System of Environmental Economic Accounting

Introduction to ARIES for SEEA, global tools and data

Training on Ecosystem Accounting in Support of the Sustainable Development Goals and Global Biodiversity Framework

8-11 September 2025, Jakarta, Indonesia

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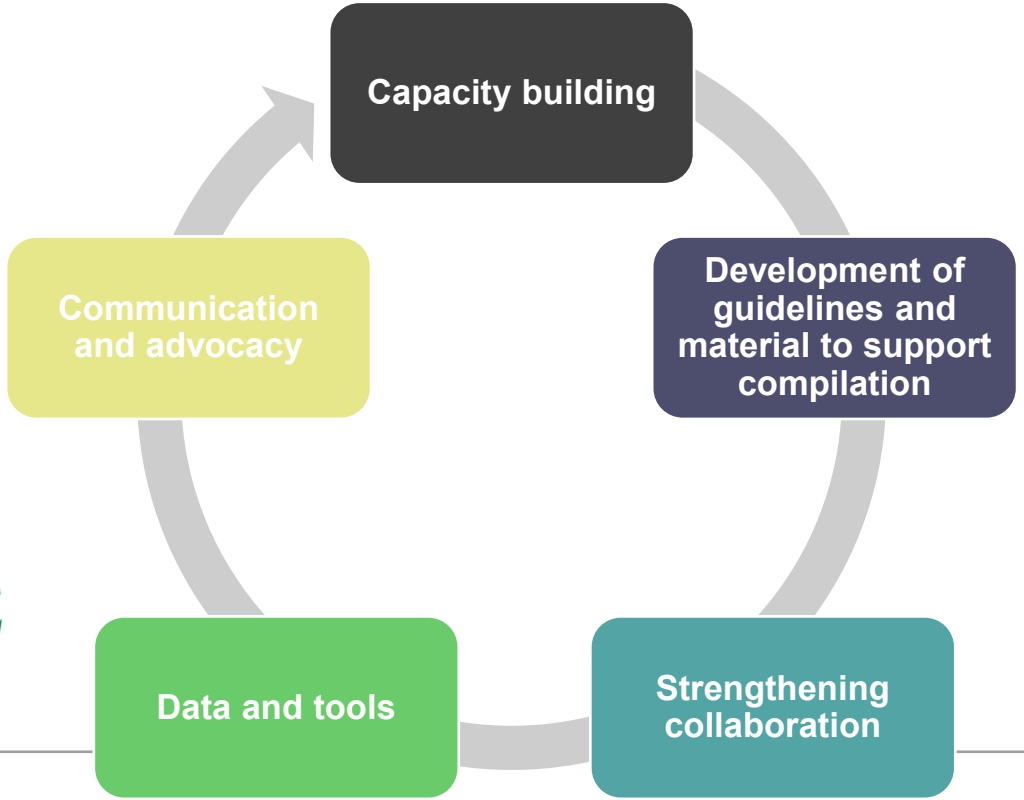
United Nations

Co-funded by the European Union

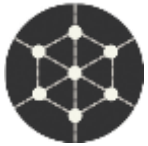
Activities in support of the implementation



Introduction to ARIES

Introduction to ARIES

#1 Decision-makers with limited data and technical capacity often lack **access to scientific knowledge**. Many are left behind due to **cost or technology barriers**.



#2 **Ever-increasing volumes of data** are held in silos – different disciplines, geographies, data types and access rights - making it challenging to connect information and make sense of it.

#3 Public **trust** is one of the biggest hurdles faced by AI technologies. People struggle to accept the decisions and answers that AI-powered tools provide as many do not make their inputs, operations, and end goals visible.

#4 The AI technology ecosystem is currently dominated by Big Tech - enclosed assets - for profit perspective. Although much software is open-source, **access to data remains tightly controlled.**

Solutions offered by ARIES

#1 It is a **modelling technology**, rather than a, collection of models or specific program/application;

#2 It is an **AI modeller**, based on **machine reasoning**, a less known branch of AI;

#3 It defines a variety of data, models and the relationships between them using **consistent and uniform terms**. This allows different data and models to be used together, depending on which data and models are "most appropriate" for the context set by the user;

#4 It uses AI to determine the "**most appropriate**" data and models for users' requests.

Reasoning algorithms + Decision rules + Multidisciplinary semantics + Open data & models + Open-source software = ARIES: Fast, FAIR multidisciplinary modeling

What can ARIES be used for?

Spatial economic valuation of ecosystem services

Conservation planning

Spatial policy planning

Forecasting changes in ecosystem service provisioning

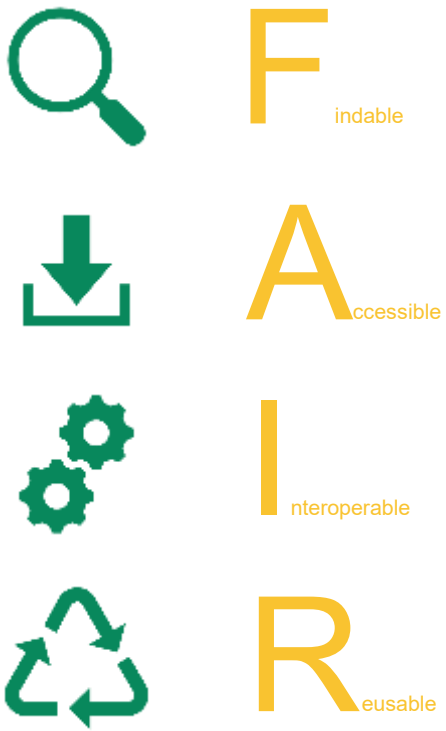
Natural capital accounting

Why artificial intelligence (AI)?

Governments agencies and policy-makers often face **high barriers** to entry in producing ecosystem accounts:

- Ecosystem accounting has high data needs;
- Large amounts of data result in long processing times, making compilation a slow exercise;
- Ecosystem accounting often makes use of biophysical models which require technical expertise.

Ecosystem accounting would **benefit** from data and models which are Findable, Accessible, Interoperable and Reusable (FAIR).



ARIES: a different approach to environmental modelling

SWAT Soil & Water Assessment Tool

https://swat.tamu.edu/software/plus/

InVEST integrated valuation of ecosystem services and tradeoffs

https://naturalcapitalproject.stanford.edu/software/invest

ARIES ARtificial Intelligence for Environment & Sustainability

https://aries.integratedmodelling.org/get-started/

Ecosystems Knowledge Network

https://ecosystemsknowledge.net/resources/tool-assessor/

European Commission

NATURE BRAID

https://naturebraid.org/

VICTORIA State Government Energy, Environment and Climate Action

EnSym

https://www.environment.vic.gov.au/..../ensym-native-vegetation-regulations-tool

INCA Platform

https://ecosystem-accounts.jrc.ec.europa.eu/about-inca

ESTIMAP: A GIS-BASED MODEL TO MAP ECOSYSTEM SERVICES IN THE EUROPEAN UNION

10.4462/annbotrm-11807

Ecosystems Knowledge Network

SWAT

VICTORIA State Government | Energy, Environment and Climate Action

EnSym

NATURE BRAID

- Programming & GIS skills required to run models

European Commission

INCA Platform

ESTIMAP

Applications to produce NCA results for countries in the European Union to support EU policies

- ✓ No programming skills to run the model
- GIS software plug-in
- Only available for Europe

InVEST

integrated valuation of ecosystem services and tradeoffs

Models based on production functions defining how changes in ecosystem structure & function affect ecosystem service flows & values across land- & seascapes.

- ✓ No programming skills to run the models
- ✓ Standalone application
- Intermediate GIS software skills required
- Need GIS mapping software to visualize results

ARIES

Artificial Intelligence for Environment & Sustainability

Online library of environment & sustainability models & data; WoldWideWeb-like archive of models growing in value to the scientific community with increasing use.

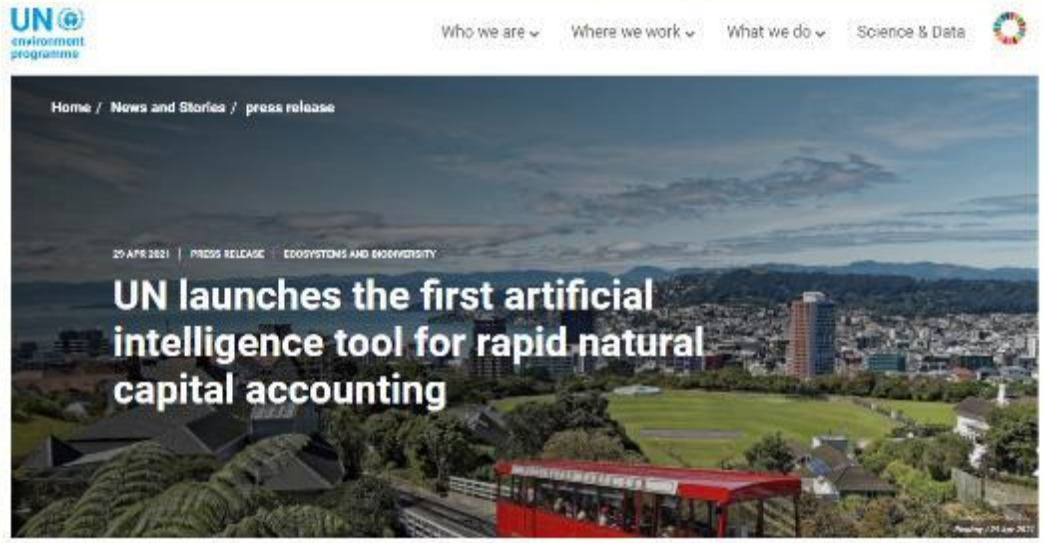
- ✓ Online free-access
- ✓ No programming skills to run the models, nor mapping software (GIS) to visualize results
- ✓ Integrated modelling platform: allows integration of other tools' models & data

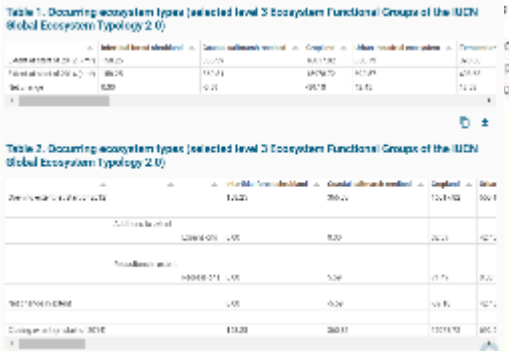
Higher to lower barriers to entry

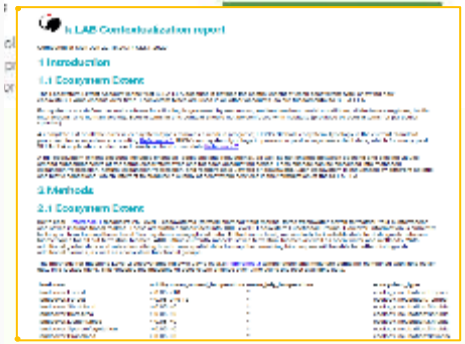
Introduction to ARIES for SEEA

ARIES for SEEA Explorer

- **AR**rtificial **I**ntelligence for **E**nvironment and **S**ustainability
- Application (by BC3) built on ARIES platform:
  - Uses global data and models to generate a basic set of ecosystem accounts
  - Enables compilation anywhere on earth (country; watershed; administrative area)
  - AI -> machine reasoning to construct “best available model”
  - ARIES has > 100 global data layers, many of them based on EO (e.g. land-cover; elevation; precipitation)
  - Improvement with national data where available
  - Transparent (metadata + download)







https://seea.un.org/content/aries-for-seea

ARIES for SEEA: Audiences

1. Countries with very limited data & experience (create accounts using common global data)
2. Countries with national data wanting to customize accounts (create accounts using national data & models)
3. Countries with sophisticated modeling capacity (contribute their data & models to global SEEA EA community)

Current focus has been on group 1; increasing focus on groups 2 & 3 in near future (e.g. Indonesia's estimates based on national data when available).

What is the ARIES for SEEA Explorer?

#1 An app, built on the ARIES technology, to compile ecosystem accounts comformant with the **SEEA Ecosystem Accounting**;

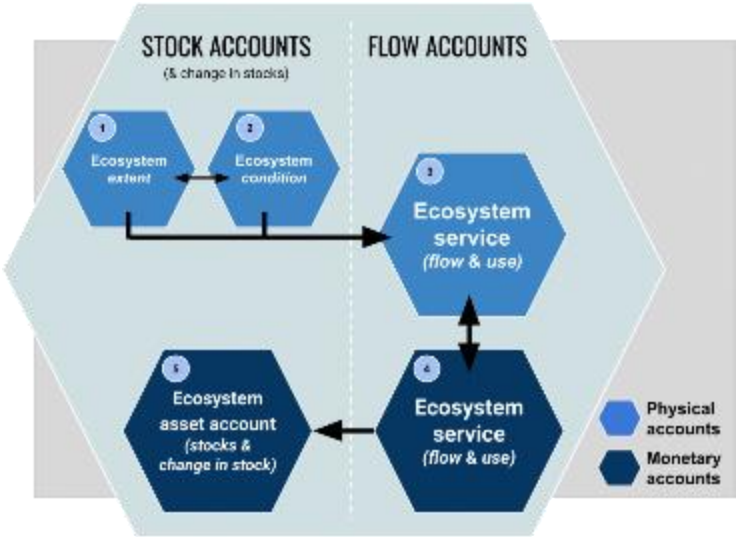
#2 It utilizes remote-sensing **data and models** where governments-endorsed data are not available;

#3 It can generate accounts for **any** user-specified **terrestrial area** in the world;

#4 It **rapidly** computes these accounts online, using a web browser;

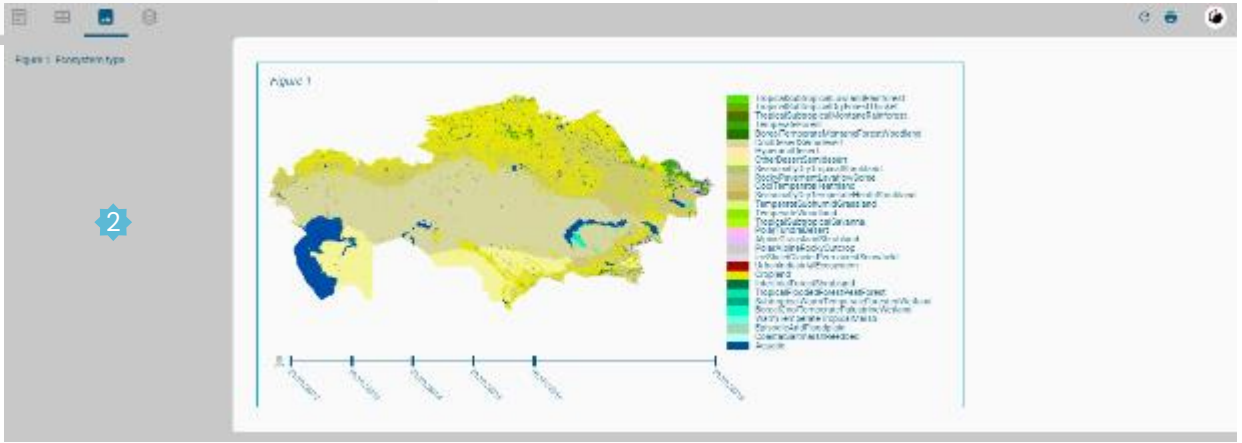
#5 It generates a comprehensive **report**, **fully documenting the data, models, coefficients and methods** used.

System of Environmental Economic Accounting



What are the ARIES for SEEA Explorer's outputs?

#1 A combination of statistical and spatial analysis summarized in **Tables(1)** and **Maps(2)**.



What are the ARIES for SEEA Explorer's outputs?

#2 Full transparency for replicability and traceability through **Reports(1)**, a **Resource Section(2)** & a **Dataflow Diagram(3)**.

Two type of users:

Non-technical users

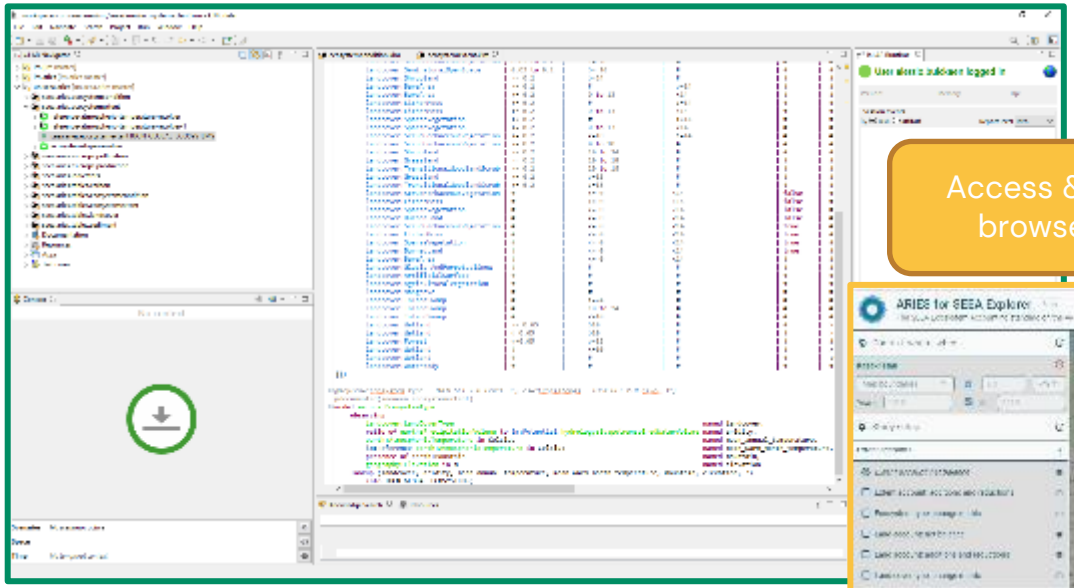
Users who want to create evaluations and explore defined scenarios.
Only a current web browser is needed, such as Chrome or Firefox to use the online tool called **k.Explorer** (the general k.LAB interface to explore by querying the knowledge base) to access k.LAB's linked data and models.

Technical users

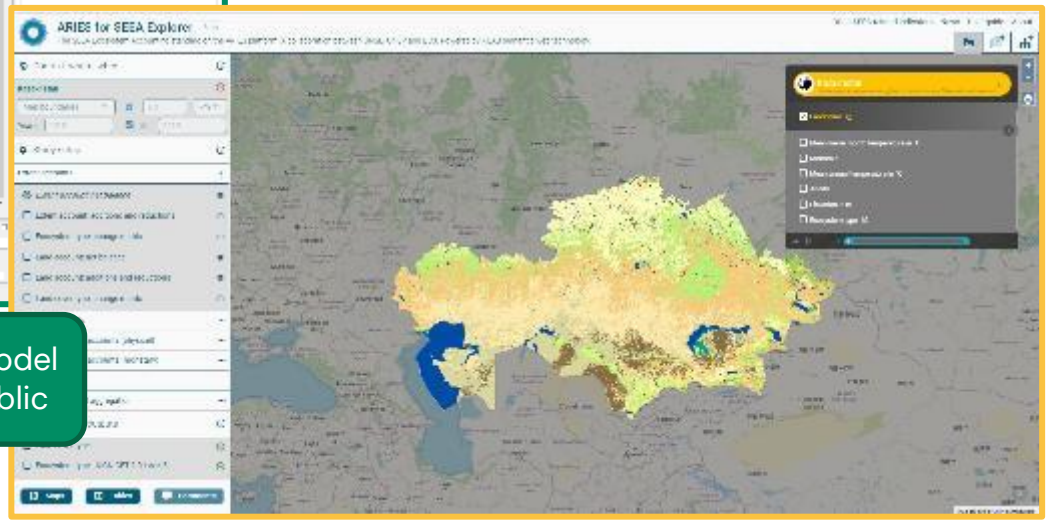
Users who want to produce data and model.
You'll need specialized tools to import, annotate, and publish data and models on the k.LAB semantic web. You have to install the Control Center software package which includes:

- The local engine (**k.LAB engine**) and its web-based user interface (**k.Explorer**)
- The Integrated development environment (**k.Modeler**)

Interfaces for technical and non-technical users



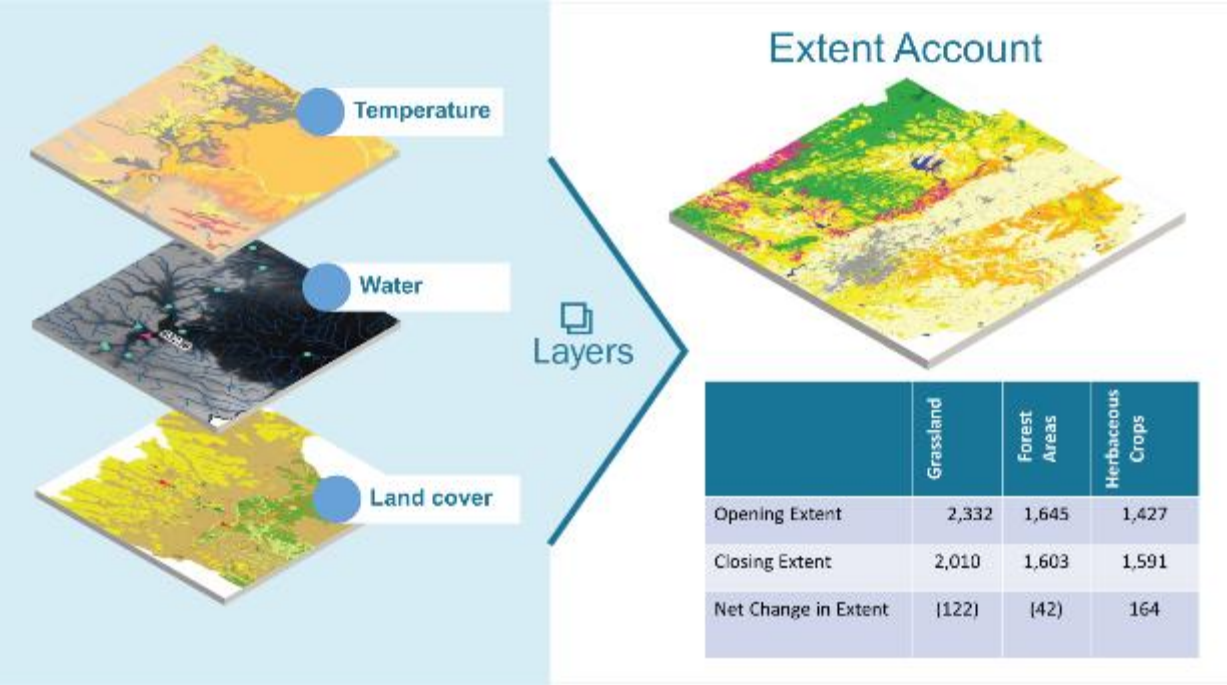
Access & run scientific models in minutes through a web browser, using cloud-based data, anywhere on Earth



Contribute & semantically annotate new data & model resources for reuse by scientific community & public

ARIES for SEEA: Ecosystem Type

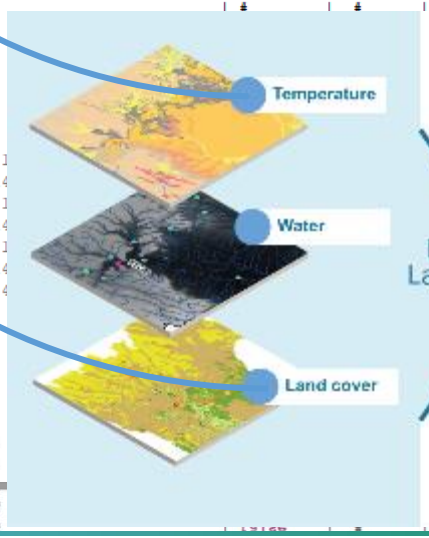
Ecosystem Type modeling



	Grassland	Forest Areas	Herbaceous Crops
Opening Extent	2,332	1,645	1,427
Closing Extent	2,010	1,603	1,591
Net Change in Extent	(122)	(42)	164

Ecosystem Type modeling

```
define IUCN_GLOBAL_ECOSYSTEMS as {{
        landcover                          | aridity       | mean_annual_temperature | mean_warm_month_temperature | mountain | elevation | ecosystem_type
    ---------------------------------------------------------------------------------------------------------------------------------------------------------------
        landcover:Forest                   | >= 0.65       |      >= 18              |   #                         | false    |   #       | es.nca:TropicalSubtropicalLowlandRainforest ,
        landcover:Forest                   | >= 0.65       |      >= 18              |   #                         | unknown  |   #       | es.nca:TropicalSubtropicalLowlandRainforest ,
        landcover:Forest                   | 0.05 to 0.65  |      >= 18              |   #                         | #        |   #       | es.nca:TropicalSubtropicalDryForestThicket ,
        landcover:Forest                   | >= 0.65       |      >= 18              |   #                         | true     |   #       | es.nca:TropicalSubtropicalMontaneRainforest ,
        landcover:Forest                   | #             |      <= 0               |   #                         | #        |   #       | es.nca:BorealTemperateMontaneForestWoodland ,
        landcover:Forest                   | #             |      0 to 18            |   #                         | true     |   #       | es.nca:BorealTemperateMontaneForestWoodland ,
        landcover:Forest                   | #             |      0 to 18            |   #                         | #        |   #       | es.nca:TemperateForest ,
        landcover:ScrubHerbaceousVegetation | 0.03 to 0.2   |      0 to 10            |   #                         | #        |   #       | es.nca:CoolDesertSemidesert ,
        landcover:SeminaturalOpenSpace     | 0.03 to 0.2   |      0 to 10            |   #                         |          |           |
        landcover:ScrubHerbaceousVegetation | <= 0.03       |      > 0                |   #                         |          |           |
        landcover:SeminaturalOpenSpace     | <= 0.03       |      > 0                |   #                         |          |           |
        landcover:ScrubHerbaceousVegetation | 0.03 to 0.2   |      >= 10              |   #                         |          |           |
        landcover:SeminaturalOpenSpace     | 0.03 to 0.2   |      >= 10              |   #                         |          |           |
        landcover:Shrubland                | >= 0.2        |      >= 24              |   #                         |          |           |
        landcover:BareArea                 | >= 0.2        |      #                  |   >= 1                      |          |           |
        landcover:BareArea                 | >= 0.2        |      0 to 13            |   < 14                      |          |           |
        landcover:LichenMoss               | >= 0.2        |      #                  |   >= 1                      |          |           |
        landcover:LichenMoss               | >= 0.2        |      0 to 13            |   < 14                      |          |           |
        landcover:SparseVegetation         | >= 0.2        |      #                  |   >= 1                      |          |           |
        landcover:SparseVegetation         | >= 0.2        |      0 to 13            |   < 14                      |          |           |
        landcover:ScrubHerbaceousVegetation | >= 0.2        |      <= 10              |   >= 4                      |          |           |
        landcover:ScrubHerbaceousVegetation | >= 0.2        |      0 to 10            |   #                         |          |           |
        landcover:Shrubland                | >= 0.2        |      10 to 24           |   #                         |          |           |
        landcover:Grassland                | >= 0.2        |      10 to 18           |   #                         |          |           |
        landcover:TransitionalWoodlandScrub | >= 0.2        |      10 to 18           |   #                         |          |           |
        landcover:Grassland                | >= 0.2        |      >=18               |   #                         |          |           |
        landcover:TransitionalWoodlandScrub | >= 0.2        |      >=18               |   #                         |          |           |
        landcover:ScrubHerbaceousVegetation | #             |      <= 0               |   < 14                      |          |           |
        landcover:LichenMoss               | #             |      <= 0               |   < 14                      |          |           |
```



	Grassland	Forest Areas	Herbaceous Crops
Opening Extent	2,332	1,645	1,427
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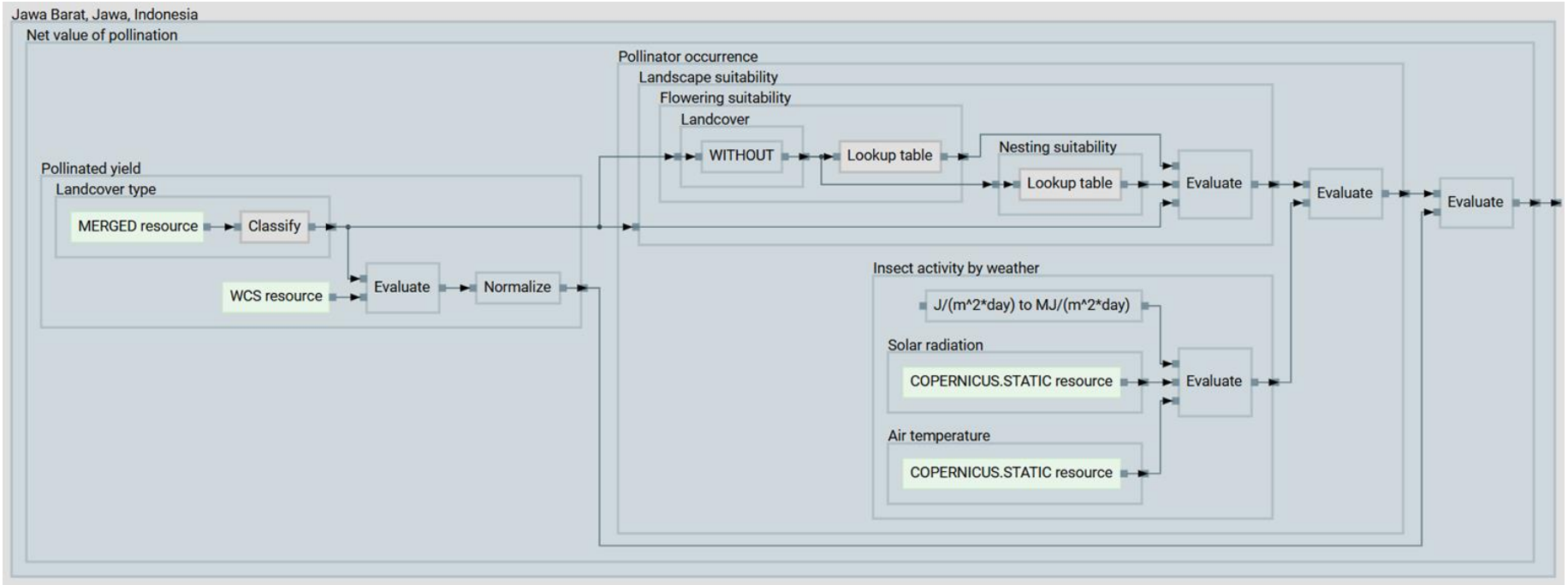
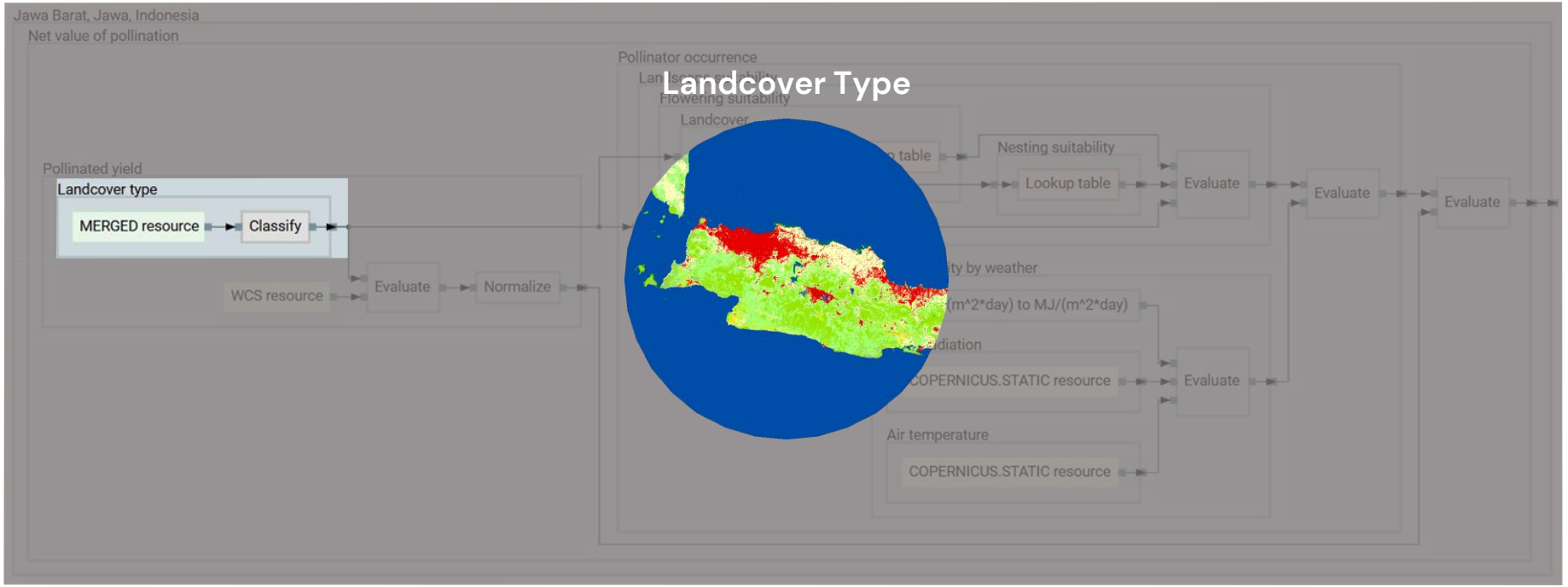
Modelling ecosystem services

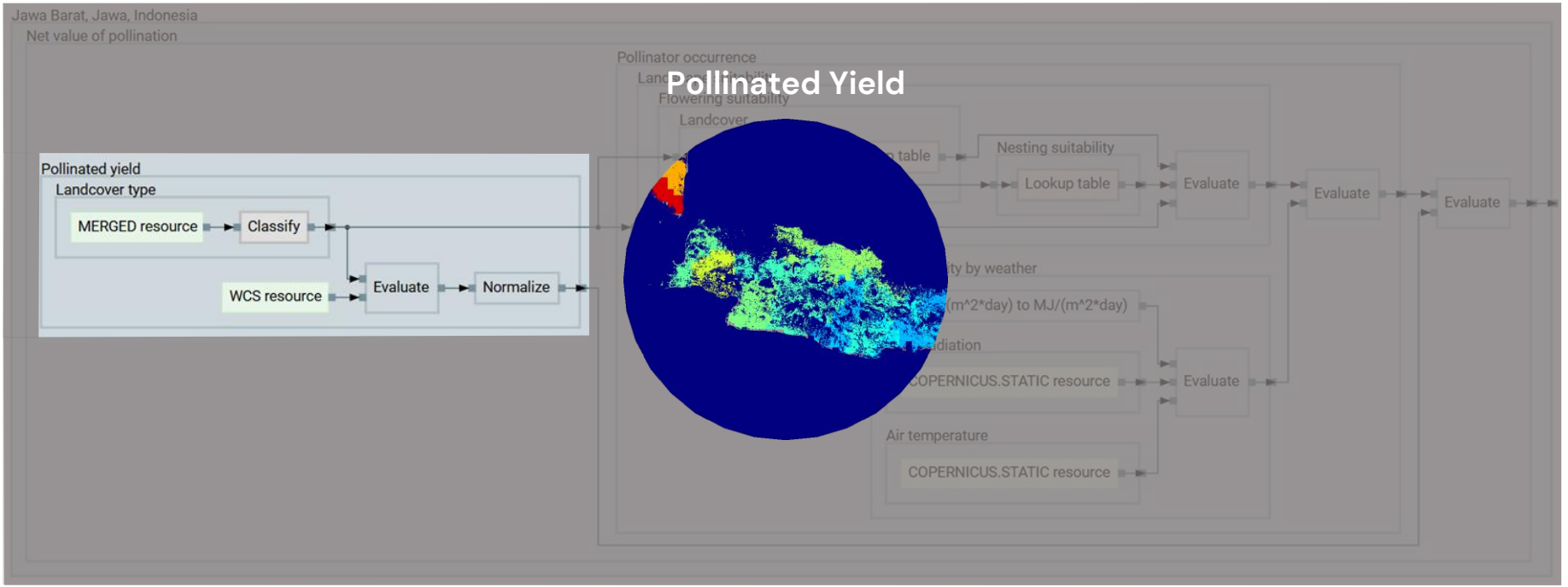
Dataflow representing the Net Value of the Pollination service



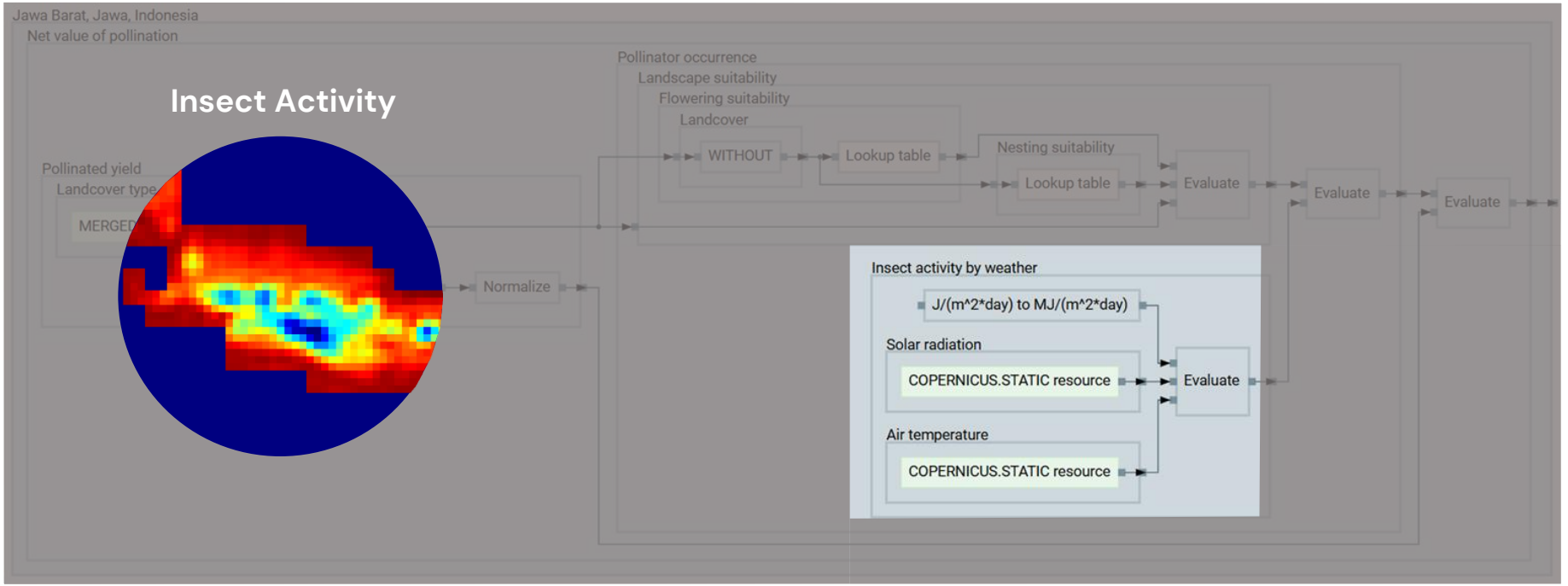
Dataflow representing the Net Value of the Pollination service



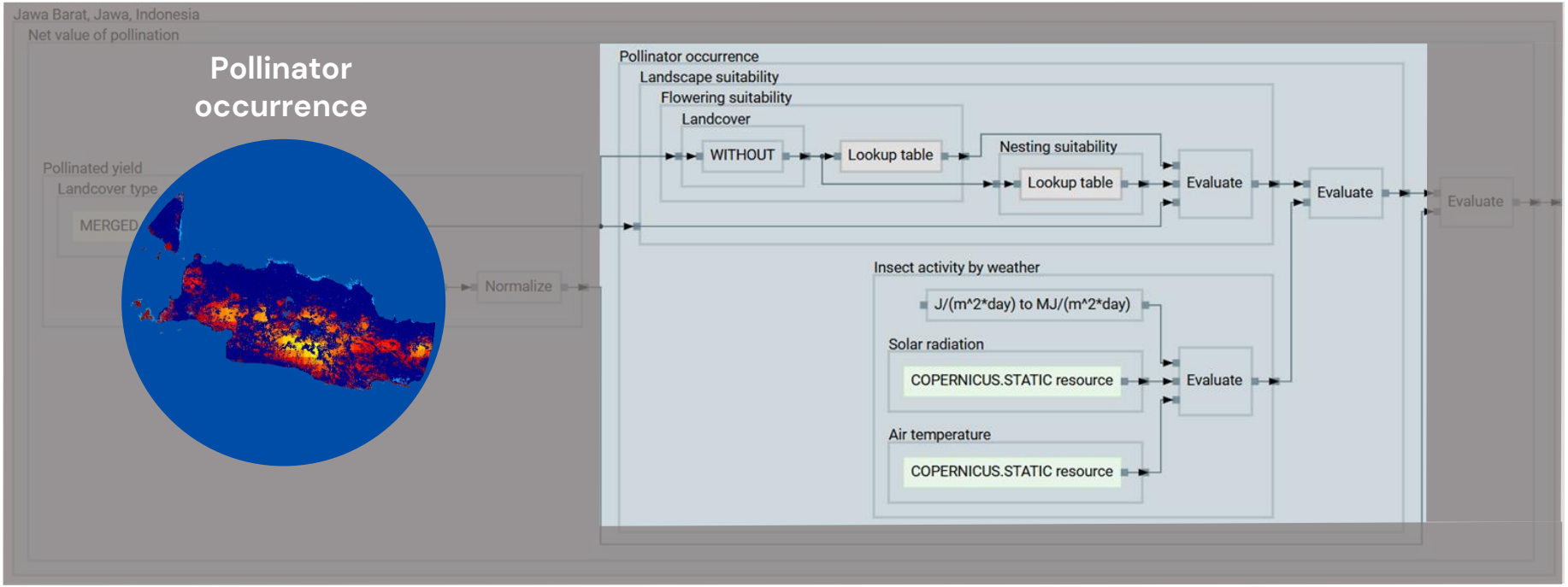
Dataflow representing the Net Value of the Pollination service



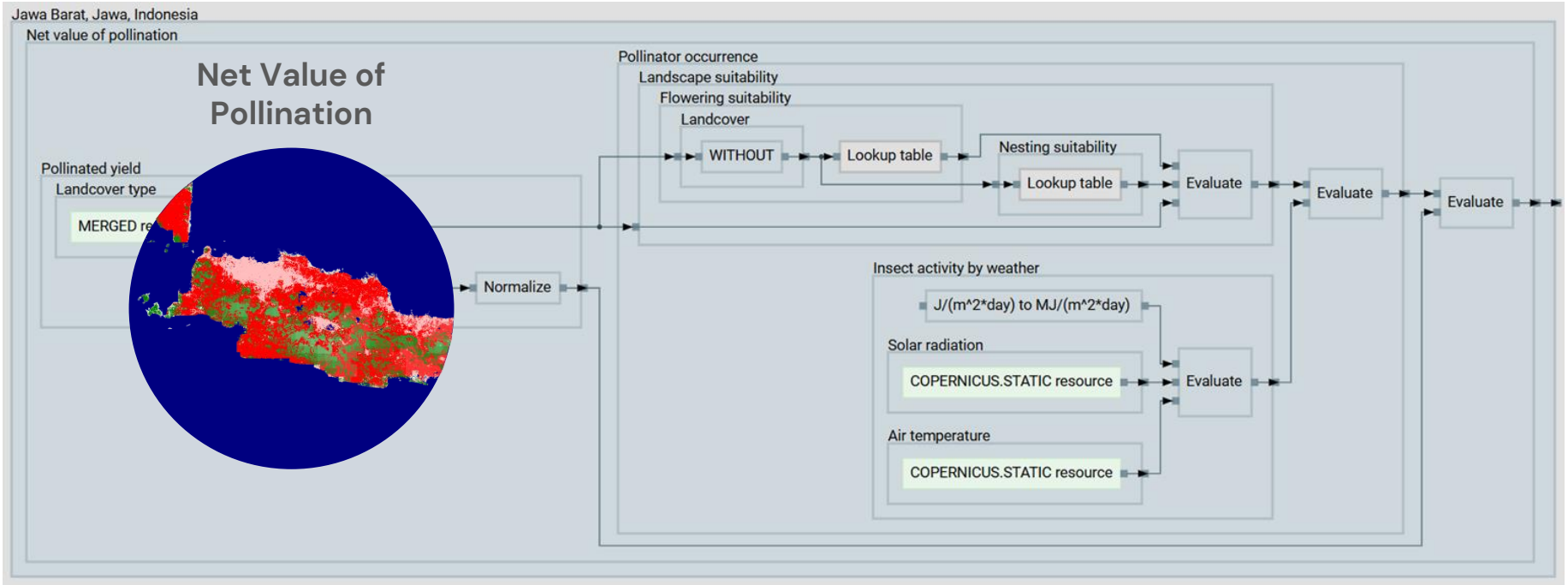
Dataflow representing the Net Value of the Pollination service



Dataflow representing the Net Value of the Pollination service



Dataflow representing the Net Value of the Pollination service



ARIES

ARtificial Intelligence for Environment & Sustainability

Recent developments with ARIES to support the GBF

Funded by the European Union

Work in support of KM-GBF (a UNSD project funded by the EU)

#1 Expand the ARIES for SEEA application to implement additional modules to estimate the physical supply of four ESs considered more relevant for biodiversity purpose and covering all the broad group categories: provisioning, regulating and cultural ESs

System of Environmental Economic Accounting

The spatially explicit approach used in ARIES allows the supply of these services to be attributed to natural ecosystems or specific ecosystem types where maps of a suitable resolution are available, supporting the compilation of GBF indicators.

#2 Global Datasets: Develop global datasets for the main **GBF headline indicators (A.2 and B.1)** to serve as fallback options when national data is unavailable

Kunming-Montreal GLOBAL BIODIVERSITY FRAMEWORK

Development of ES modules

- Development of tools to support countries in the compilation of data for reporting on the indicators and global databases to support countries
- In partnership with BC3 and ARIES for SEEA
  - Provisioning: Grazed biomass provisioning
  - Regulating: Global climate regulation services & Coastal protection services
  - Cultural: Recreation-related services
- Concept notes have been prepared for each service
- Testing with project countries

Grazed biomass provisioning

- **Supply:** Calculated based on the annual productivity of suitable ecosystems. This is determined by converting annual gross primary productivity (GPP) data into tonnes of dry matter per hectare per year.
- **Demand:** Estimated by multiplying the spatial distribution of livestock by their daily forage intake requirements.
- **Service used:** The lesser of the two values: the potential supply or the estimated demand. If demand exceeds supply, it's assumed that the remaining feed comes from other sources or through seasonal migration.
- **Key inputs:** annual dry matter productivity, the distribution of grasslands, livestock distribution (Global Pasture Watch), land cover data, and a digital elevation model (DEM) for slope constraints.

Limitations: the model relies on generalized assumptions for livestock feed intake and may not account for year-round grazing patterns. It also faces inherent errors from combining global spatial datasets at different resolutions, which while minimized still poses challenges

Climate regulation (carbon stock)

- The IPCC Tier 1 'stock-difference' methodology is used to map carbon stocks and changes;
- The model compiles a **database of carbon stock** and sequestration factors for each natural land cover type, **stratified by climate, continent, and ecological zone**;
- For forests, additional considerations are included, such as presence of primary, secondary or planted forests, as well as their age, **to stratify results by the type of forest**;
- This estimates aboveground and belowground biomass carbon stock and sequestration **according to IPCC guidelines (2006, 2013, 2019);**
- The approach can be applied to time-series data **to identify trends and locate where significant changes are occurring.**

Limitations: Despite these advances, the current model has limitations, including its reliance on Tier 1 estimates, lack of data on ecosystem degradation, and challenges in accurately mapping soil and coastal carbon.

Coastal protection

- **Supply** (Protective effect): Calculated as the difference in hazard proneness with and without marine ecosystems (ΔH = H_without - H_with). Hazard include proneness of the land to coastal flooding due to wind waves, storm waves, and surge potential.
- **Demand** (Who needs protection): Defined as populations and assets located in hazard-prone and vulnerable coastal areas, concretely low elevation coastal zones (LECZ)
- **Service used**: The realized service is the reduction in risk for exposed population (in number of people) and infrastructure (in sqrm) where ecosystems are present
- **Key inputs**: Ecosystem extent for **mangroves, seagrass, salt marsh and corals**, climate reanalysis (waves, winds, surge), and socio-economic data (population, GDP, built-up areas, night-time lights, GRDI, LECZ).
- **Outputs:** map of protective effect (ΔH), estimates of population/infrastructure by hazard class (with/without ecosystem)

Limitations: The model relies on generalized global proxies (e.g., GRDI, LECZ) that may not reflect local socio-economic conditions. Ecosystem condition and degradation are not fully captured, leading to possible overestimation of protective capacity. Finally, the integration of datasets at varying spatial resolutions introduces uncertainty and may mask small but critical areas of risk or protection.

Recreational services (cultural)

- **Supply: Recreation potential** is a combination of a landscape's attractiveness and its accessibility. Attractiveness is determined by features like ecosystem type, protected areas, visual quality. Accessibility is based on factors like transport infrastructure and distance to urban centers.
- **Demand: Visits** statistics, such as overnight stays, are integrated with the recreation potential data. Assumptions are made about the proportion of overall tourism that is nature-based. This data is then spatially attributed to different ecosystem types.
- **Key inputs**: Statistics on recreational visits (e.g., from UNWTO and national offices), land cover, protected areas, topography, and urban settlement, as well as official Recreation Opportunity Spectrum (ROS) maps.
- **Outputs**: Maps showing nature-based tourism utilization, as well as supply and use tables consistent with the SEEA-EA framework.

Limitations: The limitations of this methodology include an over-reliance on generalized assumptions and proxy data, due to a lack of detailed, consistent visitation data across many countries. This approach also omits the recreational benefits for local communities and faces challenges in accurately attributing tourism visits to specific ecosystems.

Development of global databases

- For indicator A.2 on extent of natural ecosystems:
  - Use the global synthesis map to compile ecosystem extent accounts
  - Use ecosystem extent accounts to compute the value of the A.2 indicator for countries

- For indicator B.1 on provision of ecosystem services:
  - Aiming to generate global data maps of ecosystem service supply and use for the four ES
  - Based on the maps provide estimates for ES supply by country

- Global databases to be available in AIRES for SEEA for users by end of June 2026
- Countries could use these global data to report on the GBF indicators if they wish to do so

Useful links:

- ARIES for SEEA | System of Environmental Economic Accounting
- ARIES - ARtificial Intelligence for Environment & Sustainability | ARtificial Intelligence for Environment & Sustainability (integratedmodelling.org)
- https://aries.integratedmodelling.org/collaborate/
  - > Links to wiki / confluence pages
  - > Getting started with k.LAB (integratedmodelling.org) [videos]