

## ARTIFICIAL INTELLIGENCE TECHNOLOGY FOR RAPID NATURAL CAPITAL ACCOUNTING: THE ARIES FOR SEEA EXPLORER

**Authors:** *Ferdinando Villa\**, *Stefano Balbi\**, *Alessio Bulckaen\**, *Amelia Ochoa\**

\* Basque Centre for Climate Change (BC3)

The System of Environmental-Economic Accounting (SEEA), the set of international environmental-economic standards adopted by the UN Statistical Commission, requires the integration of substantial and diverse data. These include geospatial and other data sources not traditionally used by National Statistical Offices (NSOs), whose use is necessary for spatial modelling, but which has proven challenging for some NSOs to implement. A variety of ecosystem service modelling platforms have been built over the last 15 years to meet various user demands<sup>1</sup>, as have numerous data viewers and dashboards, but

their development has been uncoordinated. These platforms often duplicate efforts, rely on data that are siloed, and rarely effectively reuse the knowledge gained from past modelling efforts.

In 2020, the Statistics Division of the UN Department of Economic and Social Affairs (UN DESA) and the UN Environment Programme (UNEP) began work with the Artificial Intelligence for Environment & Sustainability (ARIES) team to develop a concrete approach enabling data and model interoperability to support the compilation of natural capital accounts using

<sup>1</sup> <https://seea.un.org/ecosystem-accounting/biophysical-modelling>

## HIGHLIGHTS

- The ARIES for SEEA Explorer is an open-source and user-friendly digital tool that enables, for the first time, rapid and standardized yet customizable ecosystem accounting anywhere on Earth.
- The new tool makes it possible to compile accounts to monitor the extent and condition of ecosystems and the services they provide (in both physical and monetary terms), but its application can be extended to broader analyses focusing on environment and sustainability.
- The ARIES for SEEA Explorer can vastly accelerate implementation of the international standard for natural capital accounting, the System of Environmental-Economic Accounting (SEEA) Ecosystem Accounting, adopted by the UN Statistical Commission in March 2021.
- The new tool makes it easier for countries to monitor indicators related to the Sustainable Development Goals (SDGs) and the post-2020 Global Biodiversity Framework, including those related to the contributions of nature to their economic prosperity and well-being.

SEEA Ecosystem Accounting (SEEA EA), an international standard which was adopted by the UN Statistical Commission in March 2021<sup>2</sup>. The result of this collaboration developed under the EU-funded Natural Capital Accounting and Valuation of Ecosystem Services (NCAVES) project, ARIES for SEEA, can produce SEEA accounts globally and enable NSOs to more rapidly produce accounts, as well as to customize them using their own data<sup>3</sup>. ARIES is an international research project hosted by BC3, that offers an integrated, open-source modelling platform to re-define environmental and sustainability assessment for policy-making through artificial intelligence (AI), where researchers from across the globe can share their data and models using web-based repositories<sup>4</sup>.

### What it does

The user-friendly ARIES for SEEA Explorer lowers the barriers to compiling ecosystem accounts. Through a web browser interface, the application can generate ecosystem accounts for any user-specified terrestrial area in the world (such as a country, administrative region, or watershed), by using freely available global remote-sensing derived data and models, computing these accounts online, and returning results back to the user. The current Explorer functionalities are restricted to assessing 1. *ecosystem extent*, based on the IUCN Global Ecosystem Typology, 2. *ecosystem condition*, currently limited to forest ecosystem types, and 3. *selected ecosystem services* (Figures 1, 2, 3 and 4) in physical and monetary units using basic models as a starting point. The outcomes can be analysed and downloaded to further explore the results (through spreadsheet or GIS software, Figure 5).

The ARIES for SEEA Explorer automatically generates a comprehensive ecosystem accounts report, fully documenting the data, models and other methods used (Figures 6, 7, 8, and 9). Powered by the Knowledge Laboratory (k.LAB) software, the ARIES for SEEA Explorer application allows users anywhere in the world to produce rapid,

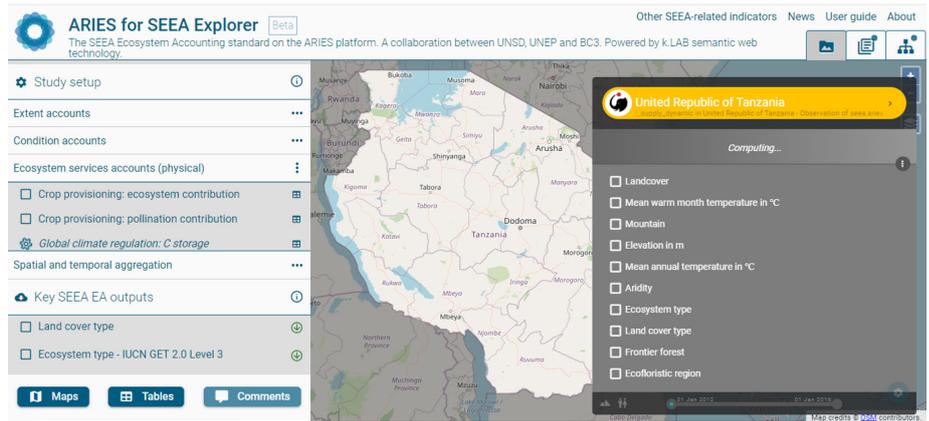


Figure 1. The ARIES for SEEA Explorer computing the biophysical value of Carbon Storage: not only the final results is shown, but also all intermediary outputs can be observed individually and downloaded  
Source: <https://seea.un.org/content/aries-for-seea>

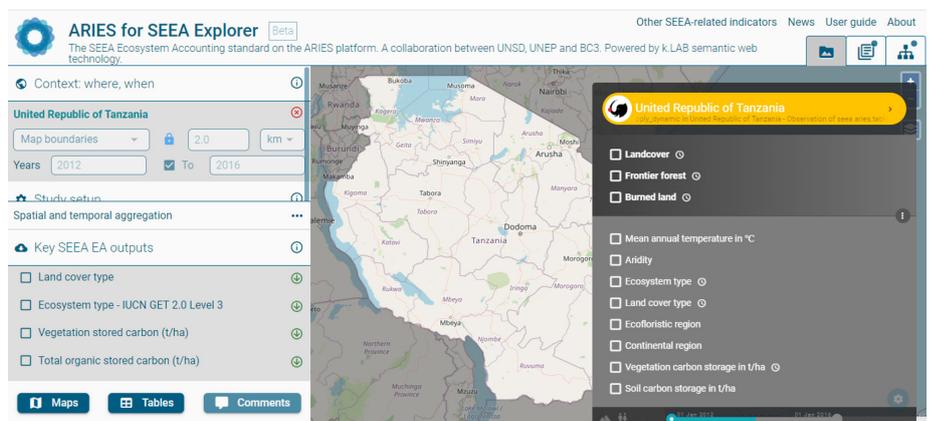


Figure 2. The ARIES for SEEA Explorer features: Spatial and temporal context of the analysis in the United Republic of Tanzania, at a resolution of 2km, from 2012 to 2016  
Source: <https://seea.un.org/content/aries-for-seea>

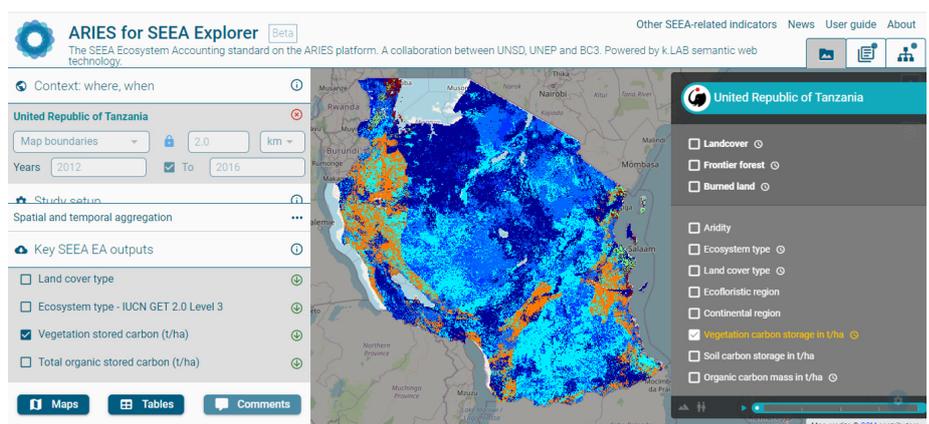


Figure 3. The ARIES for SEEA Explorer key SEEA EA outputs: Vegetation stored carbon (t/ha) in the United Republic of Tanzania, from 2012 to 2016  
Source: <https://seea.un.org/content/aries-for-seea>

<sup>2</sup> <https://www.un.org/en/desa/countries-consider-ground-breaking-change-economic-reporting-includes-natural-capital>

<sup>3</sup> <https://seea.un.org/content/aries-for-seea>

<sup>4</sup> <https://ipbes.net/policy-support/aries>

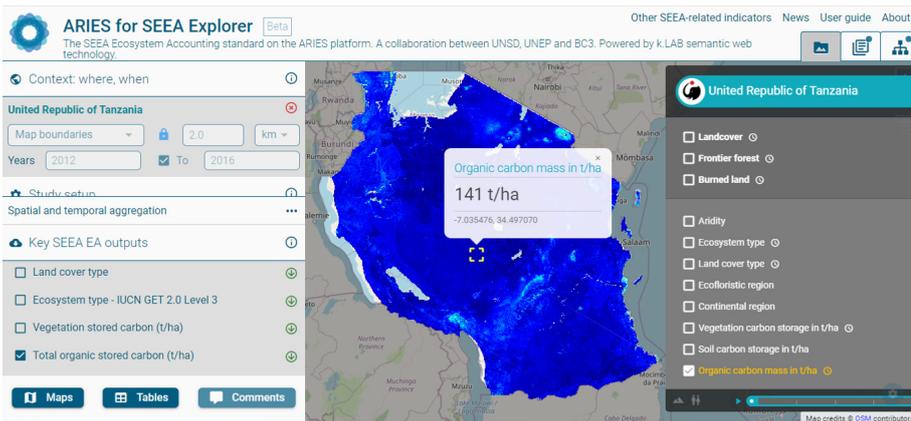


Figure 4. The ARIES for SEEA Explorer key SEEA EA outputs: Total organic stored carbon (t/ha) in the United Republic of Tanzania, from 2012 to 2016

Source: <https://seea.un.org/content/aries-for-seea>

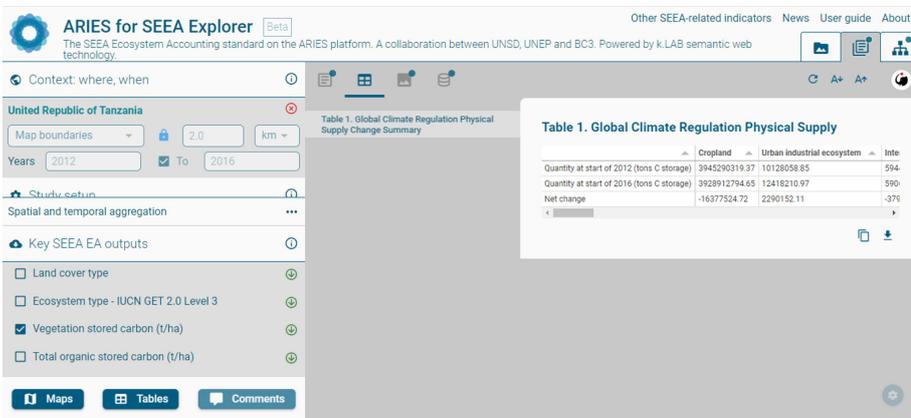


Figure 5. The ARIES for SEEA Carbon storage physical supply account results in the United Republic of Tanzania, from 2012 to 2016

Source: <https://seea.un.org/content/aries-for-seea>

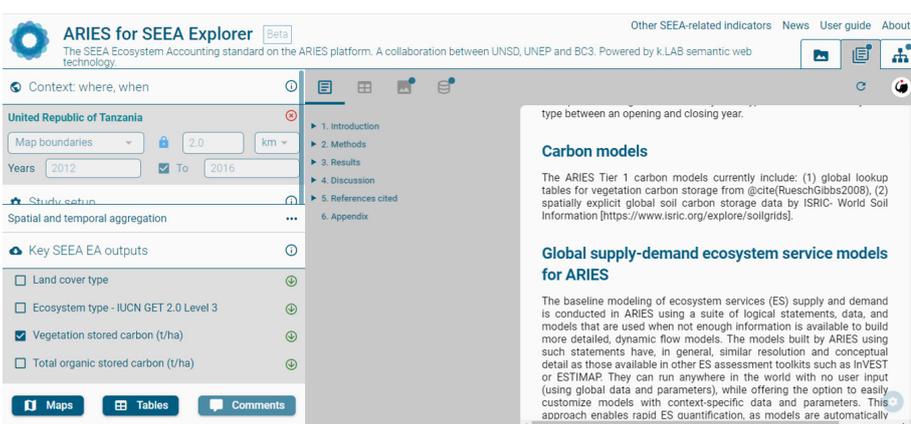


Figure 6. The ARIES for SEEA Explorer accounts report in the United Republic of Tanzania, from 2012 to 2016

Source: <https://seea.un.org/content/aries-for-seea>

standardized, scalable and customizable ecosystem accounts for their area

of interest that are consistent with the SEEA EA framework. ARIES for SEEA is

available both in English and Spanish on the UN Global Platform, a cloud-service environment that supports international collaboration in the development of official statistics using new data sources and innovative methods.

## The tool's impact

With the release of the ARIES for SEEA Explorer, ARIES facilitates better informed, nature positive decision-making from businesses and governments, by incorporating and integrating the latest data, models and understanding of natural capital accounting. The tool makes a large and growing collection of data and models easily accessible to users with limited experience in spatial modelling, including NSOs. At the same time, it ensures appropriate reuse of models, as conditions for model reuse are explicitly encoded, which guides the selection of the most appropriate approaches for the time-scale, place, and geographic resolution of the analysis.

ARIES also helps scale up knowledge sharing with the reuse and customization of Findable, Accessible, Interoperable and Reusable (FAIR) modelling approaches. ARIES builds a semantic web of data and spatial models that achieve high-level semantic interoperability, which enables a receiving system to properly understand the meaning of data that are exchanged, reusing it in an appropriate manner (see "How it works," below). To the four dimensions in FAIR, ARIES adds a reactivity dimension, in line with the original vision of a semantic web<sup>5</sup>. Reactivity enables the creation of live artifacts that can interact, improve and evolve as new information appears on the network.

The tool's low barrier to entry enables the bridging of technical gaps between countries. ARIES combines the use of global data and generalized modelling approaches in data-scarce countries yet is simultaneously able to customize accounts wherever improved data and model resources exist – thus meeting the needs of both countries with limited data who want to compile initial accounts and those capable of more customized SEEA EA approaches.

ARIES can also facilitate rapid, transparent, intelligently assembled, and inex-

<sup>5</sup> <https://www.sciencedirect.com/science/article/abs/pii/S1364815208001540>

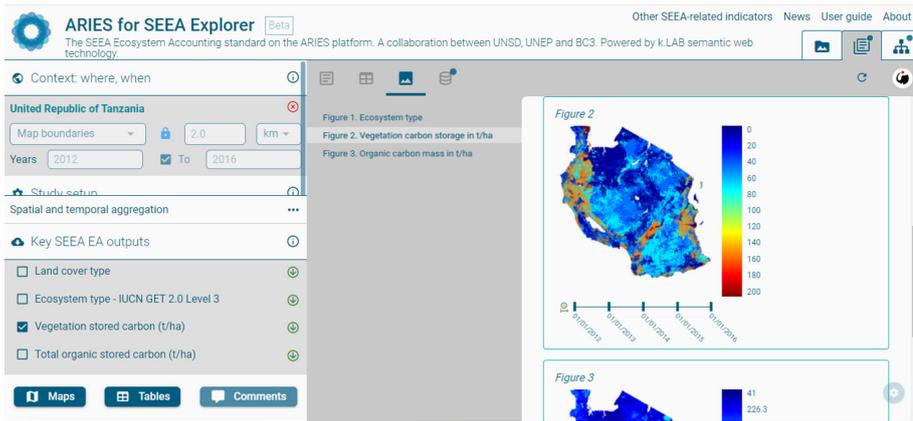


Figure 7. The ARIES for SEEA Explorer accounts figures and maps in the United Republic of Tanzania, from 2012 to 2016  
Source: <https://seea.un.org/content/aries-for-seea>

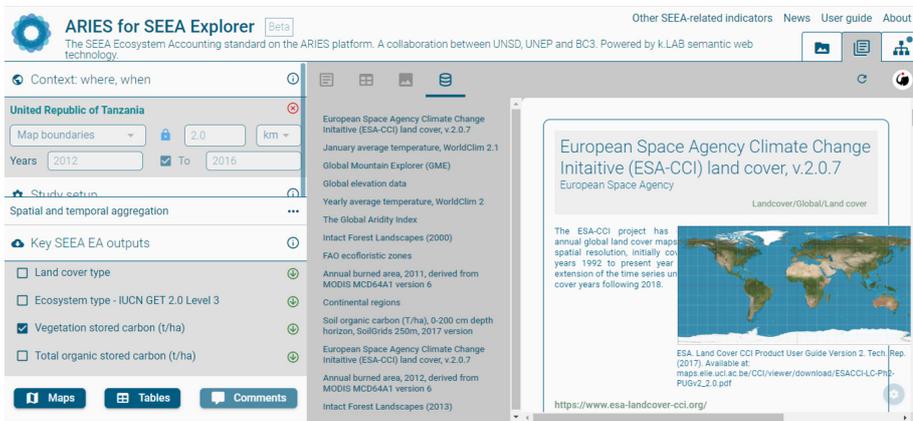


Figure 8. The ARIES for SEEA Explorer resources used for computation are listed in the dedicated section of the documentation. This feature provides full provenance of data and models, offering traceability of each component of the modelling used, allowing comparability of results and maximizing transparency in the replicability of the accounts compiled  
Source: <https://seea.un.org/content/aries-for-seea>

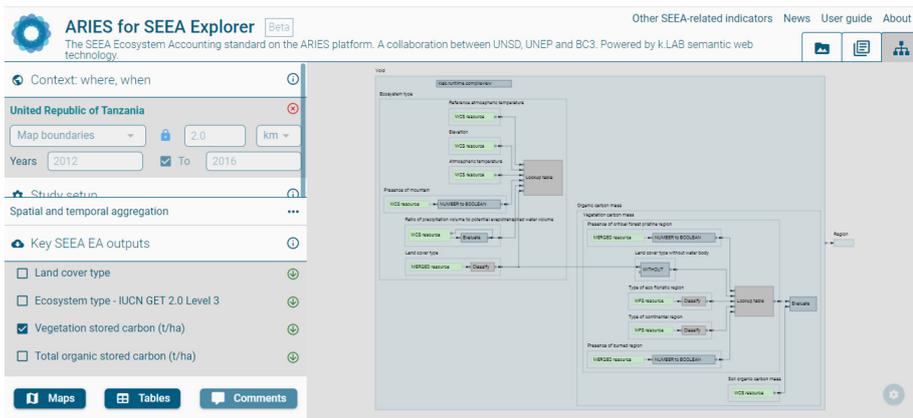


Figure 9. The ARIES for SEEA Explorer dataflow view that visually summarizes each model component and how those were combined to obtain the final results in the United Republic of Tanzania, from 2012 to 2016. This can be seen as a more visual representation of the more detailed information shown at Figure 8.  
Source: <https://seea.un.org/content/aries-for-seea>

Agreement, by automatically integrating data and models through the use of AI. Critically, the approach offers NSOs a starting point to begin needed conversations with data producers and modellers, by building basic initial estimates based on global data and pre-existing models then continually working with data producers and modellers to improve initial results using local scientific data and knowledge.

### How it works

ARIES uses an AI technology that has so far seen limited application to scientific modelling: machine reasoning. Machine reasoning enables a system to make logical deductions from the information that is available through machine-readable conceptualizations. A set of logically consistent and rigorous semantics, which defines the concepts describing each scientific data and model element and relationships between them, using an intuitive language readable by both people and computers, facilitates machine reasoning (for example, different elevation or land cover datasets, or hydrologic models, are consistently labelled with clear, uniform, and unambiguous descriptors).

When semantics are applied to data and models shared on the web, these resources become interoperable, with ARIES' AI system able to select the most appropriate data and models for the user's needs. The ARIES for SEEA Explorer combines user requests with a global network of data and models to assemble, compile, and report results for needed accounts.

The Explorer thus automates model selection based on a user's specific request. It chooses the "most appropriate" model for the location, spatiotemporal resolution and account specified (e.g., an ecosystem service or condition account for a given country and year). Using ARIES' predefined semantics and large number of web-hosted global, national, and local datasets and models, the tool generates the best-available model results for the specified problem, given the models and data sources accessible to the system. Users can also share their own data sources and models on ARIES-compatible networks, making these contributions reusable by future SEEA account compilers.

pensive reporting on key global initiatives such as the Sustainable Development

Goals (SDGs), Post-2020 Global Biodiversity Framework, and the Paris Climate

## Conclusion and further research

A number of countries have already started using the ARIES for SEEA Explorer, such as Italy, India and Brazil. Efforts are also underway to collaborate with the developers of existing models and data sources to make them interoperable and reusable in the context of ARIES. The Explorer will continue to be expanded in the near future, by adding the functionality to derive indicators that allow to assess progress towards SDGs and the emerging post-2020 Global Biodiversity Framework.

The functionalities of the ARIES for SEEA Explorer will be also continuously improved and expanded. Plans are already in place to add additional ecosystem types to the extent accounts; expand the selection of ecosystem types covered in the condition accounts, such as grass-

land condition accounts; and include additional ecosystem services, such as water supply and flood regulation. Pending interest from the global community, the ARIES for SEEA Explorer could also be tailored to support the compilation of ocean accounts.

Users will also be able to add their own datasets through a simple drag-and-drop function within the interface, which will allow the quality of the accounts to be improved by making local/national data even easier to incorporate into the ARIES for SEEA Explorer. The same users can decide how accessible these additional datasets should be, either restricted for internal use, or shared with the community for wider reuse. Finally, the ARIES for SEEA Explorer will support compilation of selected SEEA Central Framework accounts.

## References

- Villa, F., Bagstad, K.J., Voigt, B., Johnson, G.W., Portela, R., Honzak, M., and Baker, D. (2014). A methodology for adaptable and robust ecosystem services assessment. *PLoS ONE* 9(3):e91001.
- Capriolo, A., Boschetto, R.G., Mascolo, R.A., Balbi, S., Villa, F. (2020). Biophysical and economic assessment of four ecosystem services for natural capital accounting in Italy. *Ecosystem Services* 46:101207.
- Martínez-López, J., Bagstad, K.J., Balbi, S., Magrach, A., Voigt, B., Athanasiadis, I., Pascual, M., Willcock, S., and Villa, F. (2019). Towards globally customizable ecosystem service models. *Science of the Total Environment* 650(2):2325-2336.
- Hein, L., Bagstad, K. J., Obst, C., Edens, B., Schenau, S., Castillo, G., Souldard, F., Brown, C., Driver, A., Bordt, M., Steurer, A., Harris, R., and Caparrós, A. (2020). Progress in natural capital accounting for ecosystems. *Science*, 367(6477), 514-515.



*This work has been developed with the financial support of the Basque Government and the European Union.*

# bc<sup>3</sup>

BASQUE CENTRE  
FOR CLIMATE CHANGE  
Klima Aldaketa Ikergai

Sustainability, that's it!

*BC3 Policy Briefs report on research carried out at BC3 and have received only limited review. Views or opinions expressed herein are responsibility of the authors and do not necessarily represent those of the Basque Centre for Climate Change. BC3 Policy Briefs are available on the internet at <http://www.bc3research.org/policybriefings>.*

*This work is licenced under a Creative Commons Attribution - Non Commercial (CC-BY-NC) 4.0 International License. For any commercial use or queries please contact: [info@bc3research.org](mailto:info@bc3research.org)*

