustained production and consistency over time	For NSOs to engage in developing procedures to compile accounts based on EO data, it is important that they are certain that the data remains available long-term, i.e., at least a decade.
…	

Criteria for prioritization

Number	Criteria	Comments
1	Added value of EO data	Including the accuracy and timeliness that can be reached with EO data, and the presence or absence of alternative data sources
2	Policy relevance	Analyzing EO data over large areas and at high resolution requires considerable resources (time, computing power, data capacity) and priority should be given to those datasets where it is easiest to show the policy relevance
3	Feasibility of maintaining consistent time series over long time periods.	Accounting data requires consistent datasets maintained over time-period of decades. EO data that depend upon satellites that will be taken out of operation in the coming years and will not be replaced is not useful to support SEEA EA accounting
4	Representativeness / scope	Priority should be given to datasets that are relevant across a large number of countries and/or ecosystems.
5	…	