ARIES

ARtificial Intelligence for Environment & Sustainability

SEEA Ecosystem Accounting: Regional Training Workshop for Asia and the Pacific

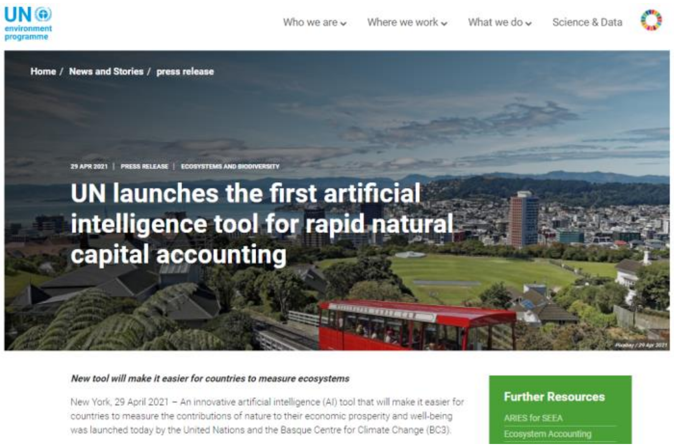
6th of June 2023

Making Science Matter in Policy-Making Where Nature Counts.

ARIES for SEEA

ARIES for SEEA - modeling environment & data hosting platform to support countries' compilation of ecosystem accounts

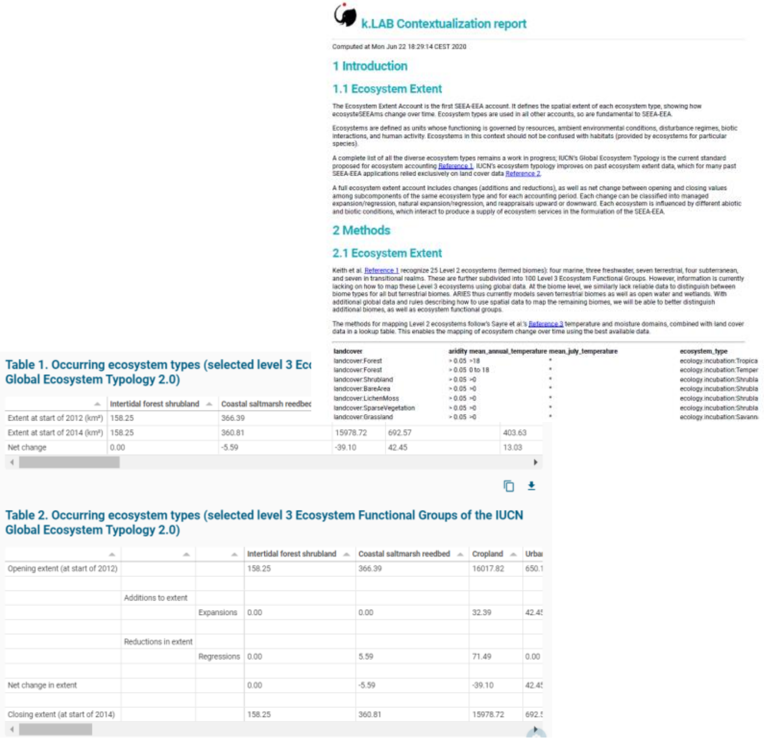
- ➢ Enables SEEA EA compilation anywhere on earth for national review/ vetting
- ➢ Where local knowledge (data, models and model parameterizations) are available:
  - Data and models made interoperable & reusable to substantially ease future application, production of maps & tables
  - Development of data collection template
  - Handbook/guide to obtain accounts-ready data to assist countries with less experience and build capacity within their teams



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

ARIES for SEEA Explorer[1], an application running on the ARIES platform

- Most common global data sets, many of them based on EO (e.g., land-cover; elevation; precipitation) already integrated
- ARIES' modular modelling nature (opposed to monolithic approach) facilitates the improvement and dissemination of national/local data & models
- AI → **machine reasoning** to construct best-available model for region of interest
- **Transparent** (metadata + download + analysis replicability + free access)



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

Global vs. local datasets

Global data (e.g., ESA-CCI land cover) harmonise information for all countries on Earth, are **consistent over time**, enabling **direct comparison across years & countries.**

Local data are typically **more accurate, trusted, well-suited** for local/national use but are single observations. Combining & harmonizing multiple versions to obtain a time series can be **cumbersome**.

Possible solution:

1. **Semantic** annotation provides **consistent definitions** of the data

What does semantic annotation mean?

identifying and correcting inconsistencies (e.g., different projections or country boundaries, illogical transitions, no-data values)

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Web-semantic modelling

Semantics are concepts

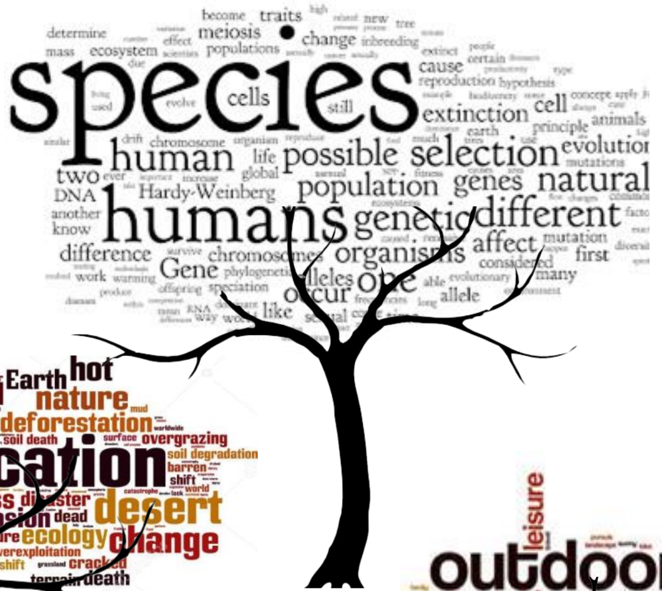
spe
cies

FARM

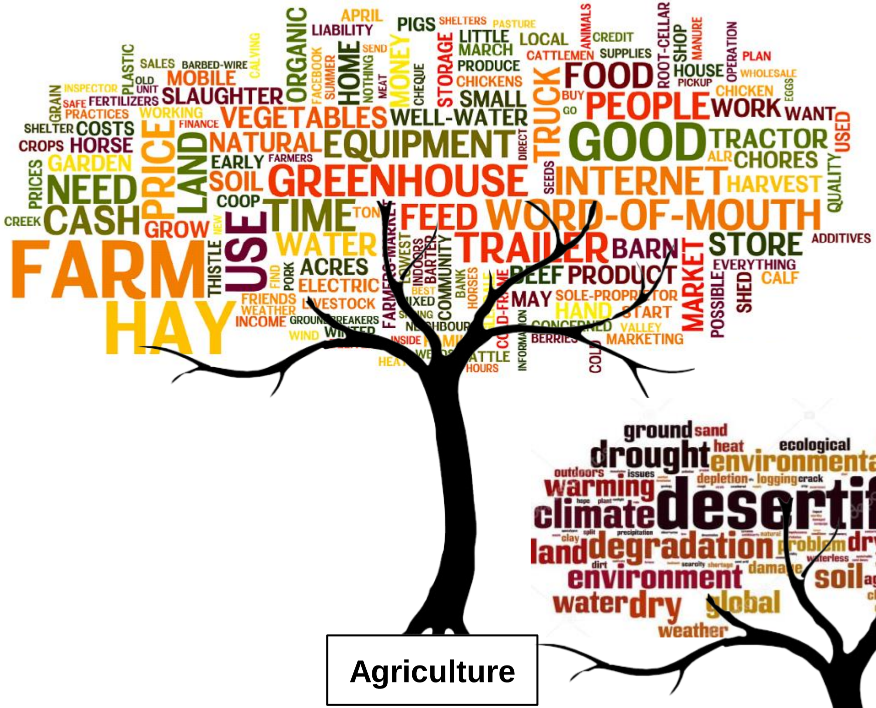
global

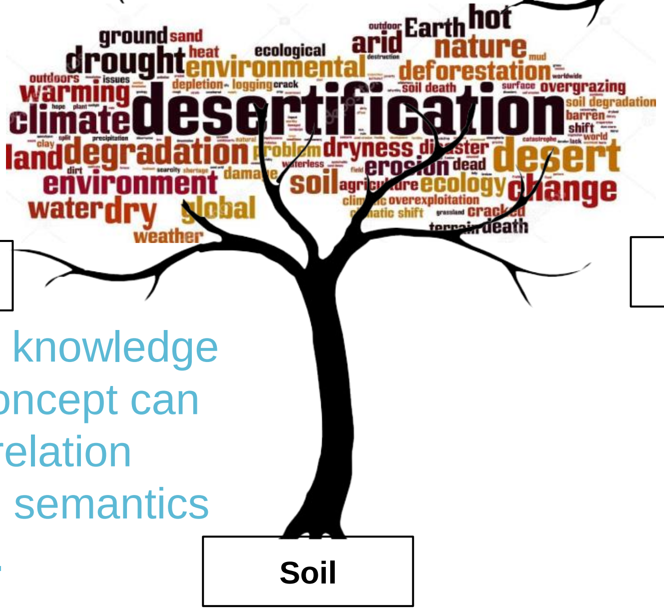
outdoor

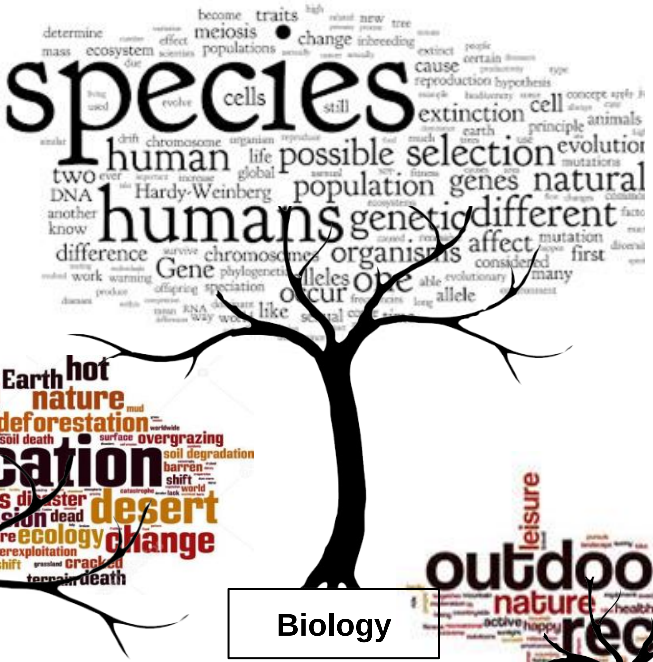
What do they mean and how are they interconnected with each other?

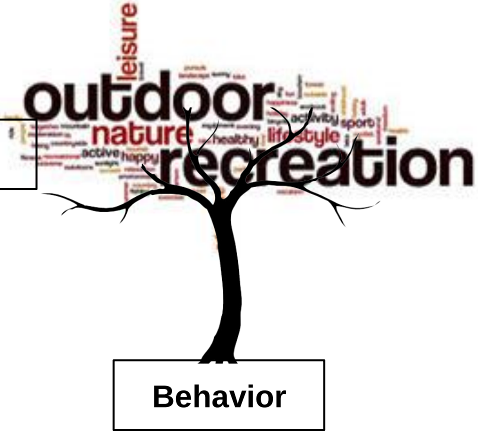


The definition and the relation with other concepts are defined in the **ontology**









Depending on the area of knowledge applied, each semantic concept can change its definition and relation (ontology), for this reason semantics are grouped by **domains**.

Growth

im

```
abstract process Growth
"Any endogeneous transformation happening in a system its internal structure."
        is IntransitiveProcess
        has children
                (Growth
                        "Positive or negative growth makes a system acquire a larger size or functional throughput"
                creates Collapse);
```

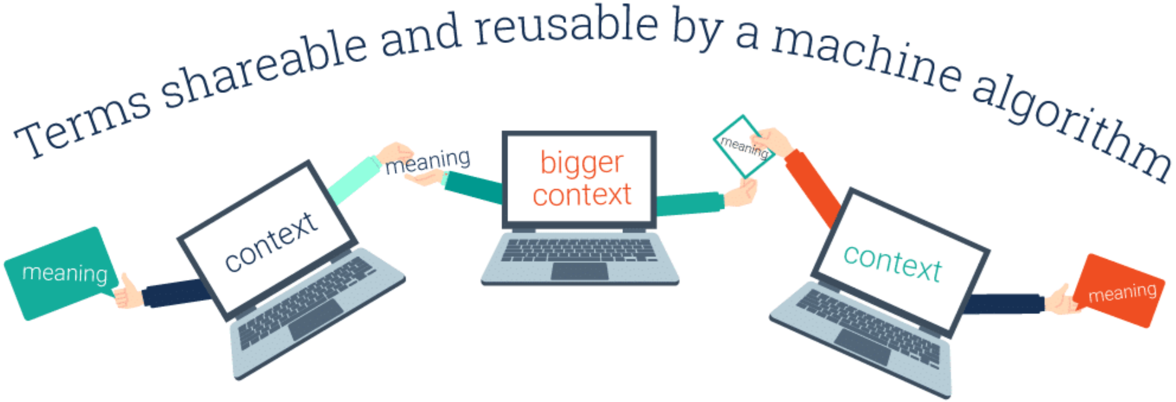
Ecology

```
process Growth
"Growth in ecology refers to population growth."
        is im:Growth within Population
```

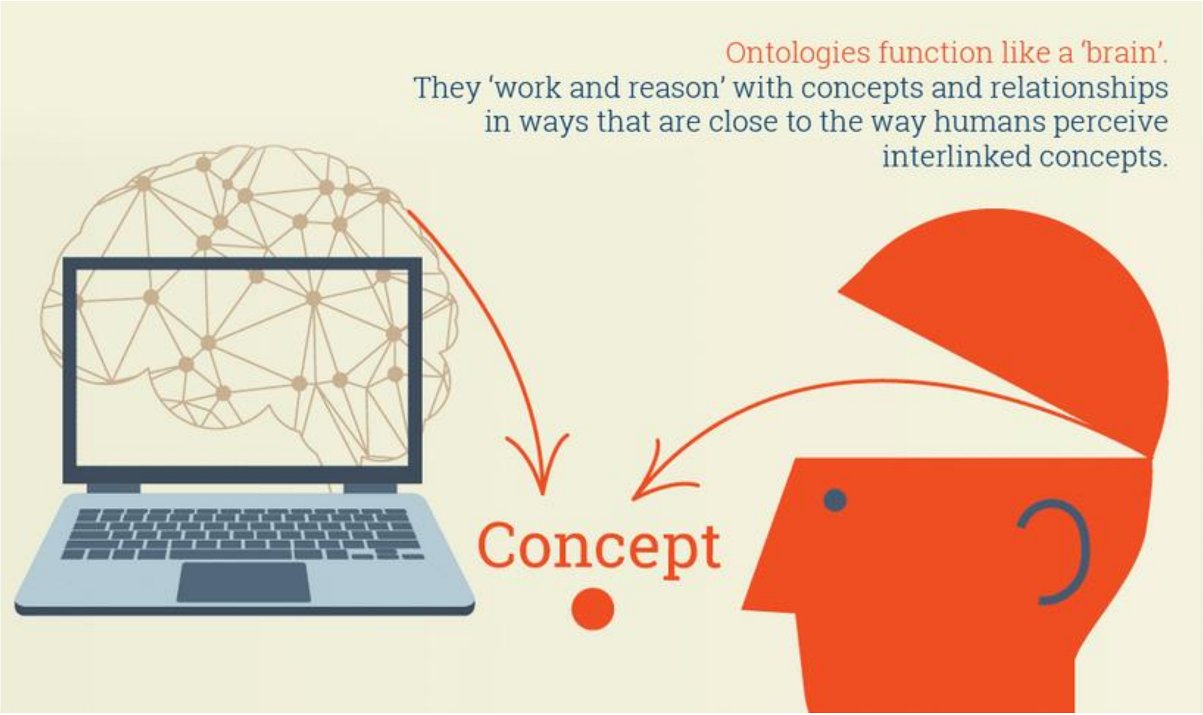
Biology

```
process Growth
"Biological growth only happen during life and affects the biomass of an individual."
        is im:Growth
                affects Biomass within Individual
                applies to Life;
```

Well-defined concepts, are written in our language but also machine-readable. This allows is the ability of the artificial intelligence to think automatically or semi-automatically **(the machine reasoning).** Moreover, this enables the information to be exchanged with other machines and also adjusted to different contexts. Since it's an **open and collaborative** system, this is **constantly improving**



N. Guarino, D. Oberle and S. Staab, "What Is an Ontology?" In: S. Staab and R. Studer, Eds., Handbook on Ontologies, Springer Berlin Heidelberg, Berlin, Heidelberg, 2009, pp. 1-17.



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```
Model'local:alessio.bulckaen:im.countrysupport.philippines:im-nca-philippines.lc_32651_50m_vnd_2010',
     'local:alessio.bulckaen:im.countrysupport.philippines:im-nca-philippines.lc_32651_50m_vnd_2015'
   as landcover:LandCoverType classified into
landcover:NonIrrigatedArableLandHerbaceous if 1,
landcover:OpenMixedForest if 2,
landcover:Shrubland if 3,
landcover:InlandWaterBody if 4,
landcover:ClosedMixedForest if 5,
landcover:Grassland if 6,
landcover:BareArea if 7,
landcover:ArtificialSurface if 8,
landcover:InlandSwamp if 9,
landcover:WaterBody  if 10,
landcover:PermanentCropland if 11,
landcover:Wetland if 12;
```

```
model "klab:copernicus.static:sis-agrometeorological-indicators:rainy_days_per_month”
as count of earth:Storm during im:Month named rainy_days_per_month;
```

```
model 'im.data.global:im-data-global-geography.elevation-global 90m
#interpolation=bicubic'
as geography:Elevation in m;
```

```
@intensive(space)
model ecology:Vegetation chemistry:Carbon im:Mass in t/ha
observing
landcover:LandCoverType without landcover:WaterBody named land_cover_type,
presence of chemistry:Burned earth:Region named burned_land,
type of geography:ContinentalRegion named continental_region,
presence of im:Critical (conservation:Pristine ecology:Forest earth:Region) named frontier_forest,
type of ecology:EcoFloristicRegion named ecofloristic_region
lookup (land_cover_type, ecofloristic_region, continental_region, frontier_forest, burned_land, ?)
into VEGETATION_CARBON_TABLE;
```

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Possible solution:

1. **Semantic** annotation provides **consistent definitions** of the data

2. ARIES can help verify whether data are suitable for accounting by **identifying and correcting inconsistencies** (e.g., different projections or country boundaries, illogical transitions, no-data values)

Data harmonization and time series

Geographical boundaries

Data **extent** must be **aligned**

Spatial resolution (BSU)

Common **resolution**

(the **coarsest** resolution of model inputs can determine spatial resolution **for the entire series**)

Consistency over time

Main causes:

Technology used to obtain satellite imagery

Algorithm & methods to **process** the **satellite images**

Different **classification**

Main correction:

Harmonize classifications & data content through **semantic annotation**

Correct **illogical transitions**

How can NSOs/governments use ARIES for SEEA

STEP 1
Methodologies for calculating SEEA accounts

STEP 2
Catalog national & subnational data, methods, models

STEP 3
Make data & models interoperable with ARIES for SEEA

STEP 4
Test & validate the models using ARIES for SEEA until positively endorsed by NSOs

STEP 5
Produce accounts using ARIES for SEEA; revisit underlying data & methods as new data/models become available

- **Note**: at no point above is there a step for "run ARIES for SEEA in your country using default global data/models," nor to "directly compare outputs derived from global data & models to results from step 4." Those steps could optionally happen, but publicizing results using global data/models too early may risk undermining confidence in the process.

Making models interoperable

- ARIES for SEEA is **not** just for countries with less experience in the compilation of accounts
- By making better science interoperable and reusable, developed data/models in other context could improve global uptake of SEEA EA more than traditional capacity building,
    - Model developers specify conditions under which a particular model or parameterization of a model is appropriate for reuse

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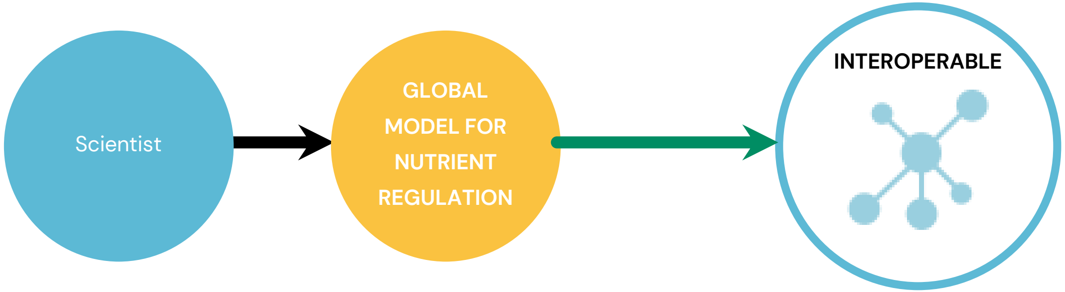
Example 1

A scientist has developed a global model for nutrient regulation (a service not currently available in ARIES for SEEA),



By making it interoperable, this ES can now be added to SEEA EA accounts in nations around the world

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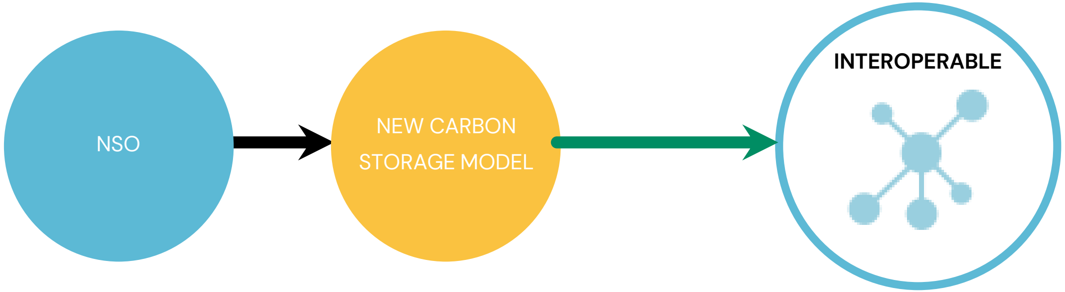
Example 2

A NSO has developed and vetted a new carbon storage model that works well within a large, multi-nation bioclimatic region



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- Given the power of this paradigm, we hope that agencies with more experience and stronger capacity support this more, benefiting other countries too.

Future opportunities

- **Strongly support EO4EA** & similar initiatives, which are essential **to mainstream adoption of environmental accounting**
- Working towards future data becoming **accounts-ready**
- Move towards (semantic) interoperability of data & models. For instance:
  - > Custodians of data sets (global & national) to share data through APIs / nodes
  - > Interconnect data through semantics / classifications
  - > For land use & cover, align with FAO-LCCS / LCML, for Ecosystem Type align with IUCN GET through experts' input - authorities & classifications custodians play an important role

Application Programming Interface is a way for two or more computer programs to communicate with each other. It is a type of software interface, offering a service to other pieces of software

A **node** is any physical device within a network of other tools that's able to send, receive, or forward information. A personal computer is the most common node.

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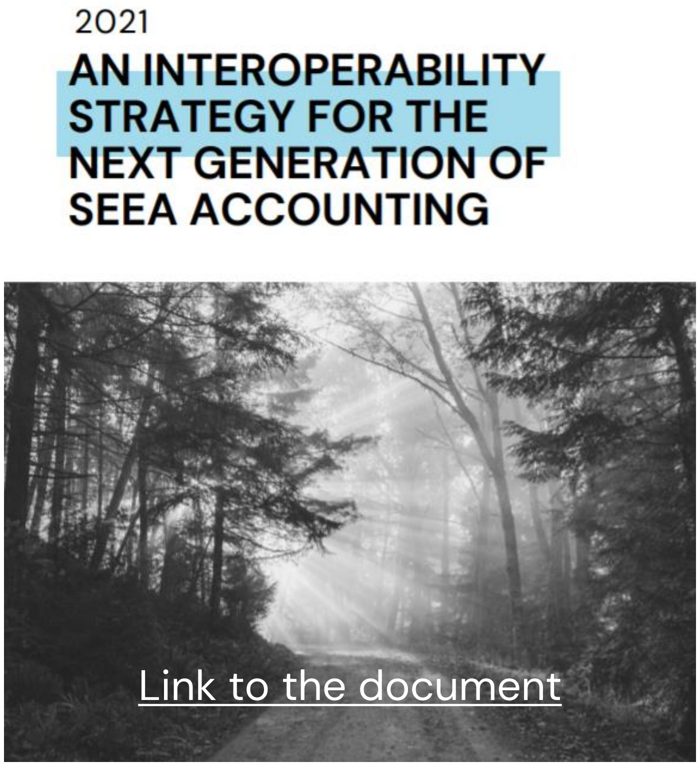

Roles of key stakeholders

- **Data providers** (NSOs, science agencies, academic scientists): agree on & provide data using common formats & hosting protocols (e.g., OGC[1] standards for spatial explicit data, SDMX[2] for tabular data)
- **Modelers** (science agencies, academic scientists): use modeling practices that will make models more easily linked & documented (more modular, less monolithic); use community consensus semantics
- **NSOs & other institutions** (NSOs, space/mapping agencies, GEO initiatives, large academic collaborations): endorse and maintain interoperable data & models over the long term.

- Publication Ethic: giving credit where credit is due - **Credit** for data and models provider(s) in ARIES

1. Open Geospatial Consortium – more info
2. Statistical Data and Metadata eXchange – more info

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Environmental modelling: finding Simplicity in Complexity

The complexity of environmental modelling

Data access and manipulation

- Difficulties to access the data
- Time to process the data
- Data storage capacity
- Access to results

The complexity of environmental modelling

Data access and manipulation

Multidisciplinarity

Forest

Environment

Biology

Geography

Ecology

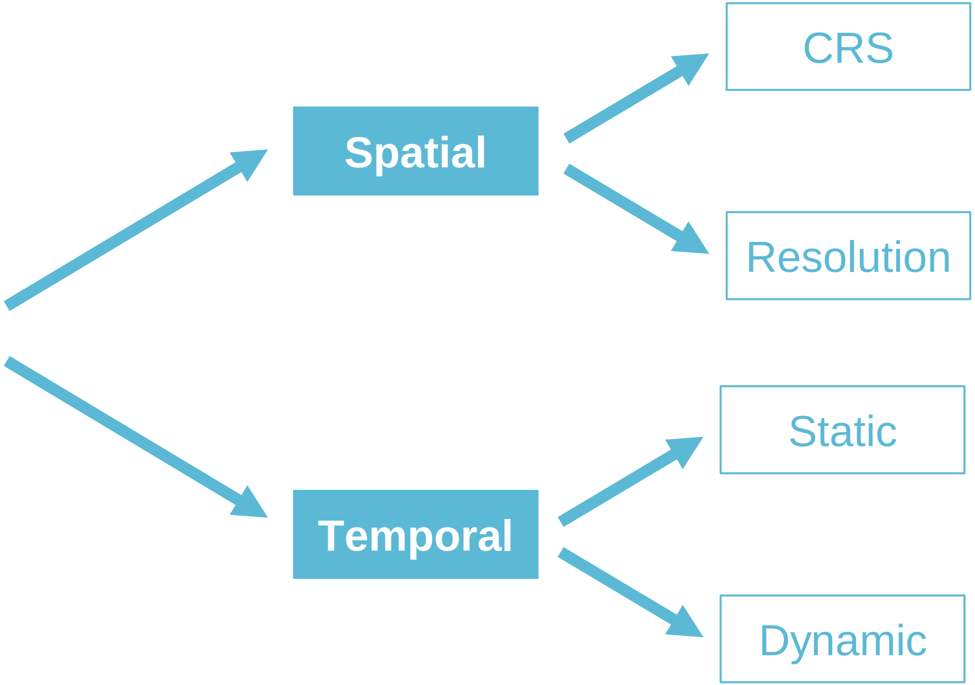
Social Agents

The complexity of modelling

Data access and manipulation

Multidisciplinarity

Different spatial and time scales


Spatial
CRS
Resolution
Temporal
Static
Dynamic

The complexity of modelling

Data access and manipulation

Multidisciplinarity

Different spatial and time scales

Blackbox models


Input
?
Output

FAIR principles

FINDABLE

Open, free and accessible data

ACCESSIBLE

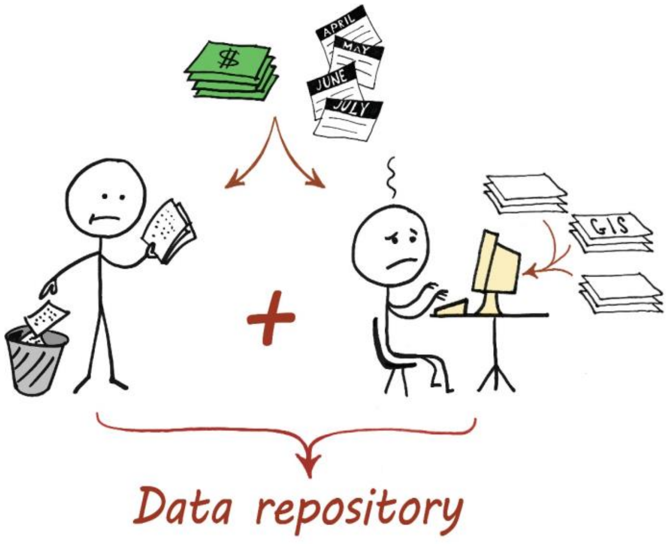
Unique identifier that allows to find data quickly and efficiently

INTEROPERABLE

Data are organized by thematic areas, but also related interconnected across them

REUSABLE

Data (and models) can be applied to other spatial and temporal contexts

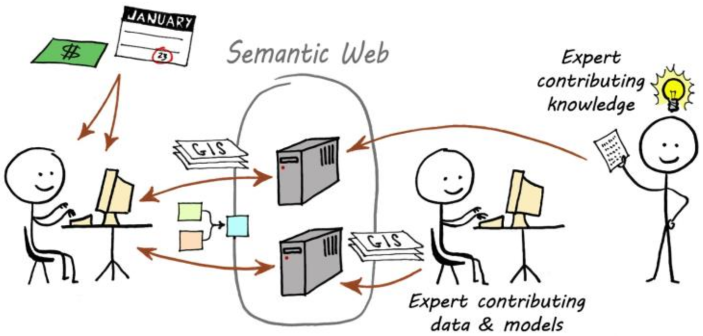


Status quo

A methodology is often **difficult to implement:**
- Time to obtain and process the data;
- Access and process the data and models;
- Limited computational capacity;
- Limited storage capacity.

Double-efforts are very common.

Everyday **accessibility hindrances**:
- Final users cannot access **results** (many time she's not a technician);
- Technical users cannot access the **models** to re-use, adapt or improve them.



Optimizing the processes through interoperability and the web-semantic

Totally transparent access to:

- Data;
- Methodology;
- Processing steps (the combination of the above);
- Results.

Great storing and computational **capacity**.

Interoperability within data and models.

Access for all users: expert, technical and non-technical.

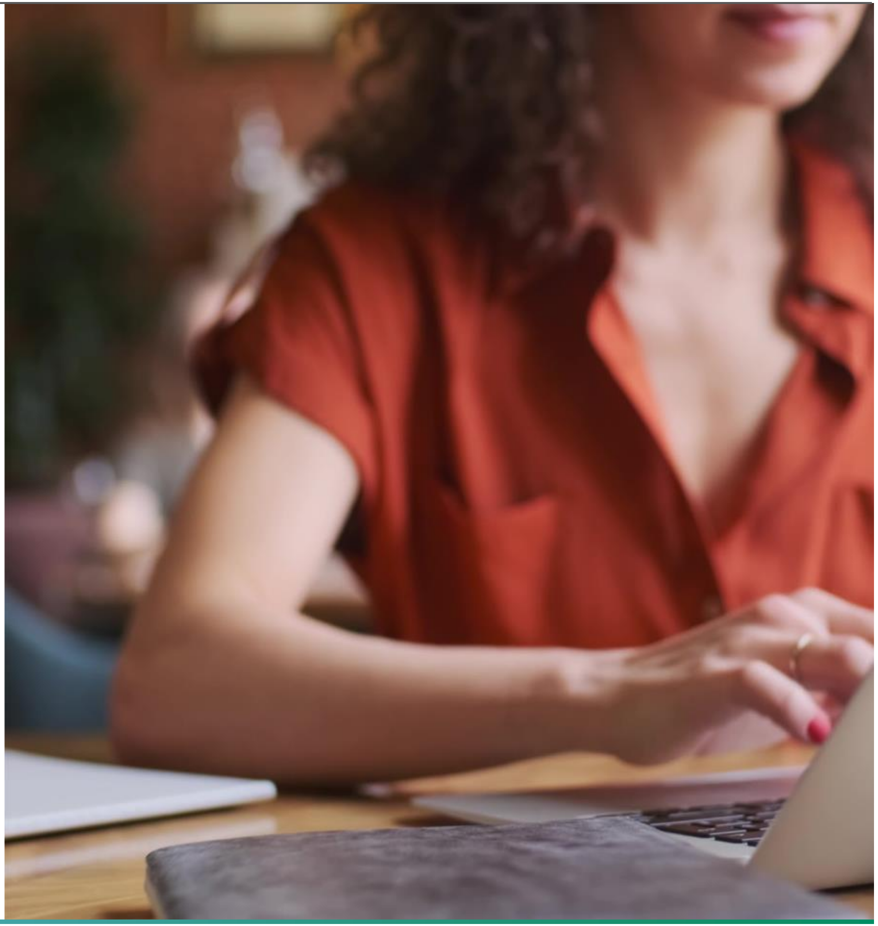
Collaborative platform to optimize efforts made by different experts in different areas.

Access the application

1. The first step is to **register** in the Integrated Modelling hub
2. Once created a profile, **access the link** to launch the application from your browser (or download the Control Center – the software for modelers, and install it on your engine)
3. Use the intuitive user-interface to **compile account(s) everywhere on earth**

Useful links to explore

1. ARIES for SEEA explorer
2. Registration in the IM hub
3. Technical note
4. YouTube channel
5. Write us for support at support@integratedmodelling.org or for if you're interested to join our modelling journey at aries@integratedmodelling.org



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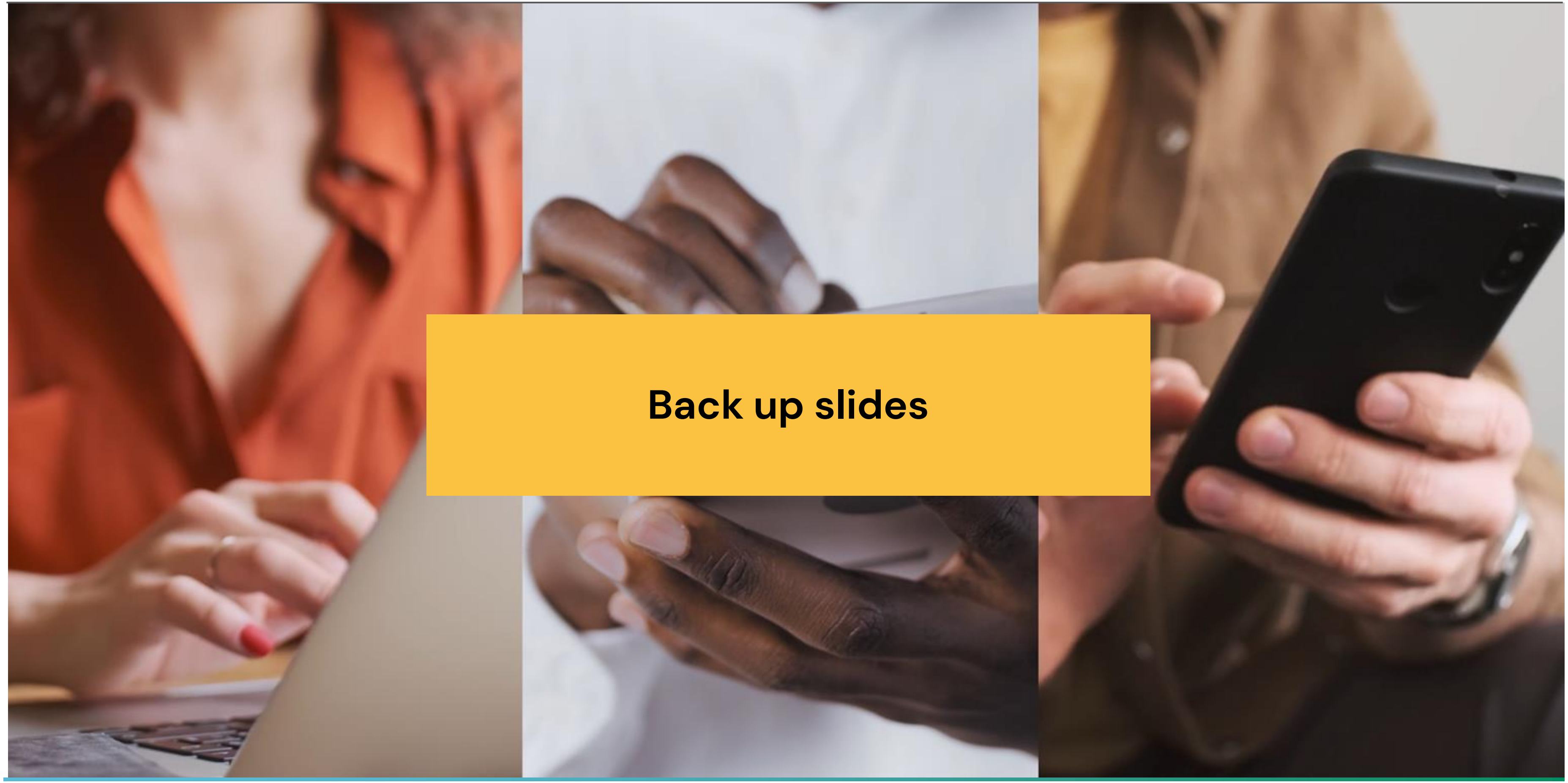
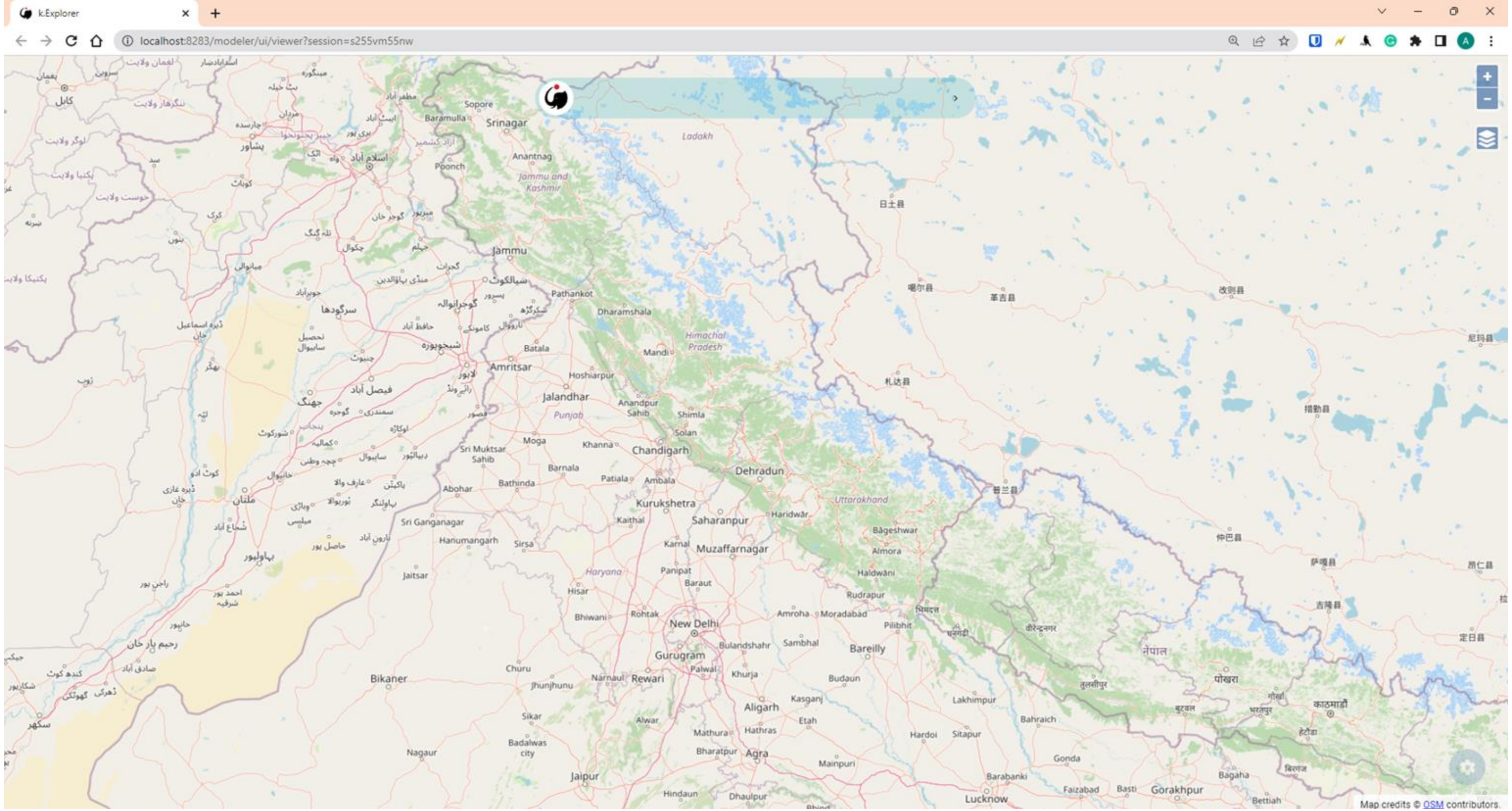
Thank you!



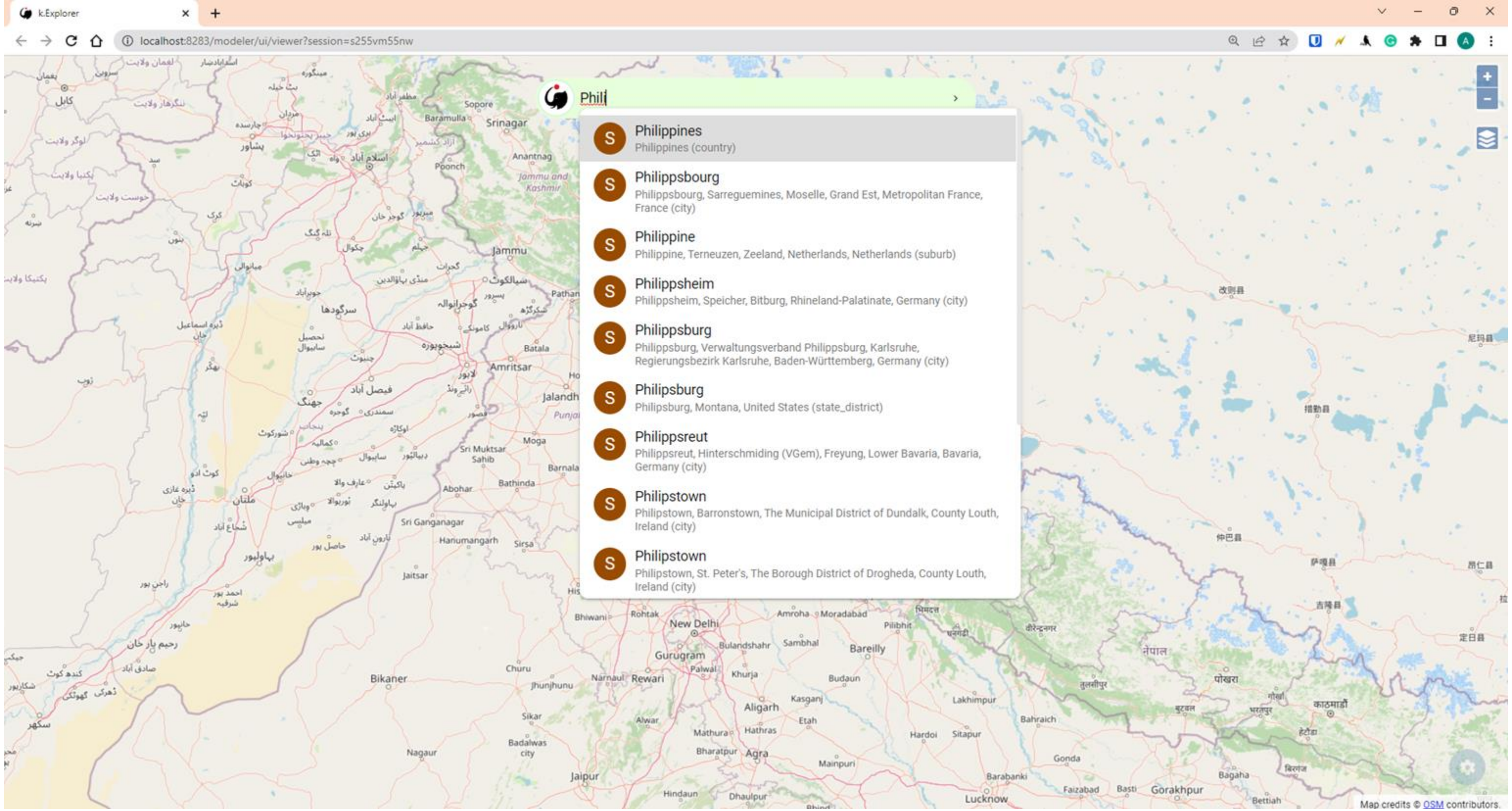
Back up slides

Hands-on session on the k.Explorer

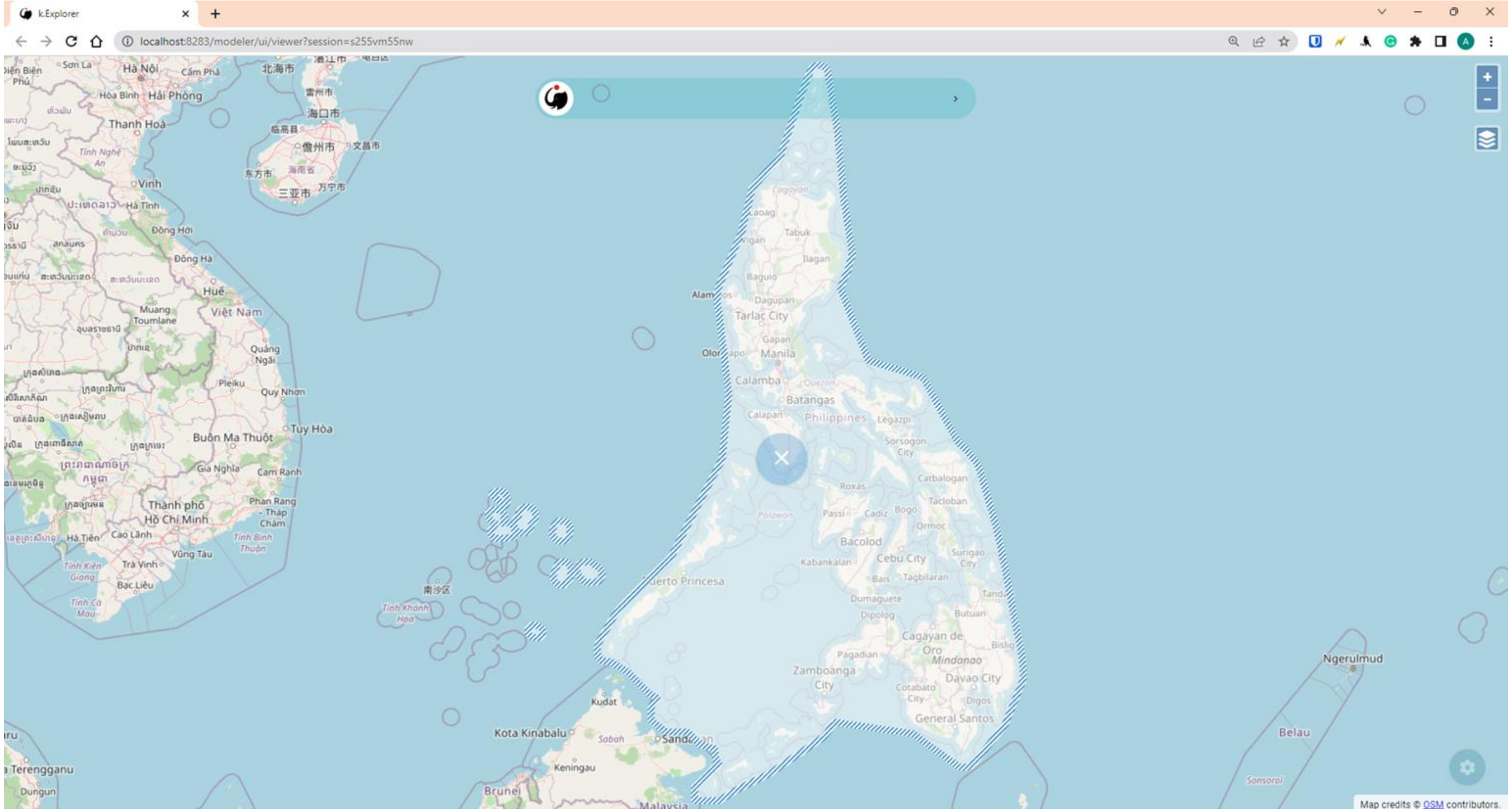
set a context by typing in the geographic location



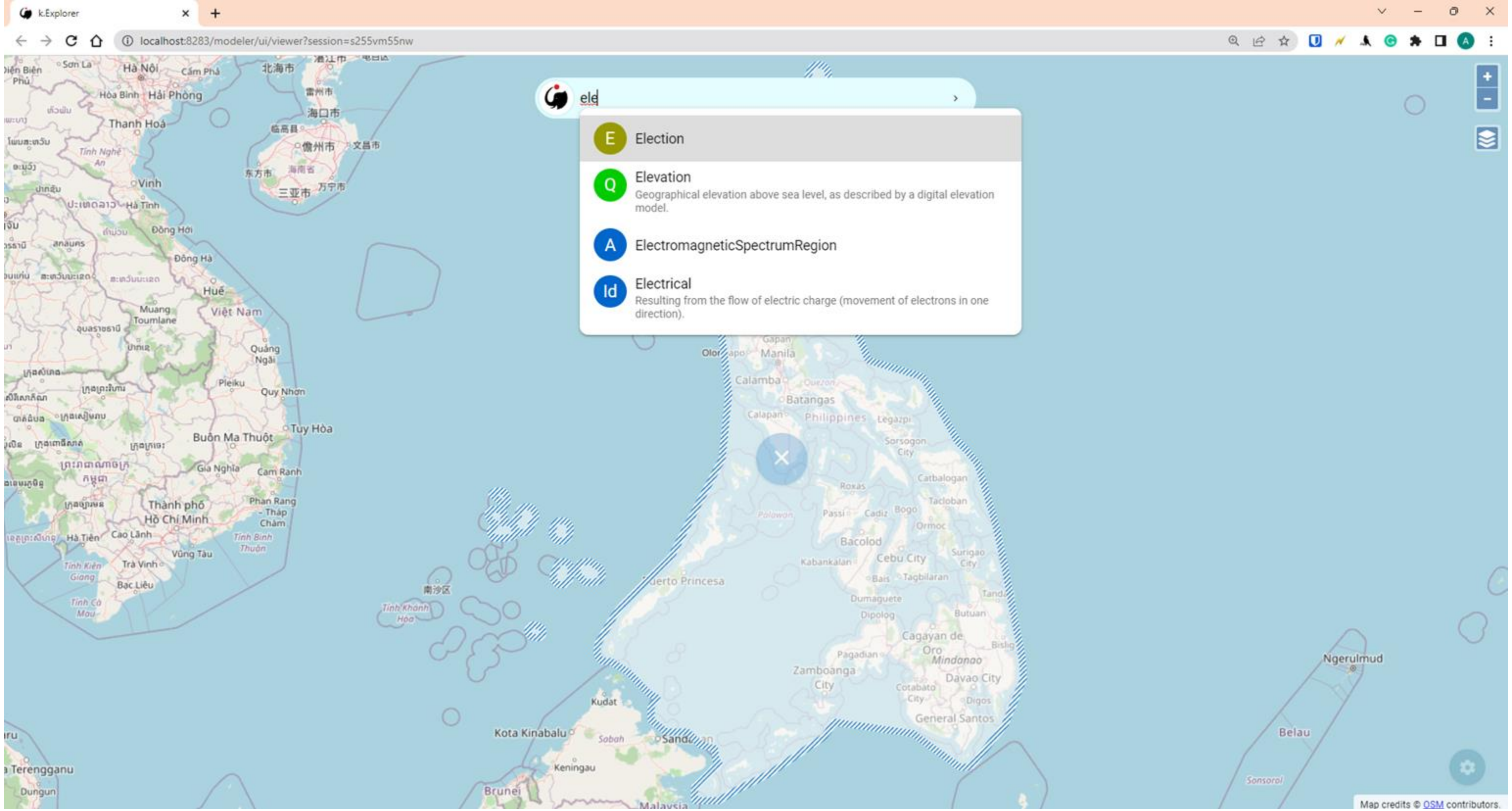
(use the upper case to browse for the name)



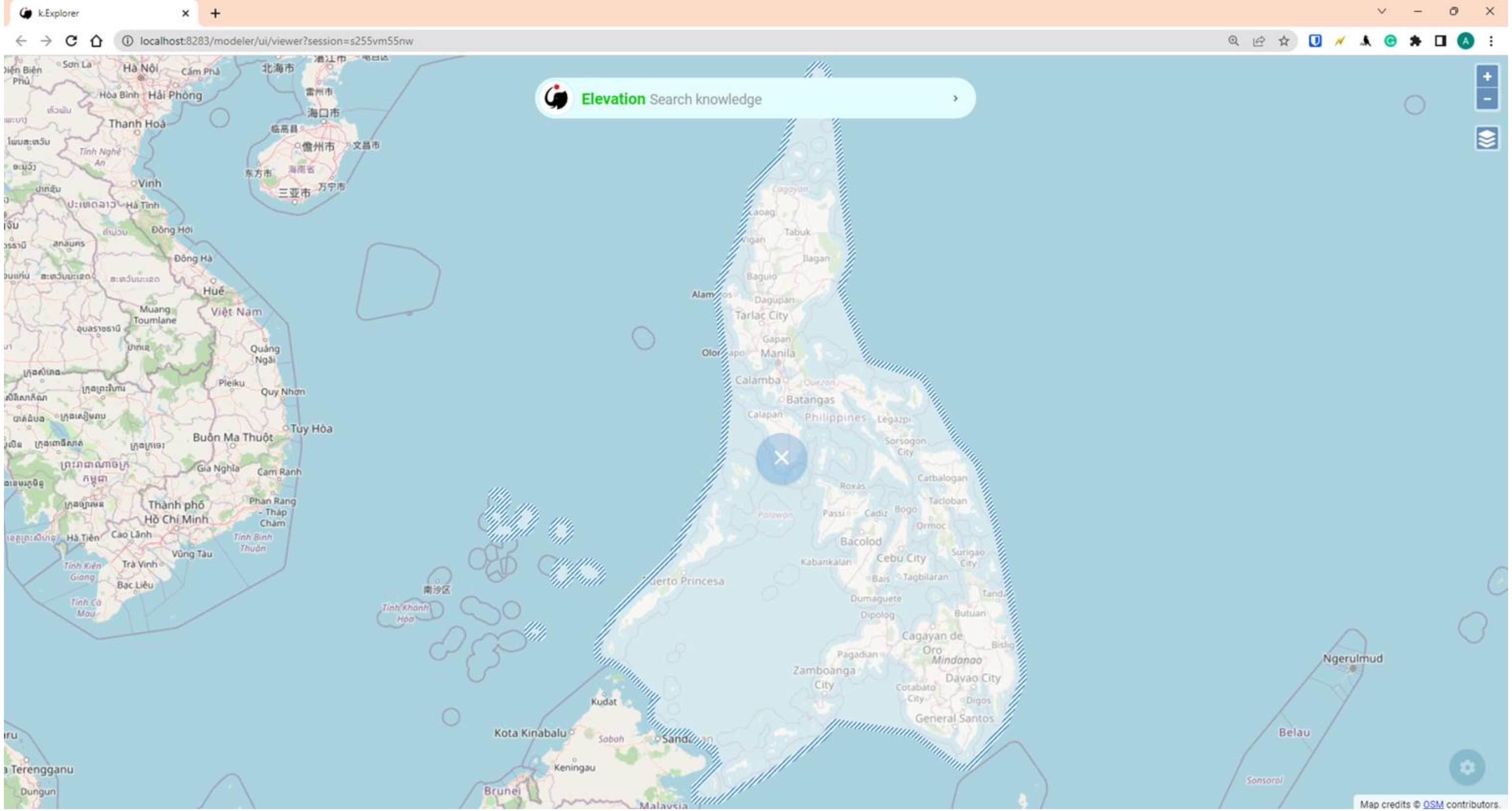
the k.Explorer sets the spatial context of your analysis



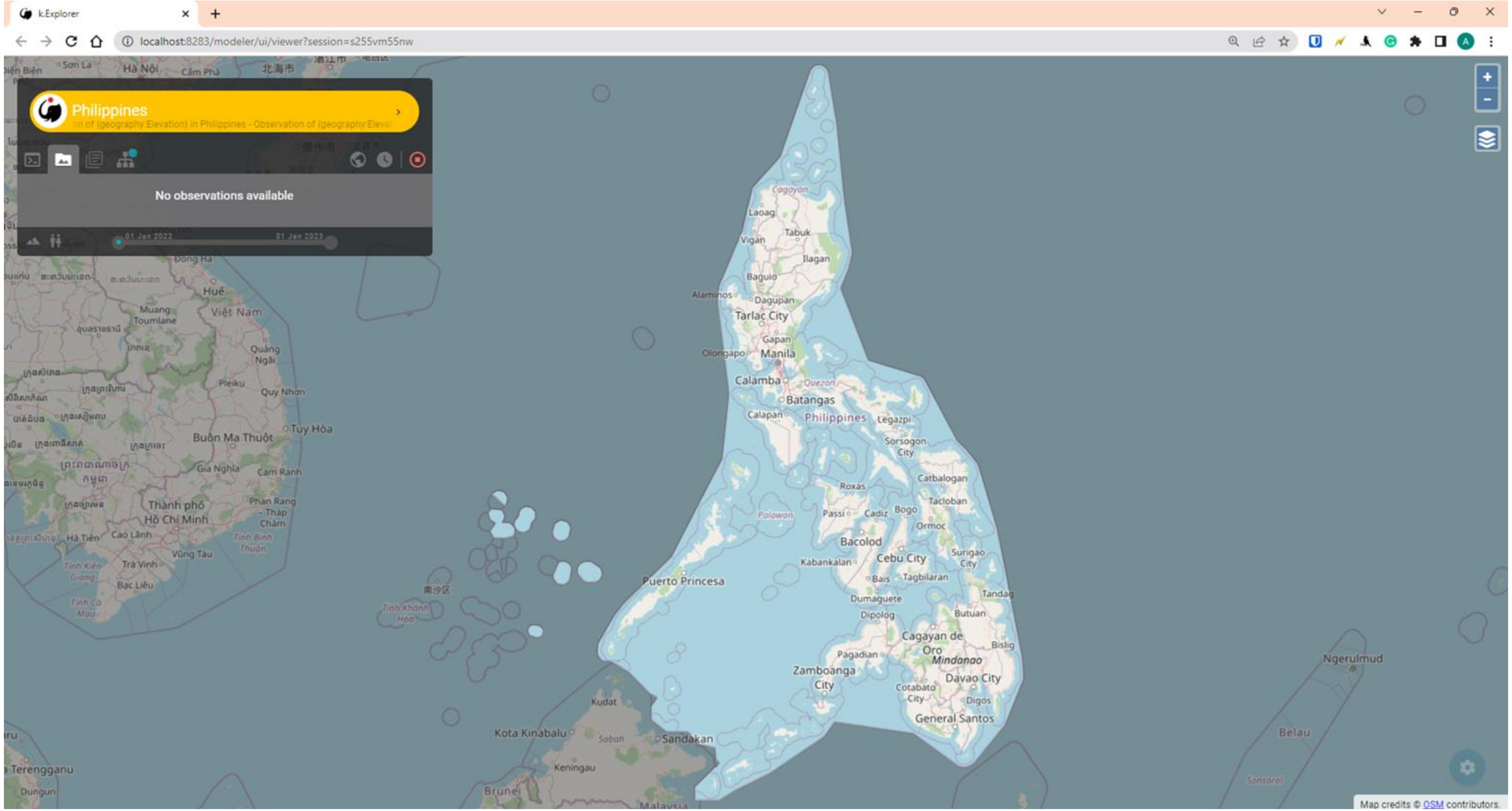
query what you want to observe (use lower case)



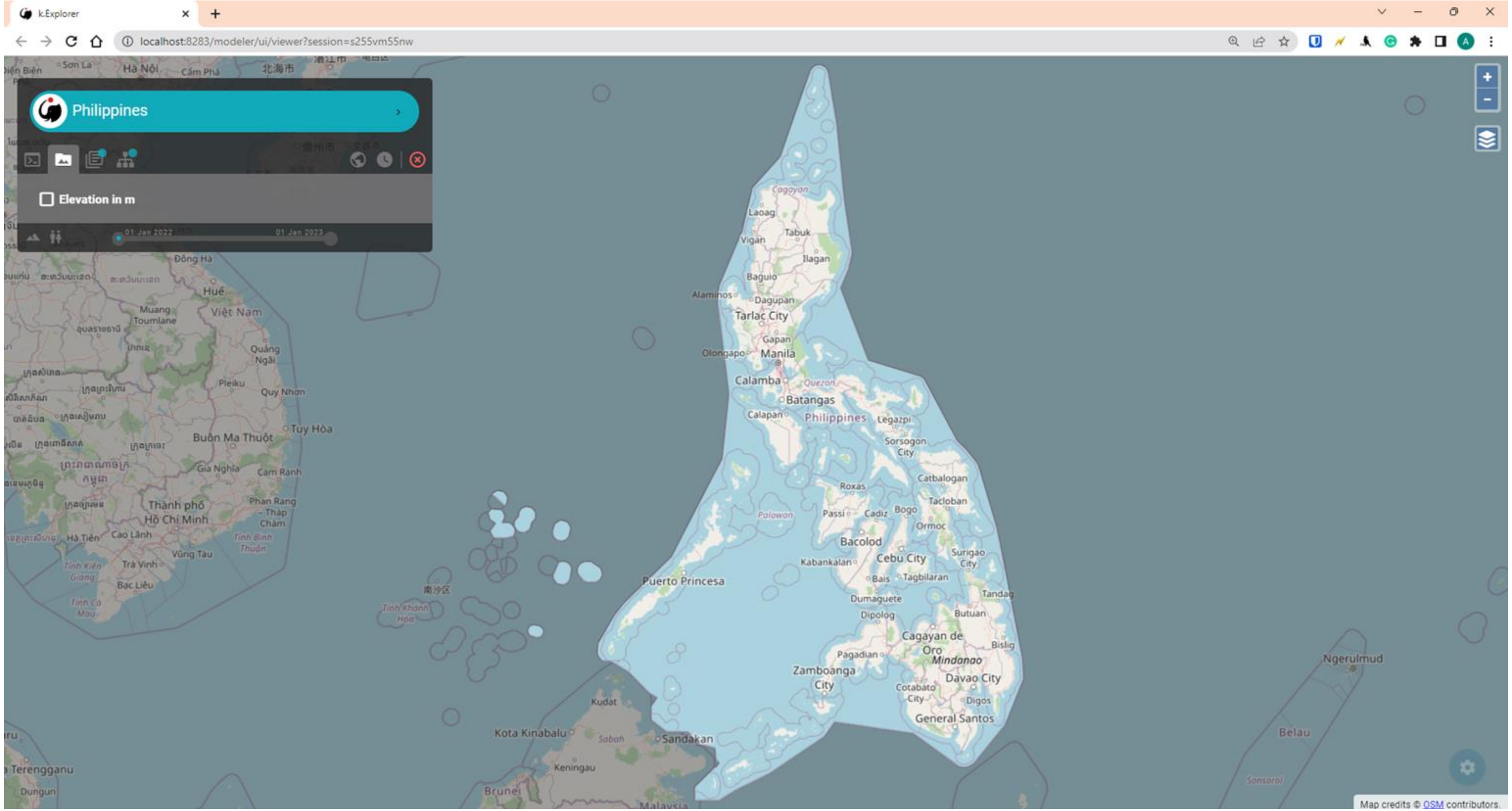
select the concept and press Enter



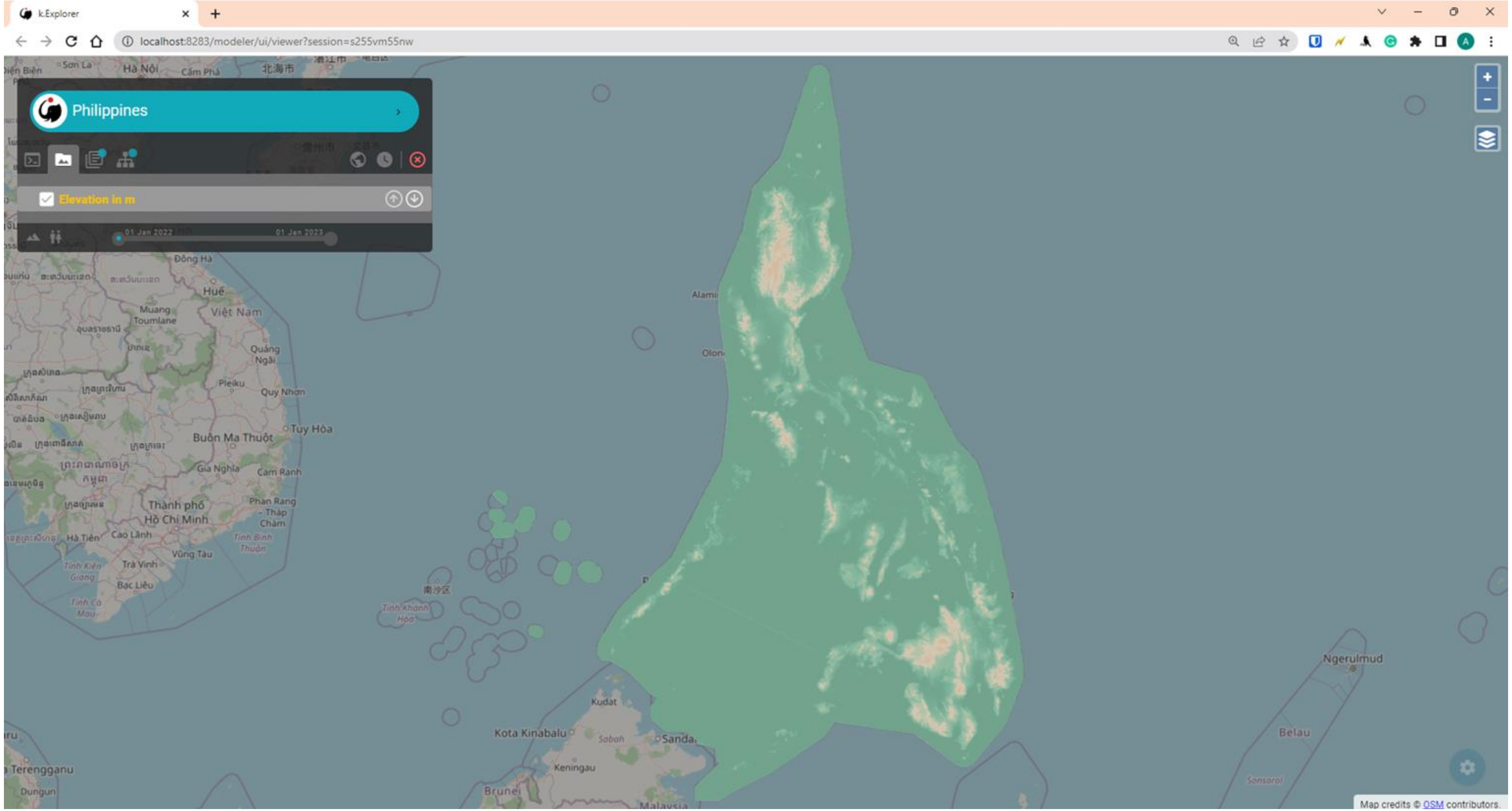
the k.Explorer starts the computation



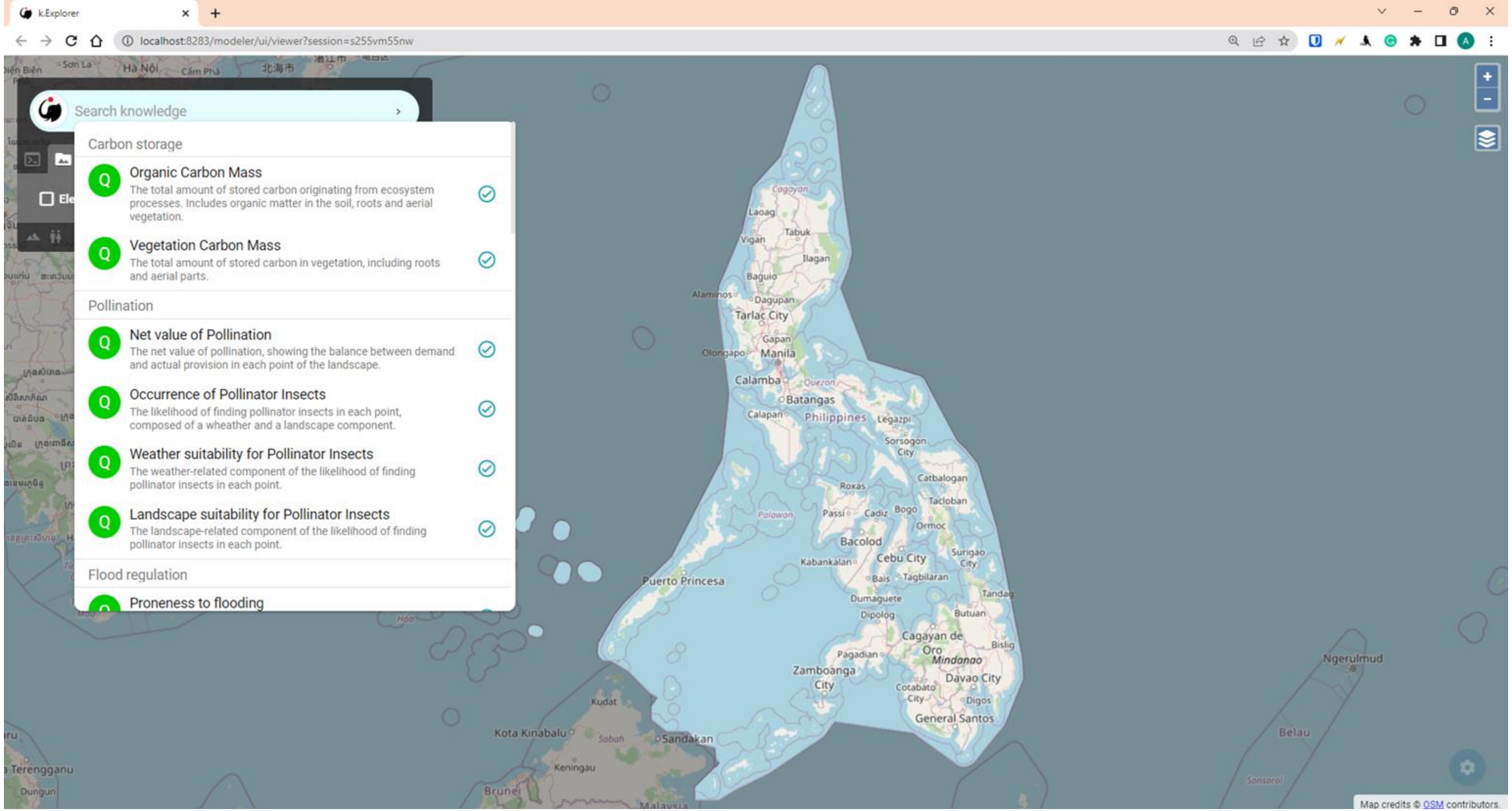
providing the answer for that context



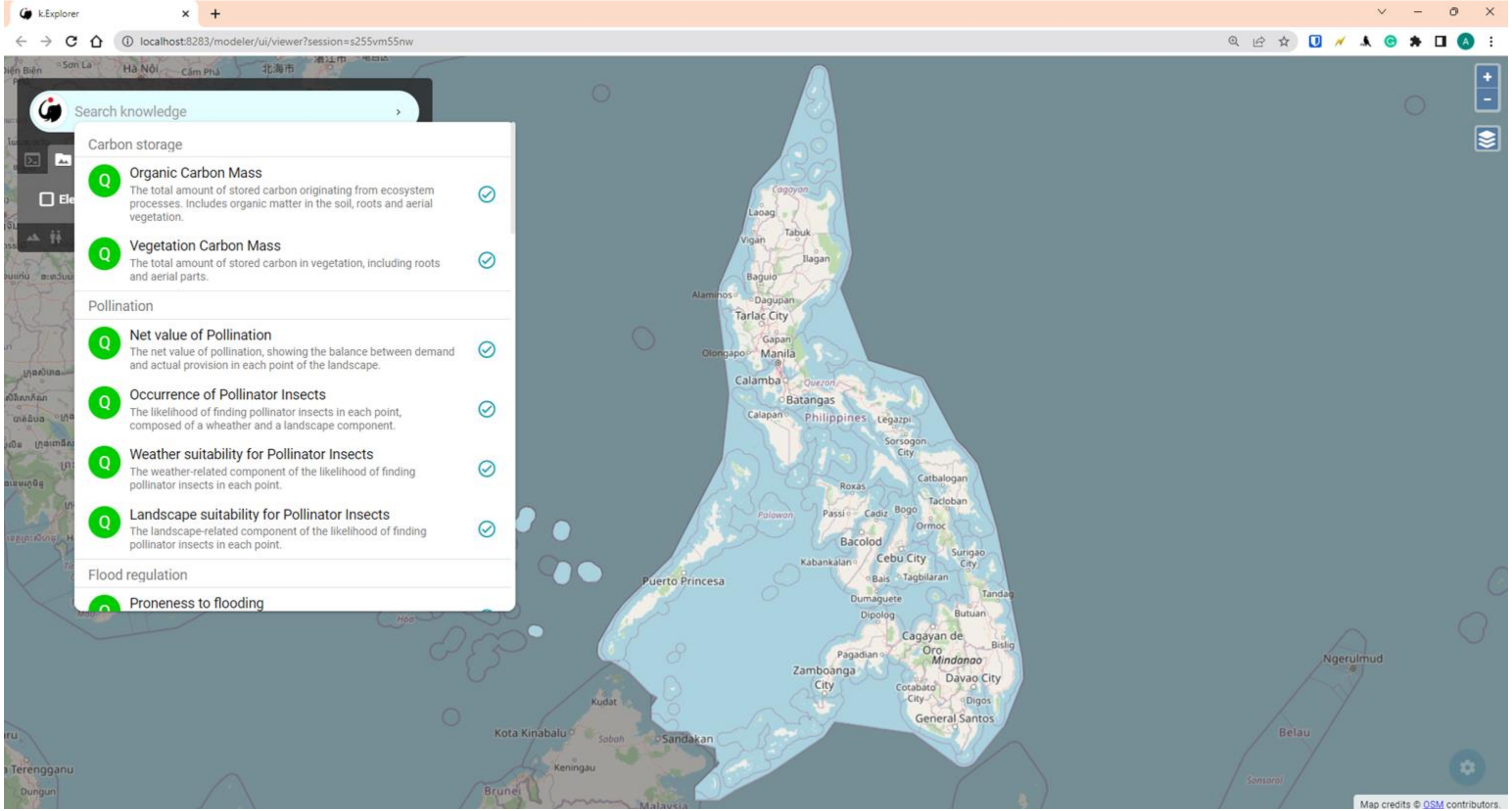
each output can be visualized in the interface



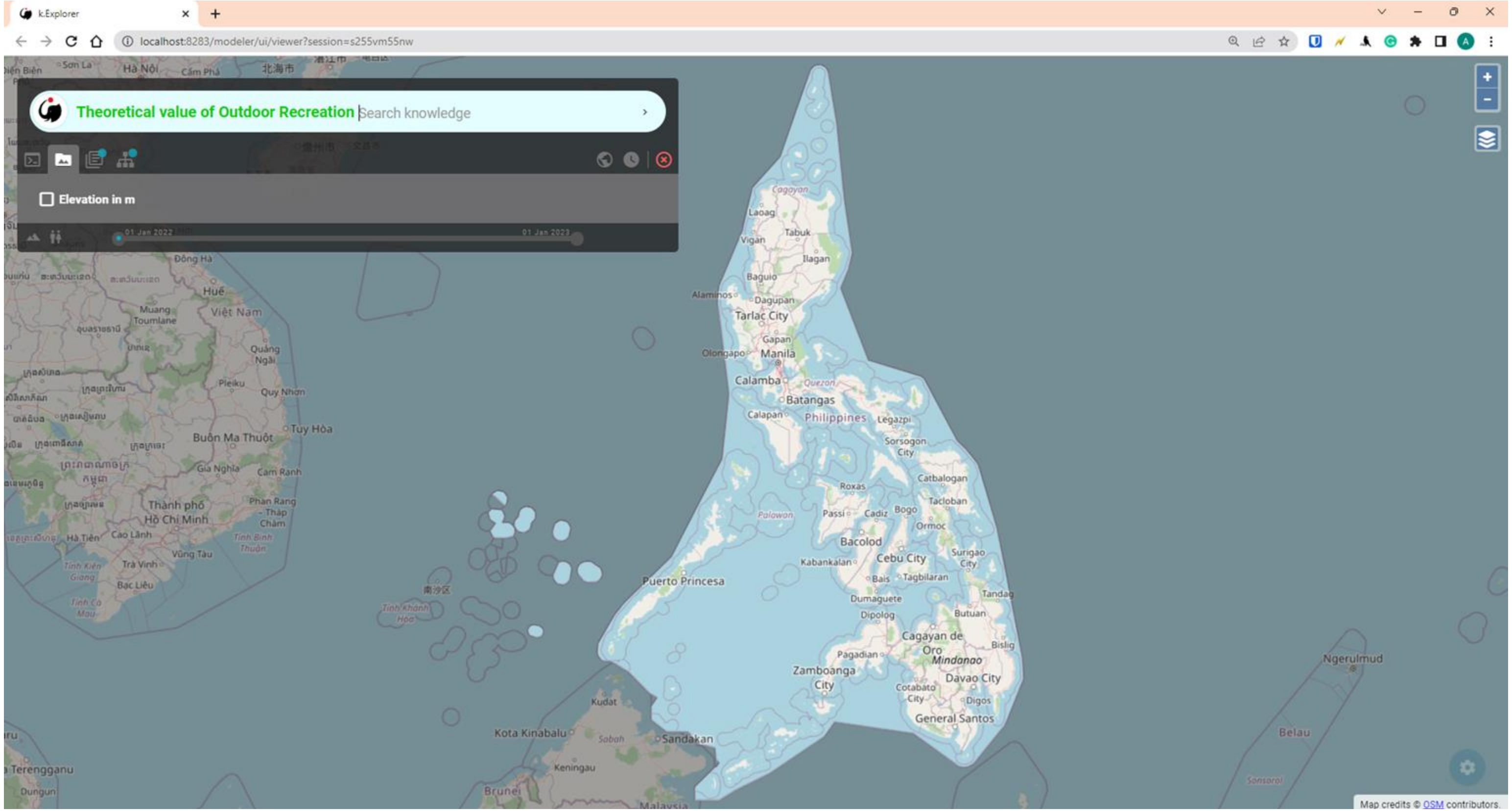
from the *Search knowledge* press the space bar



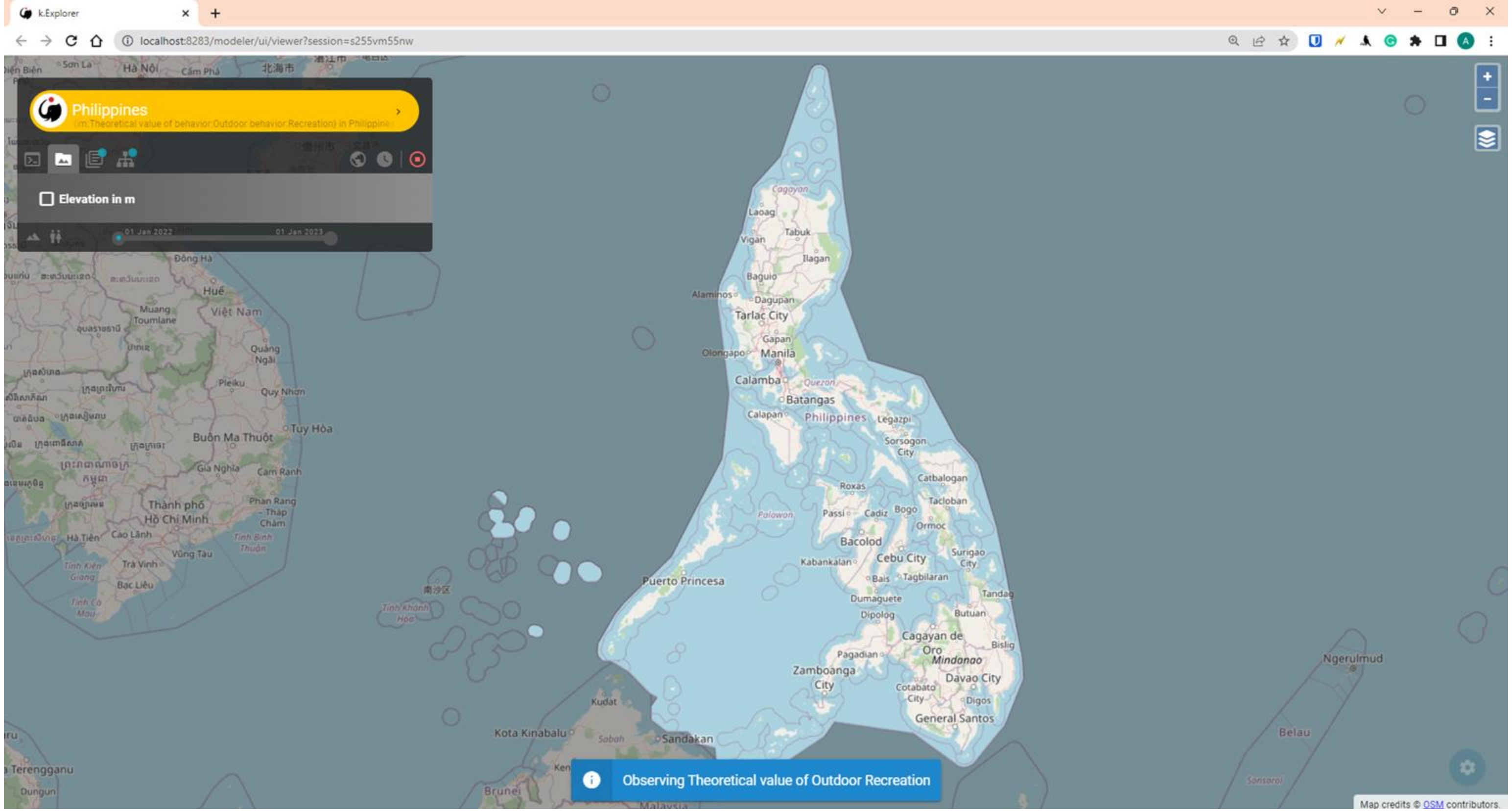
to obtain a drop-down menu suggesting commonly-used models



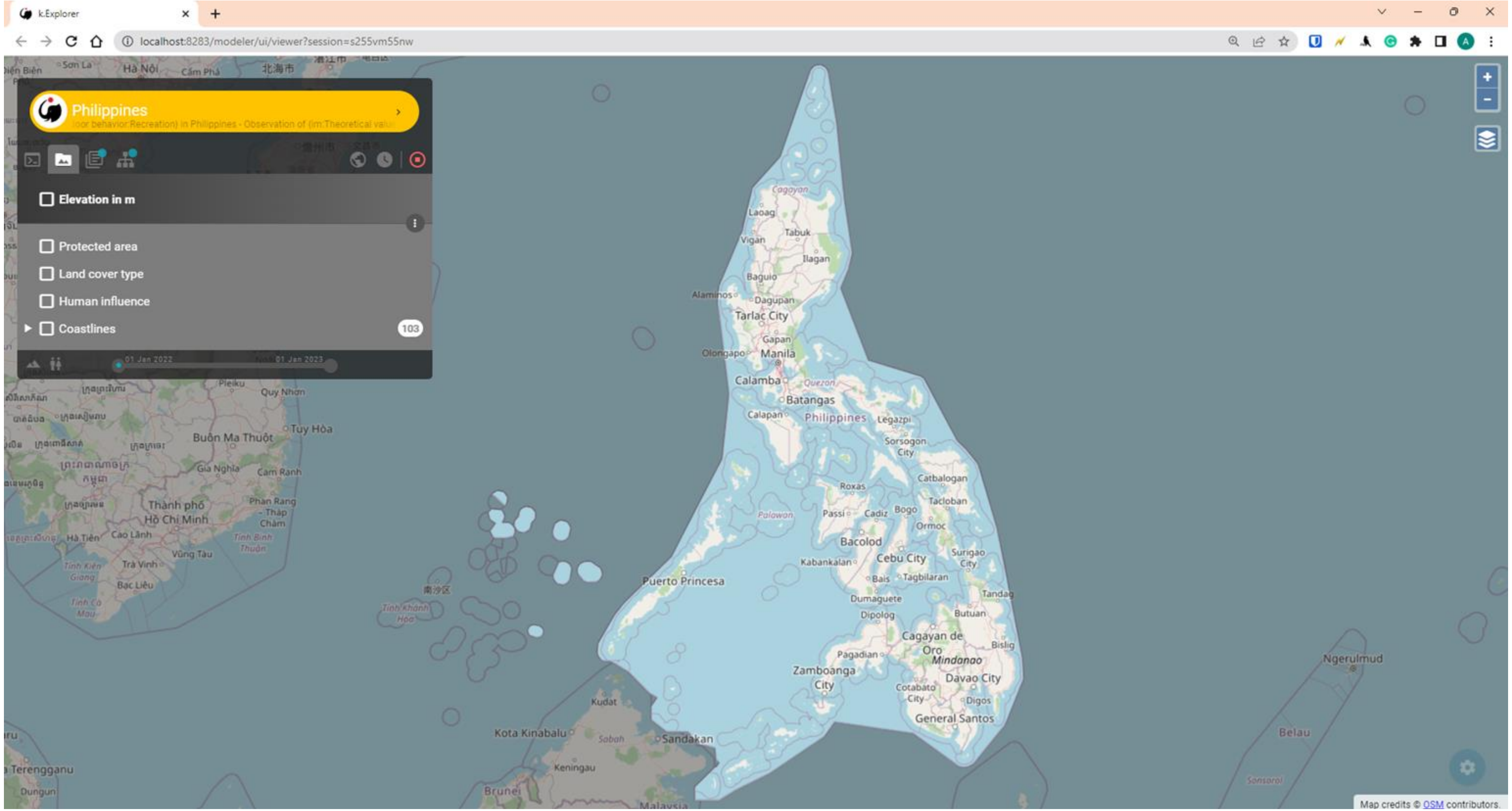
select the model



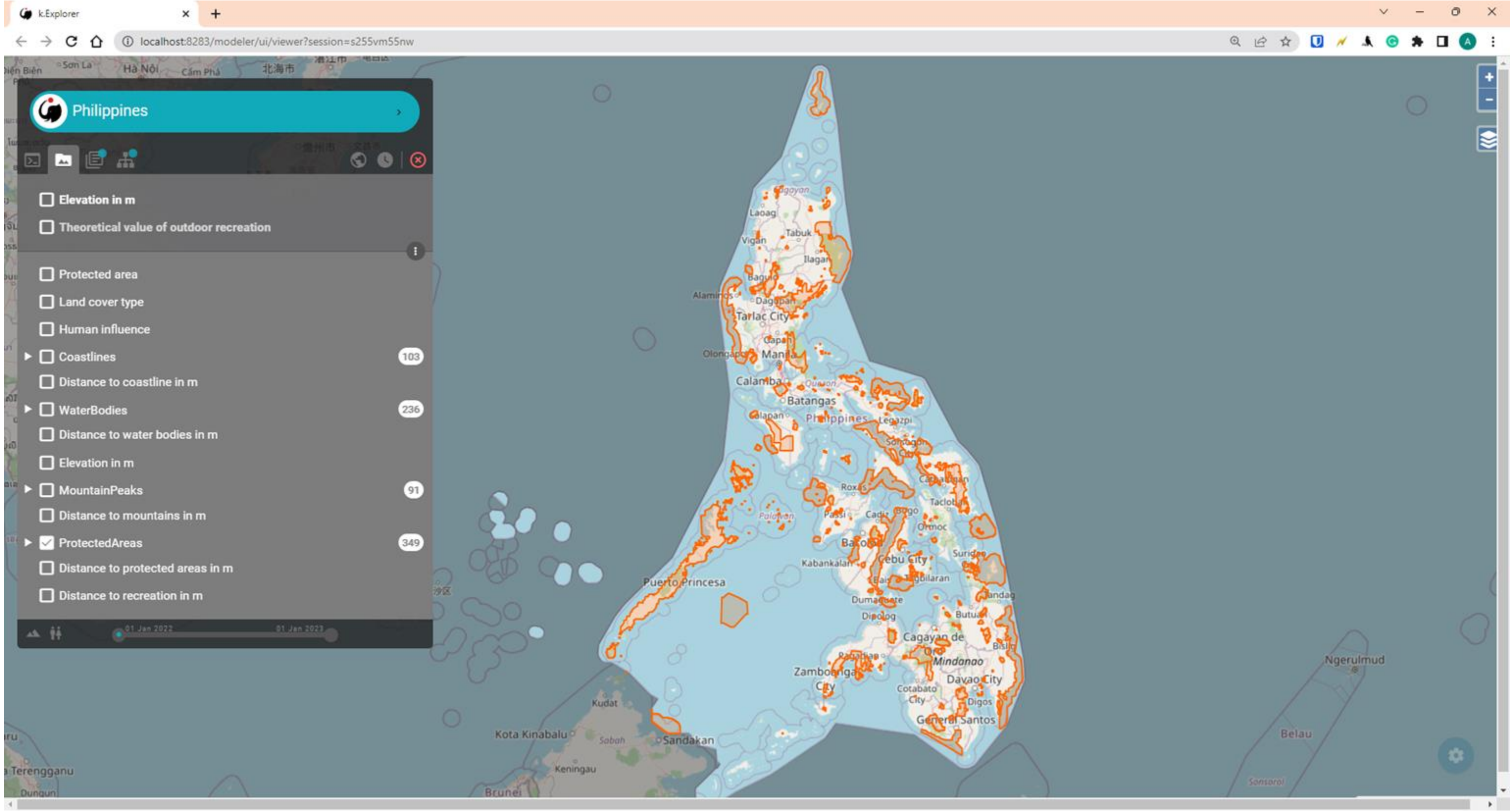
Press Enter to start the computation



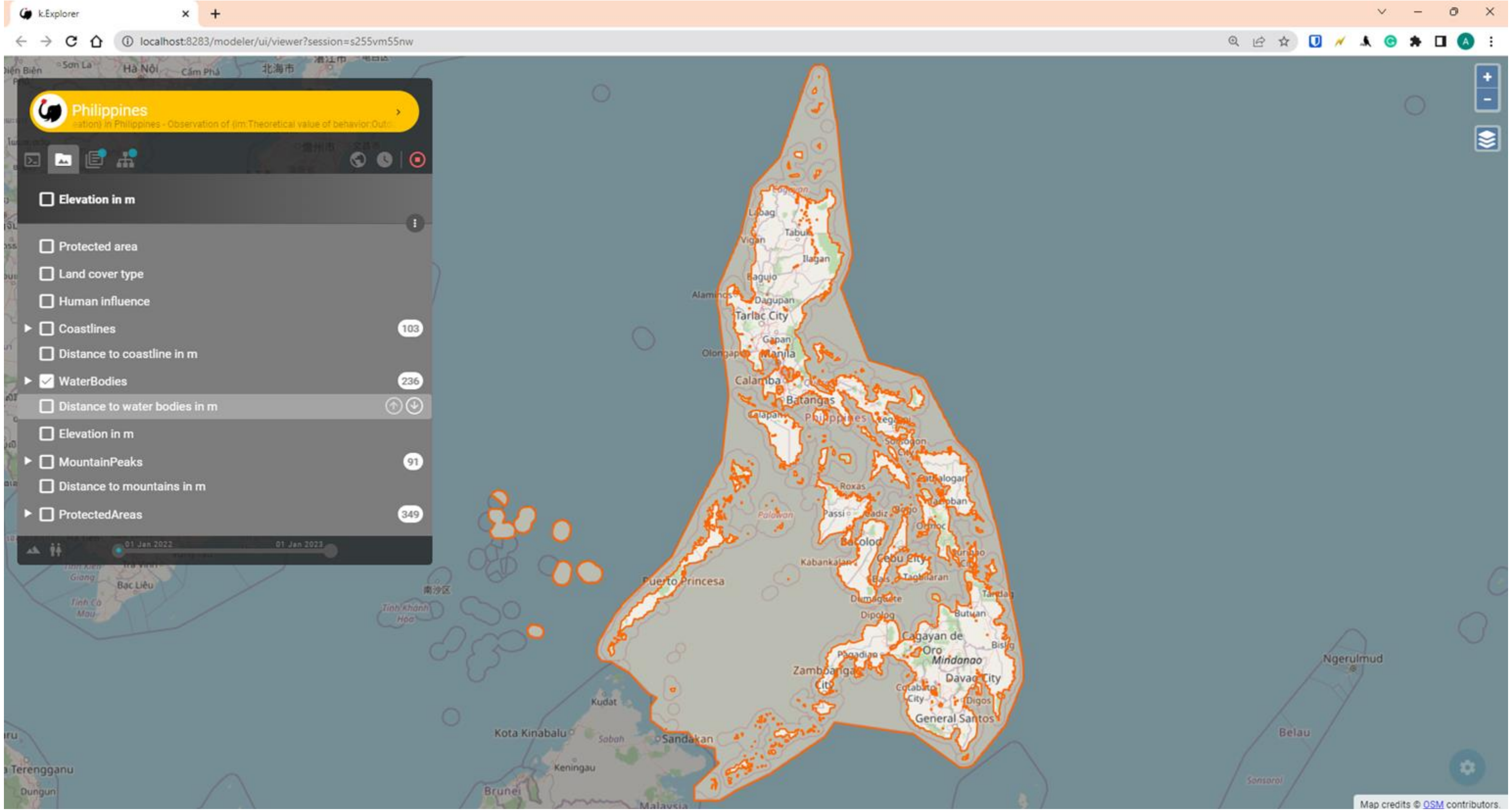
as intermediate outputs are computed they are listed



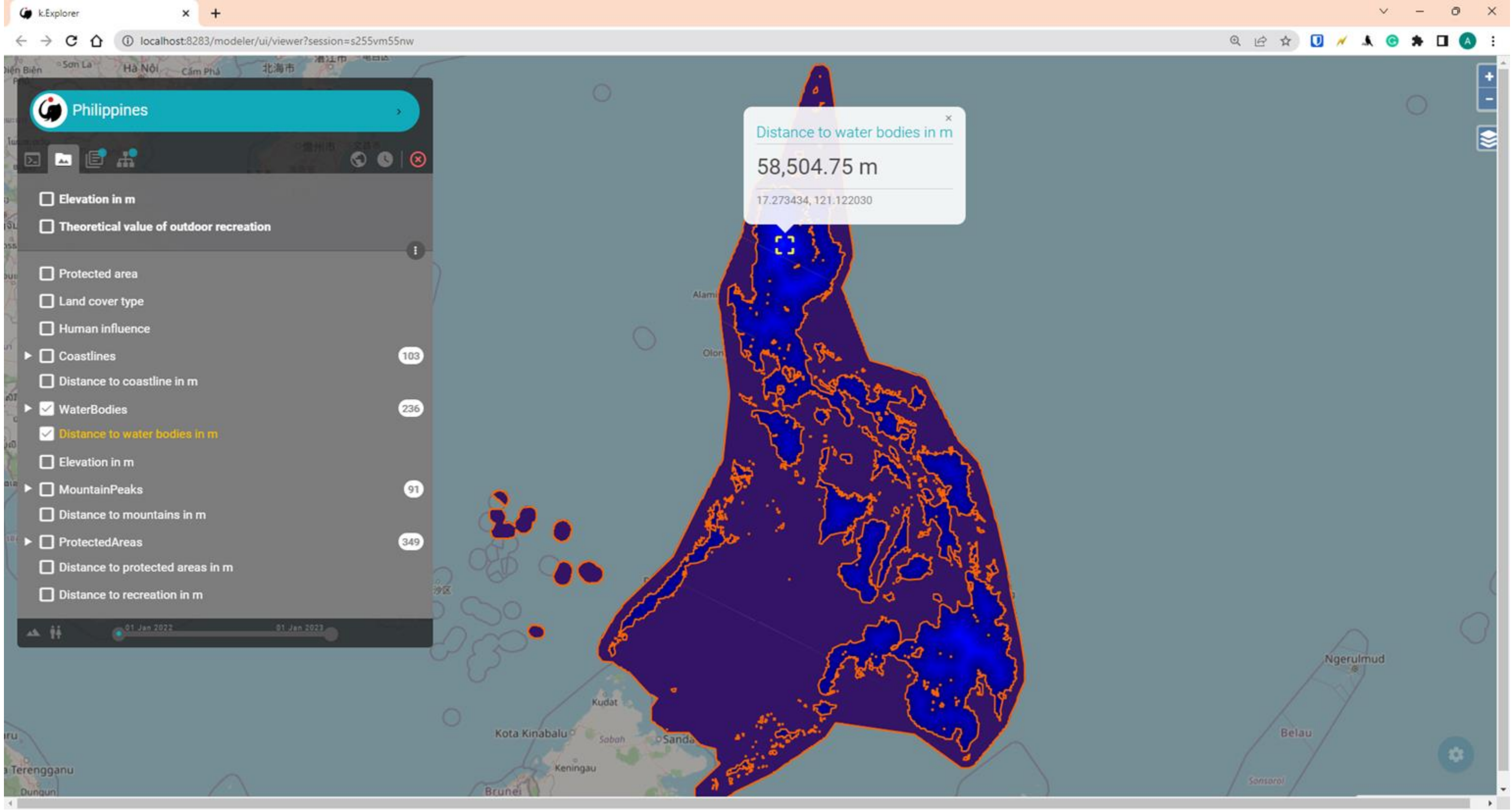
maps can be result of vectorial information



example of the vector map (basic input – original layer)



example of a map built on the original layer



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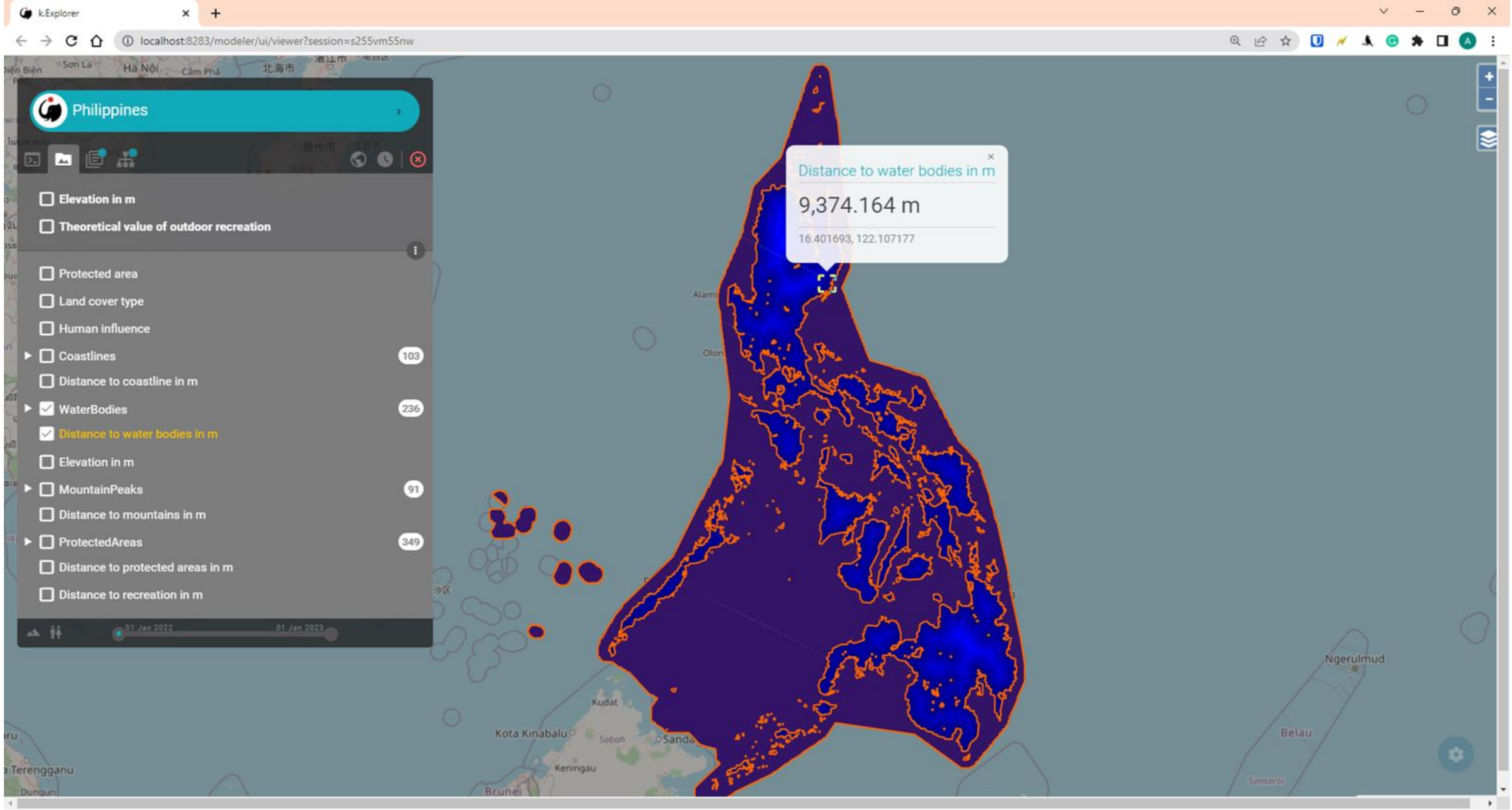
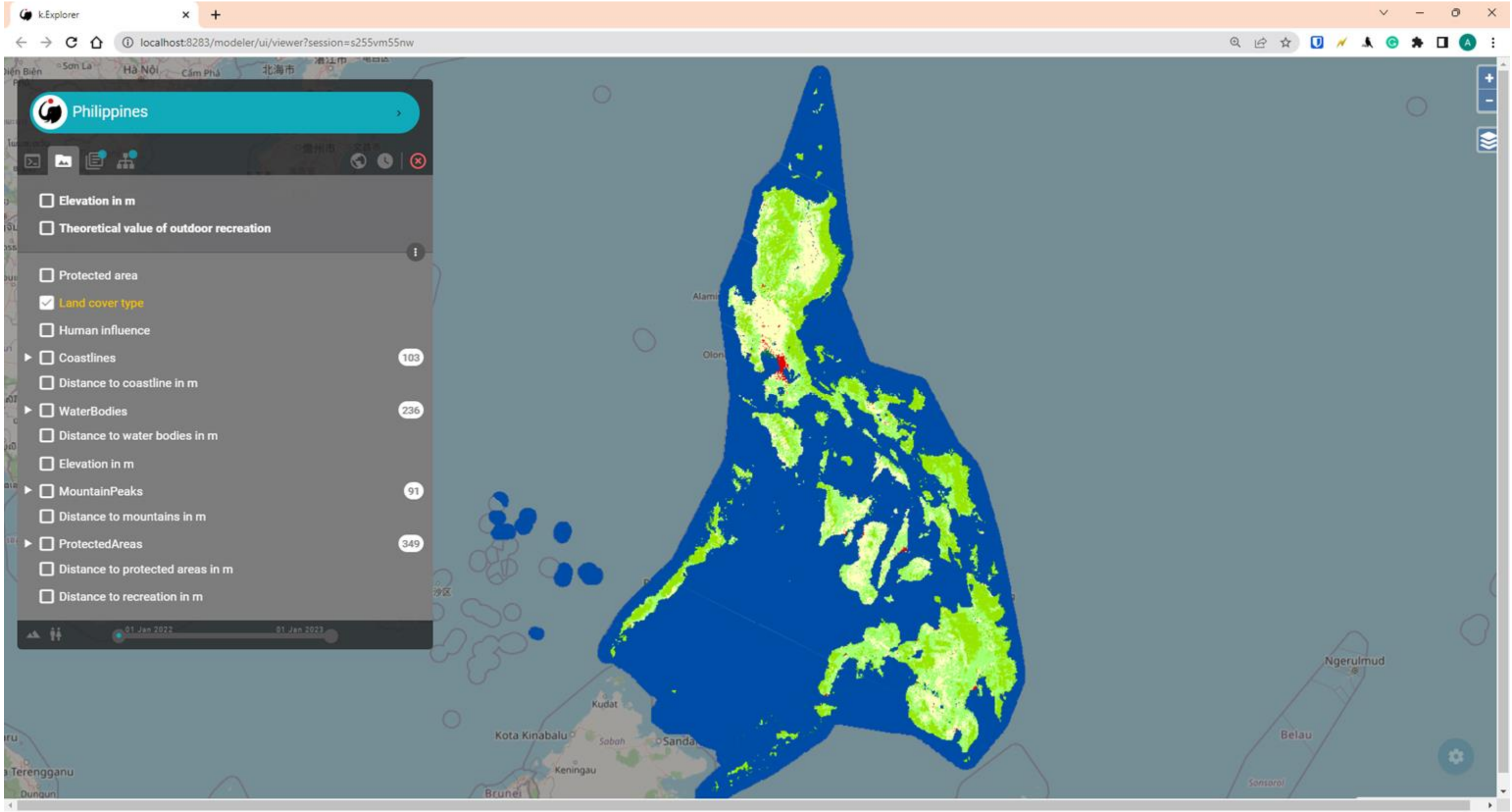
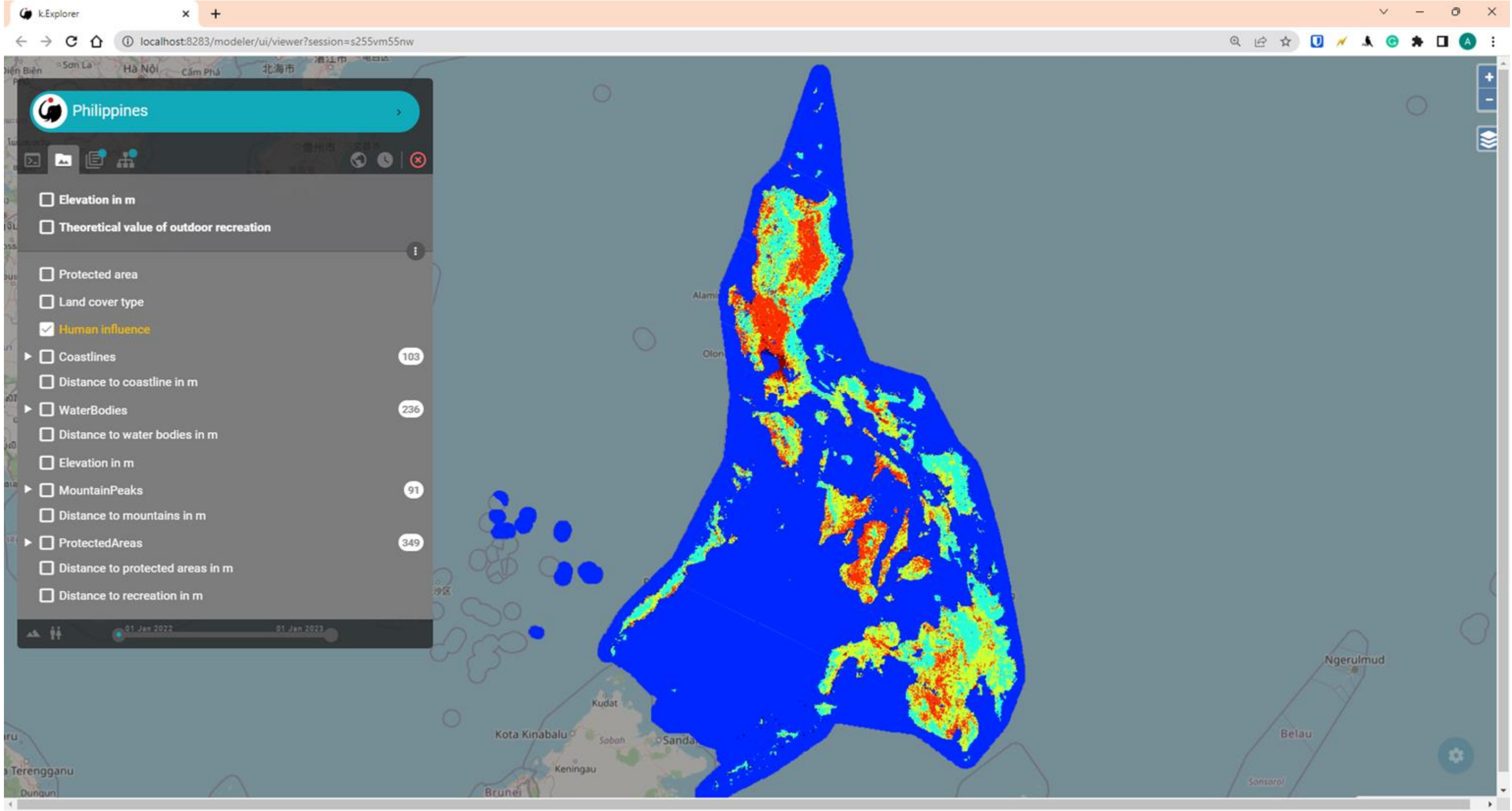


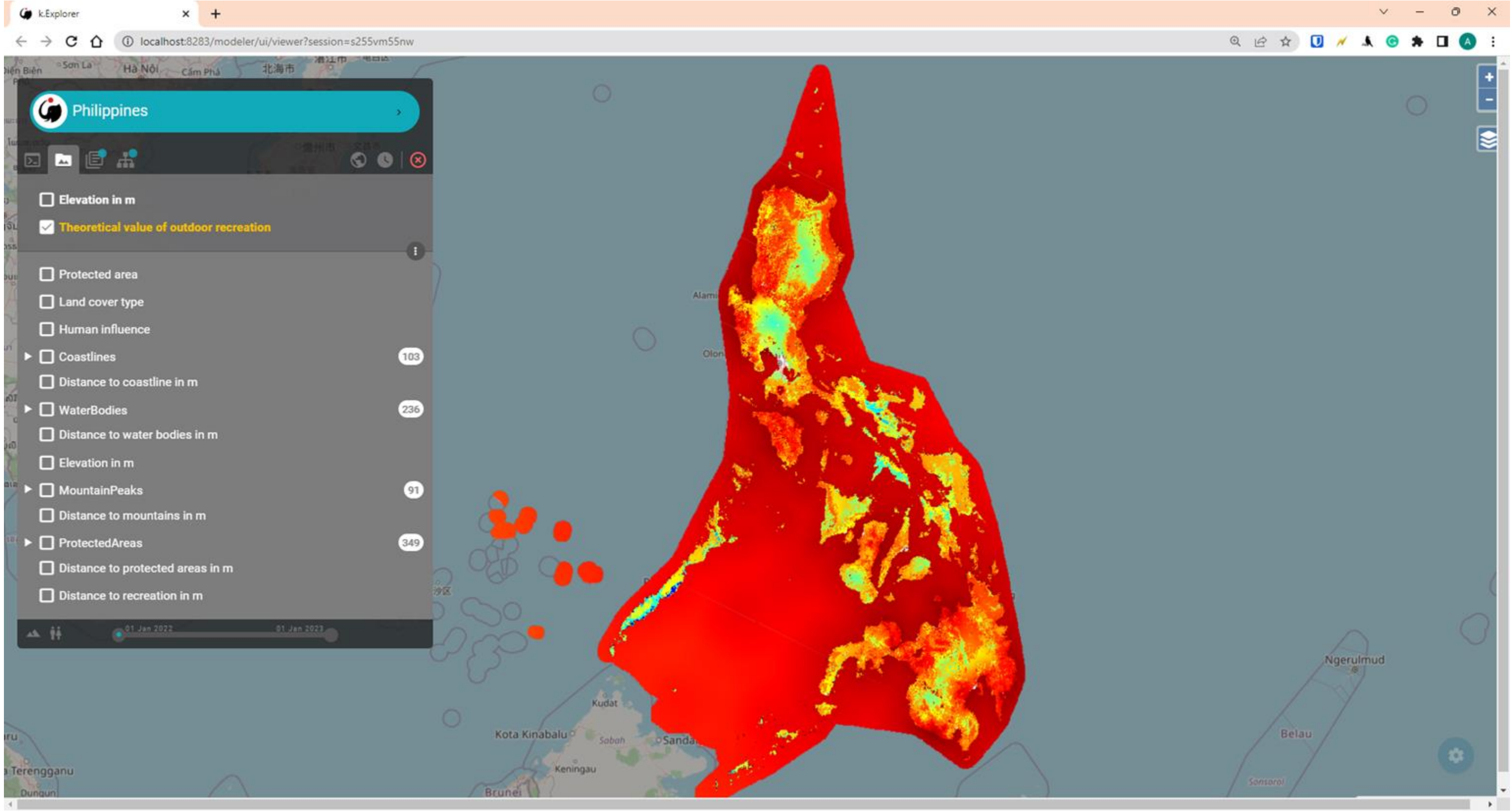
maps can carry ecological information



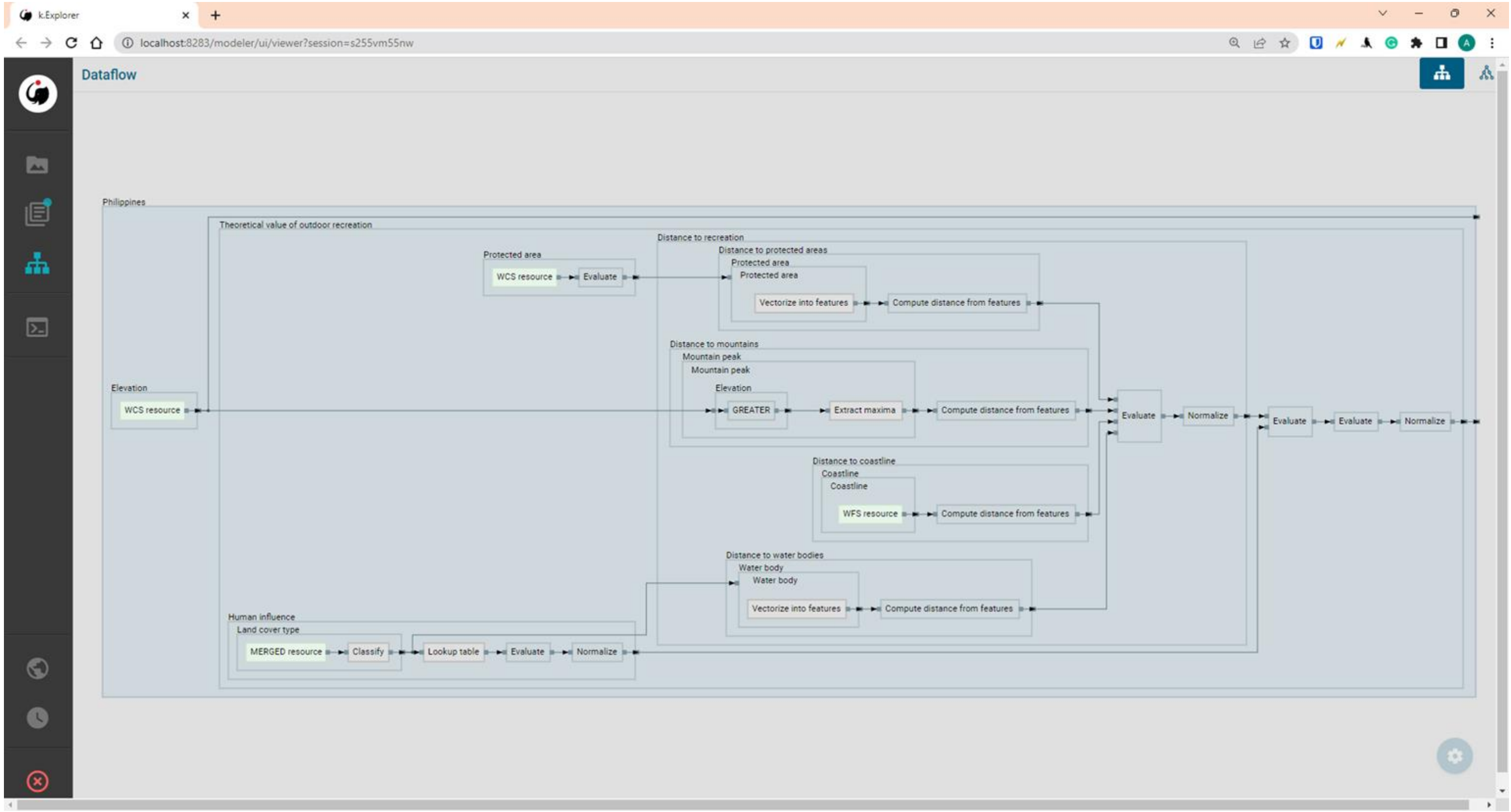
as well as social and economic components



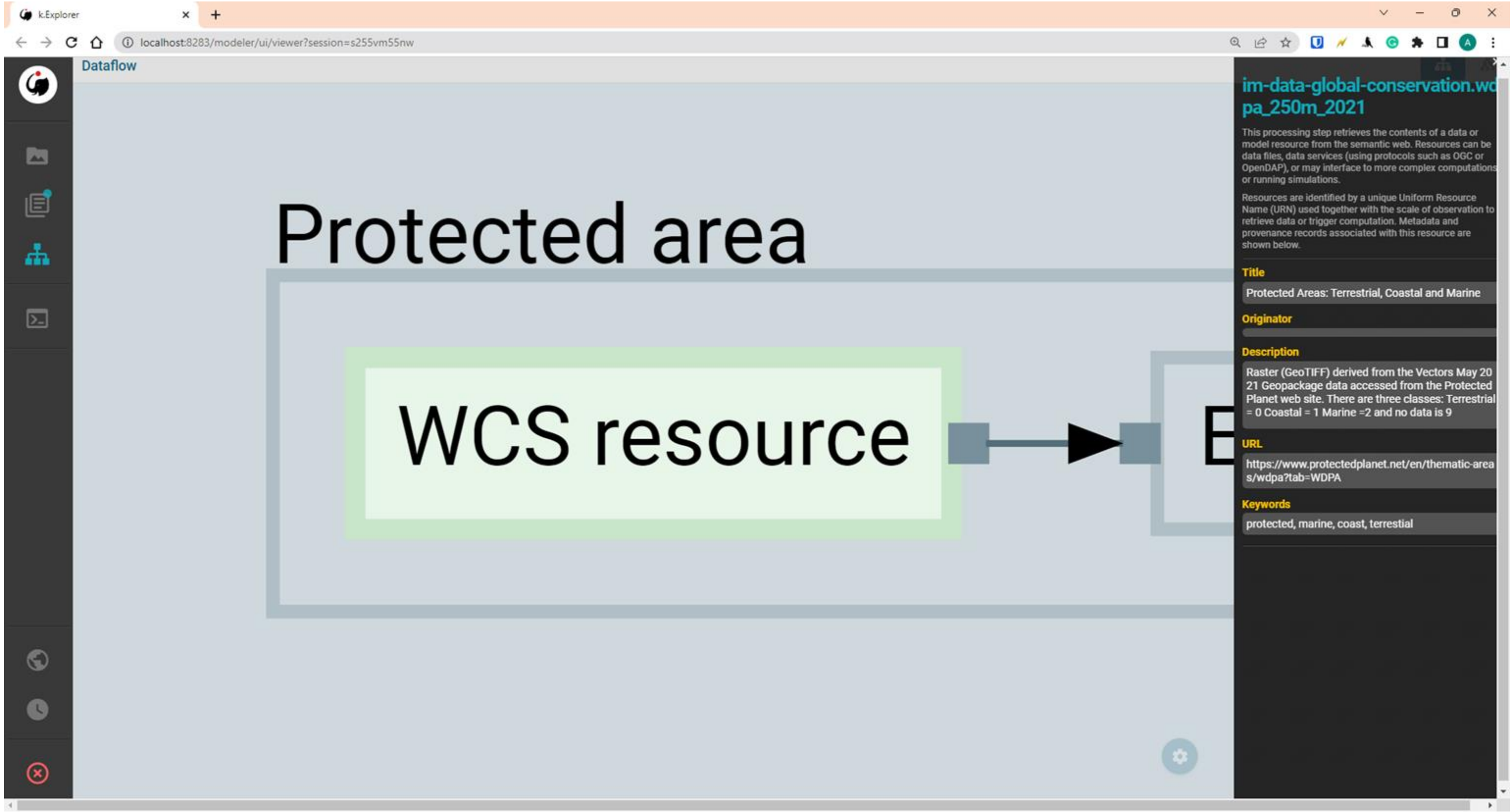
map of the final output



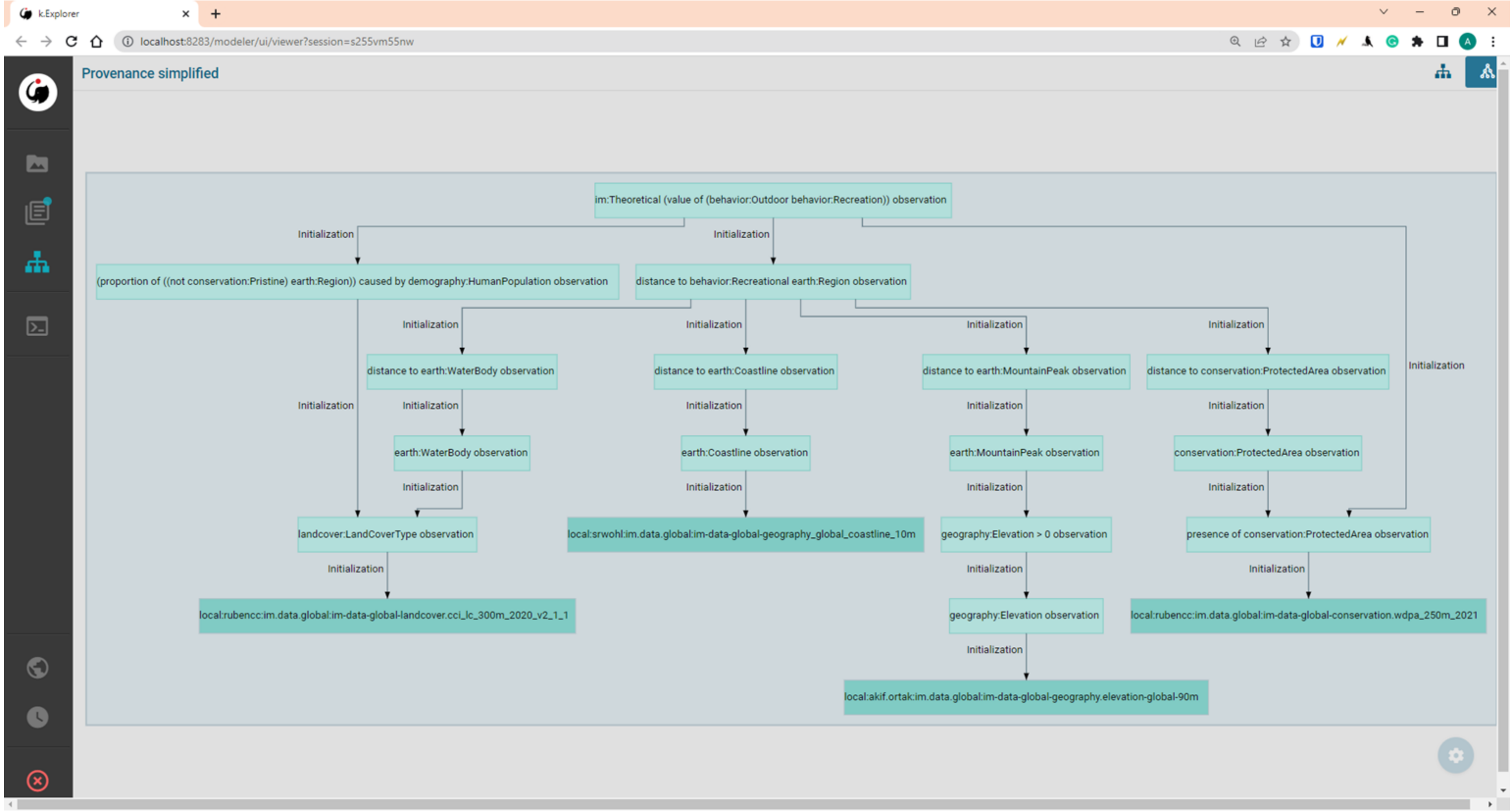
the dataflow section showing the modelling “strategy”



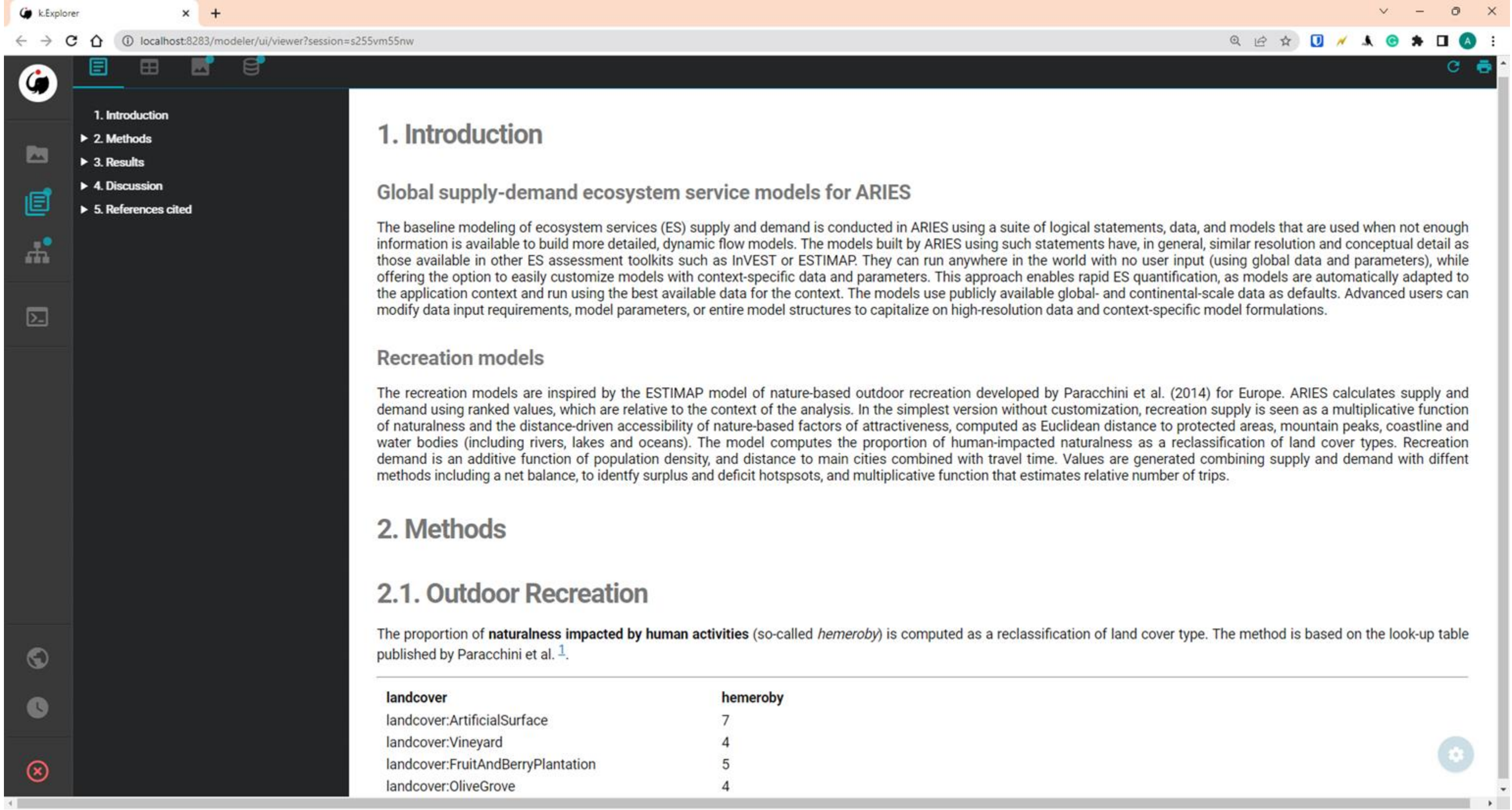
data documentation



simplified data provenance section



automatically generated report



1. Introduction

Global supply-demand ecosystem service models for ARIES

The baseline modeling of ecosystem services (ES) supply and demand is conducted in ARIES using a suite of logical statements, data, and models that are used when not enough information is available to build more detailed, dynamic flow models. The models built by ARIES using such statements have, in general, similar resolution and conceptual detail as those available in other ES assessment toolkits such as InVEST or ESTIMAP. They can run anywhere in the world with no user input (using global data and parameters), while offering the option to easily customize models with context-specific data and parameters. This approach enables rapid ES quantification, as models are automatically adapted to the application context and run using the best available data for the context. The models use publicly available global- and continental-scale data as defaults. Advanced users can modify data input requirements, model parameters, or entire model structures to capitalize on high-resolution data and context-specific model formulations.

Recreation models

The recreation models are inspired by the ESTIMAP model of nature-based outdoor recreation developed by Paracchini et al. (2014) for Europe. ARIES calculates supply and demand using ranked values, which are relative to the context of the analysis. In the simplest version without customization, recreation supply is seen as a multiplicative function of naturalness and the distance-driven accessibility of nature-based factors of attractiveness, computed as Euclidean distance to protected areas, mountain peaks, coastline and water bodies (including rivers, lakes and oceans). The model computes the proportion of human-impacted naturalness as a reclassification of land cover types. Recreation demand is an additive function of population density, and distance to main cities combined with travel time. Values are generated combining supply and demand with diffent methods including a net balance, to identfy surplus and deficit hotspsots, and multiplicative function that estimates relative number of trips.

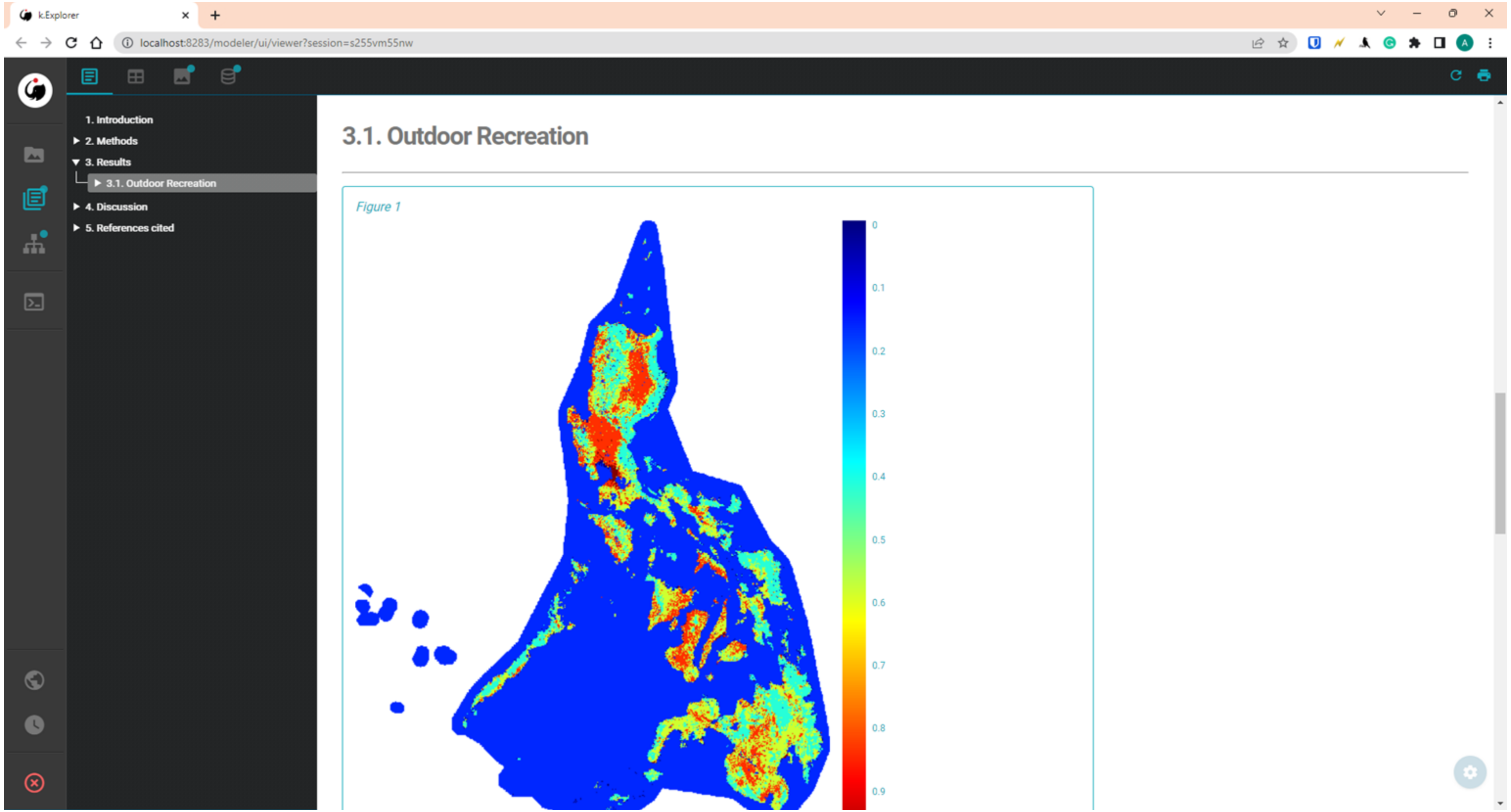
2. Methods

2.1. Outdoor Recreation

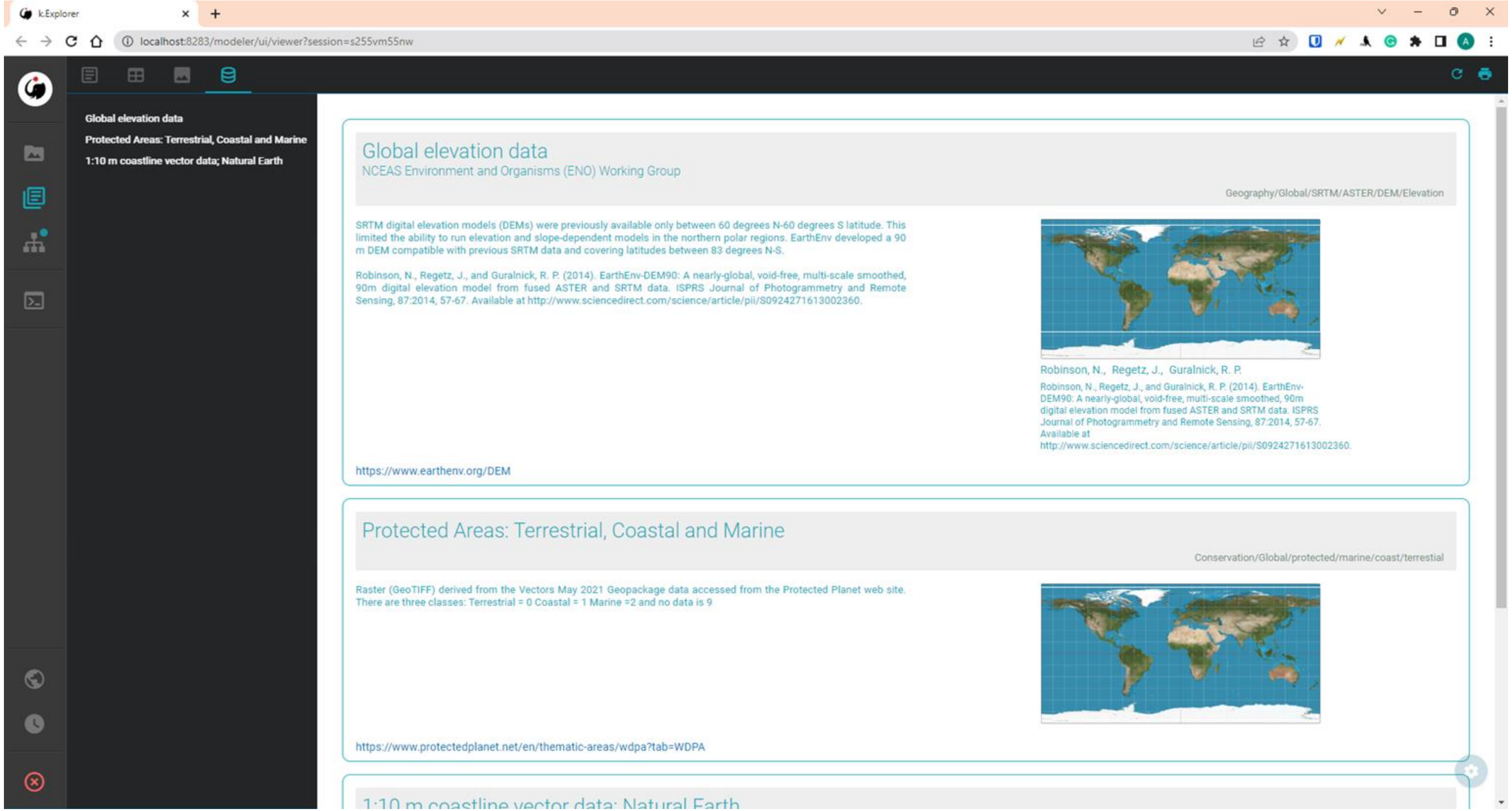
The proportion of **naturalness impacted by human activities** (so-called *hemeroby*) is computed as a reclassification of land cover type. The method is based on the look-up table published by Paracchini et al. [1].

landcover	hemeroby
landcover:ArtificialSurface	7
landcover:Vineyard	4
landcover:FruitAndBerryPlantation	5
landcover:OliveGrove	4

summarizes all information



as well as detailed descriptions of the datasets used



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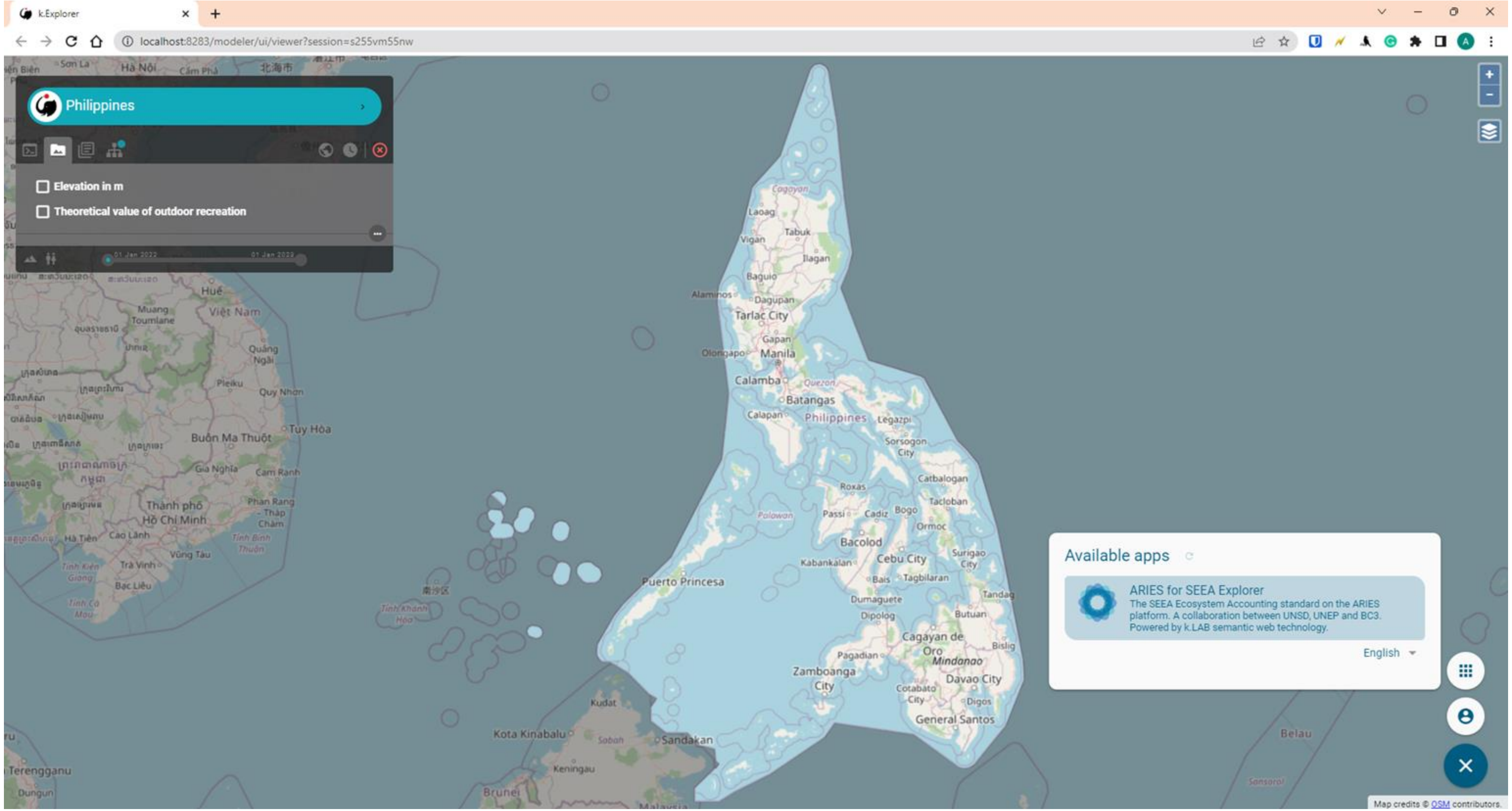

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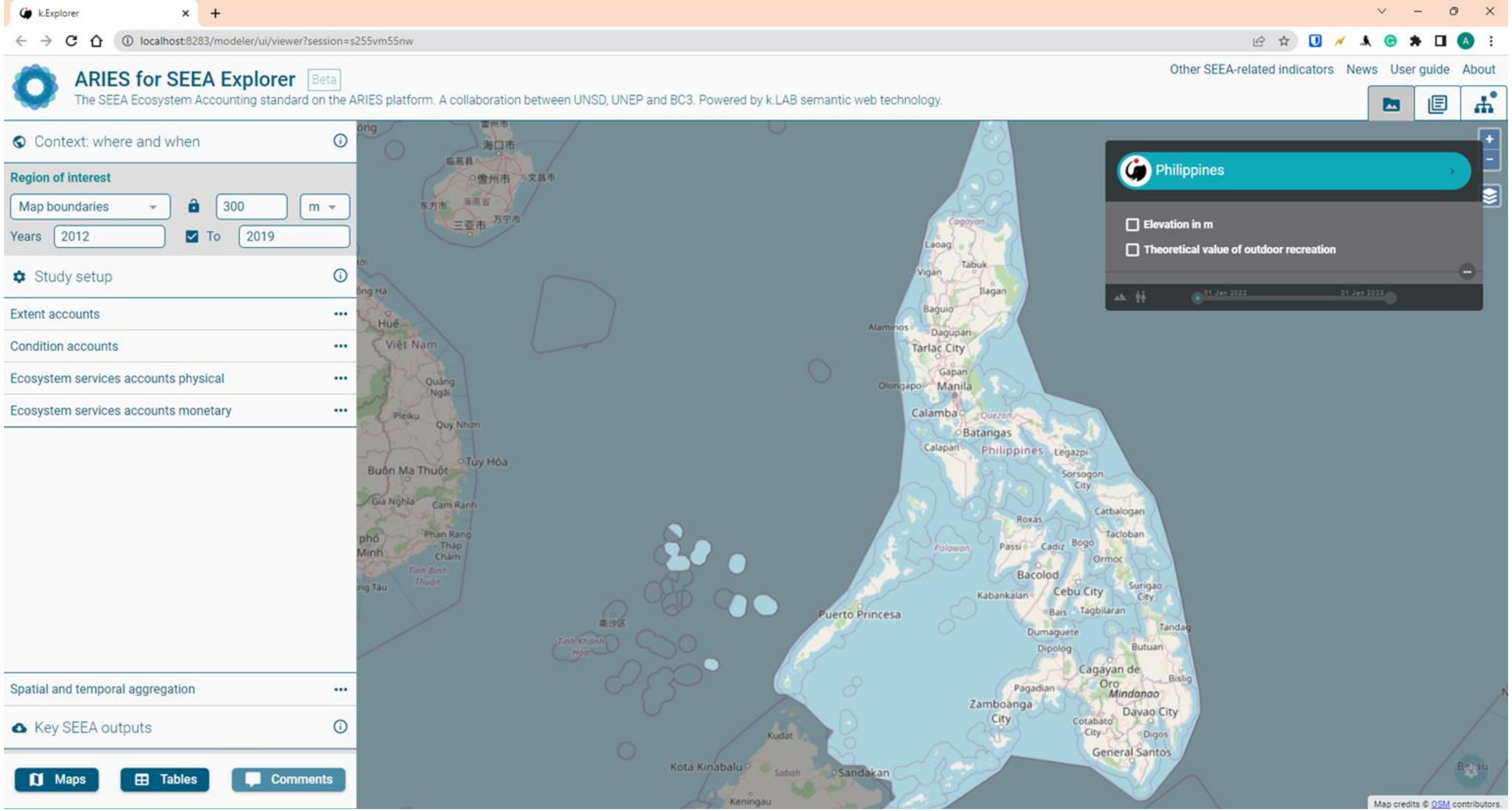

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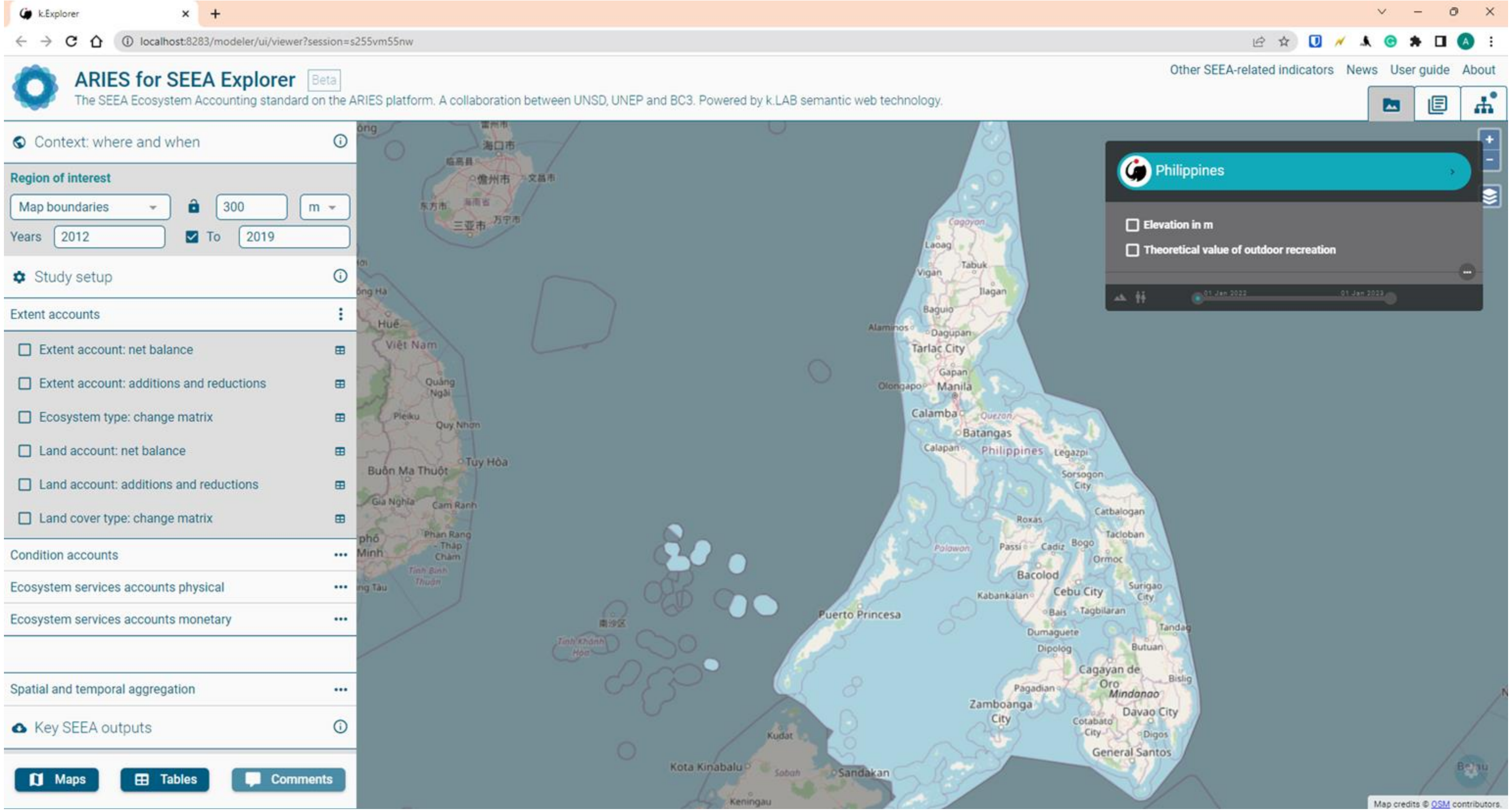

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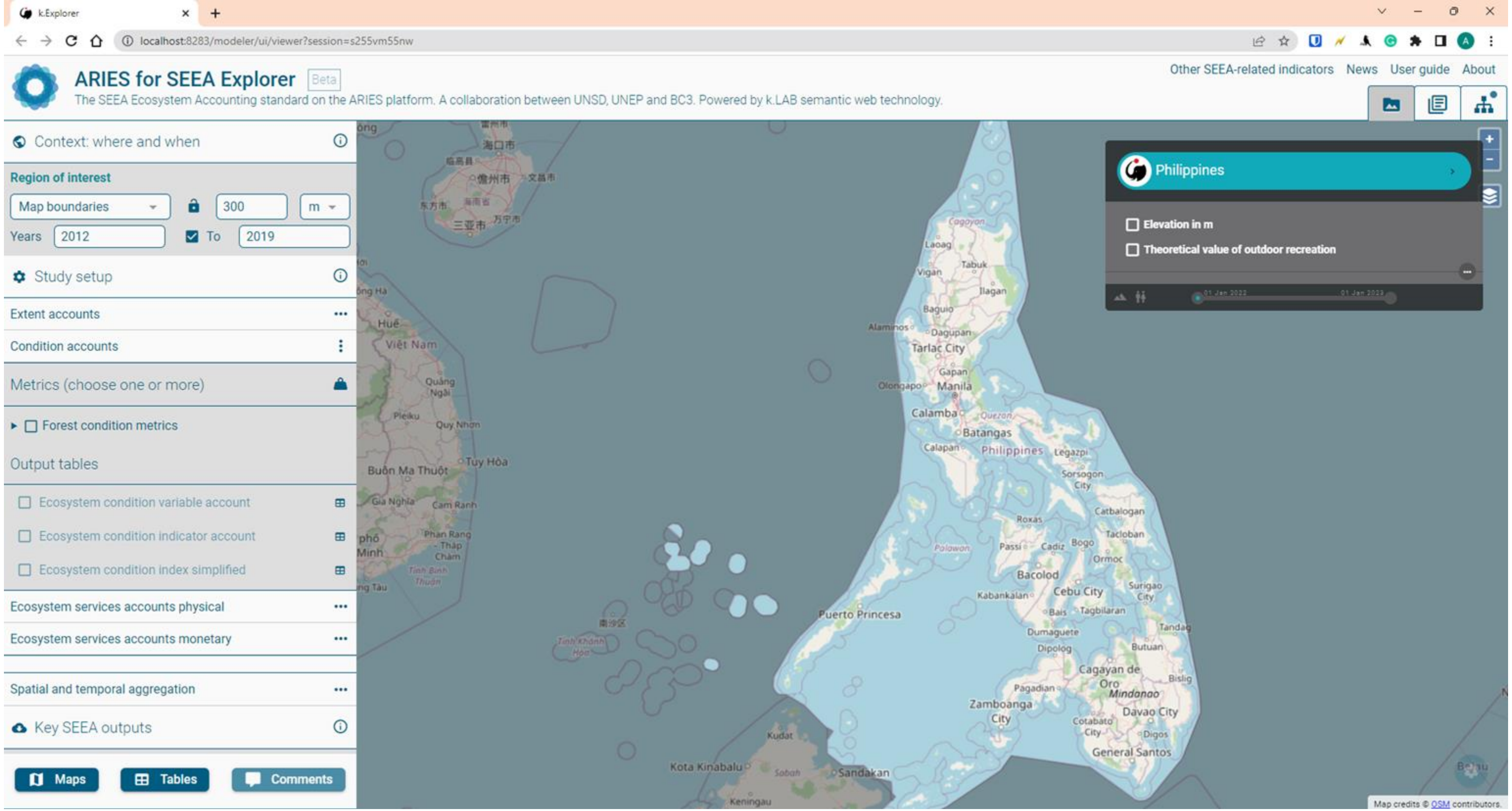

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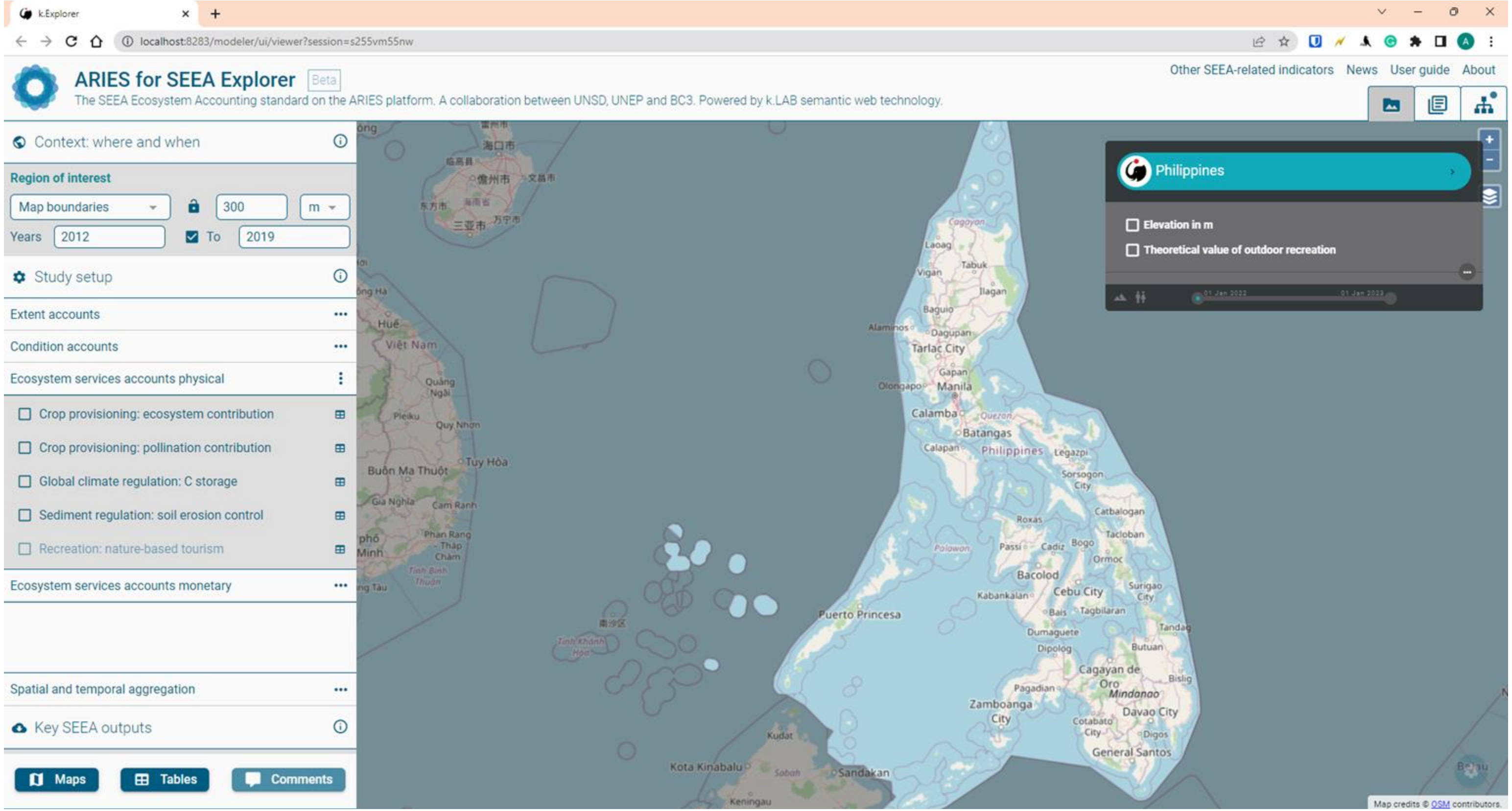

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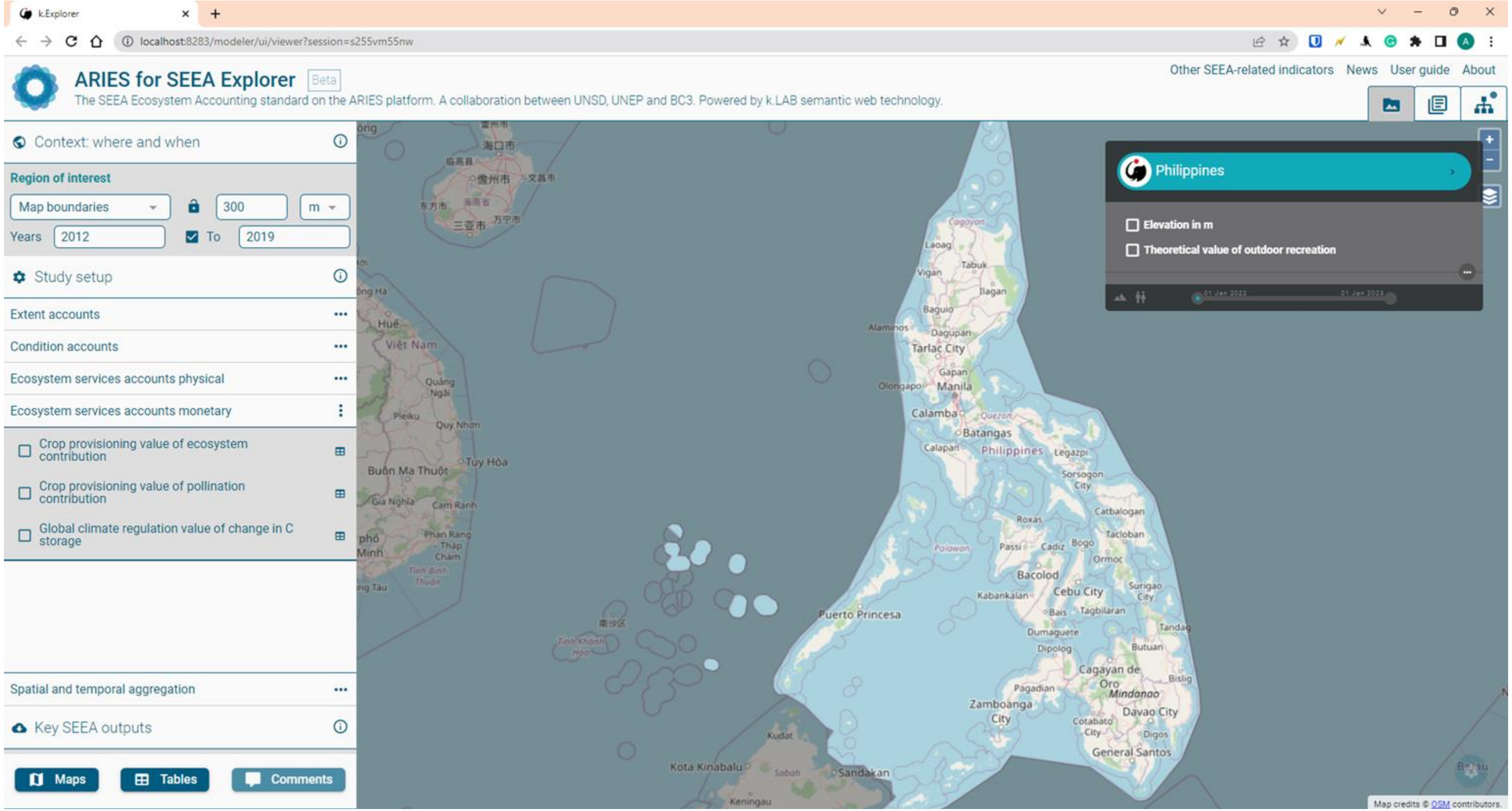

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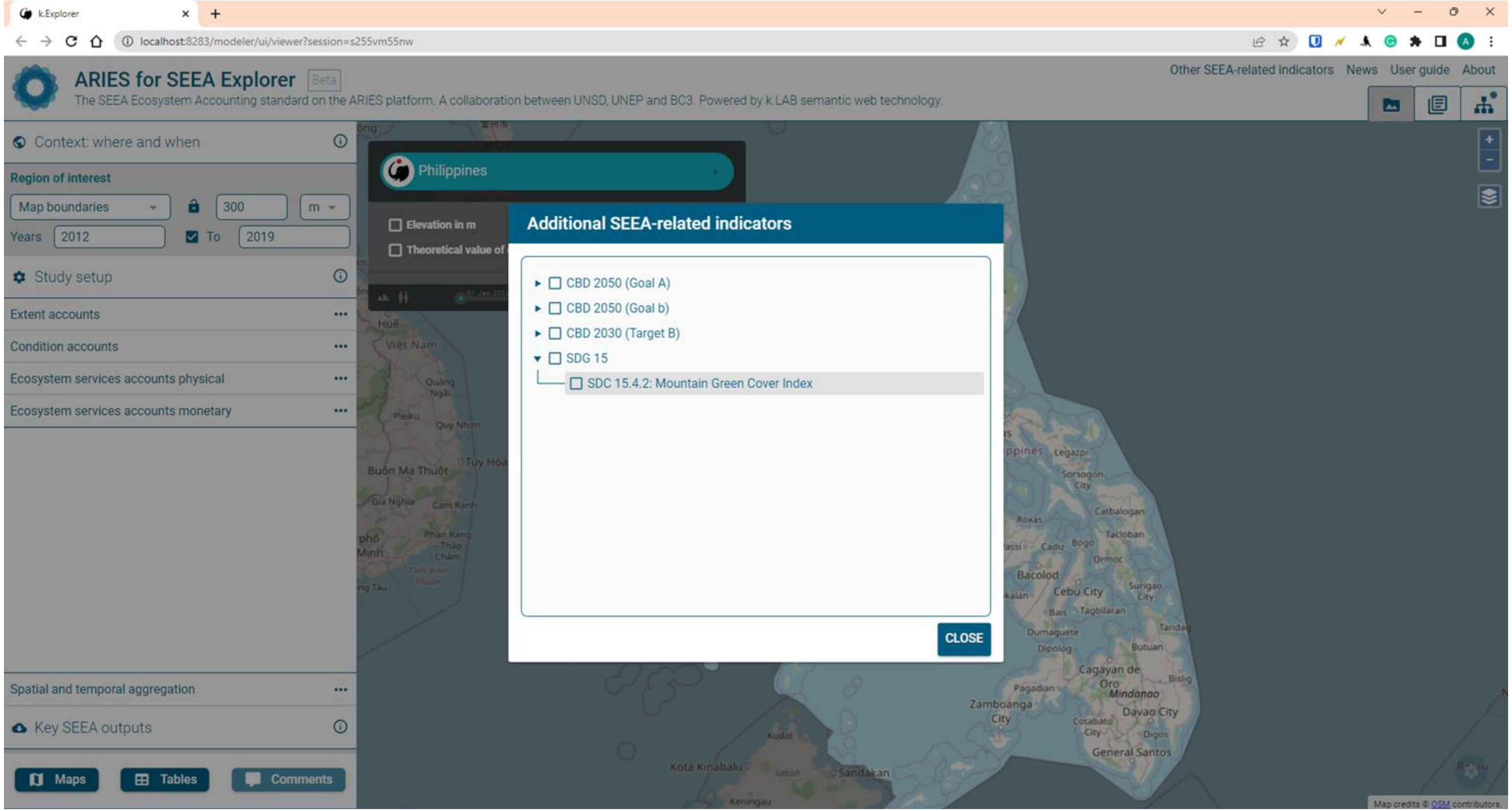

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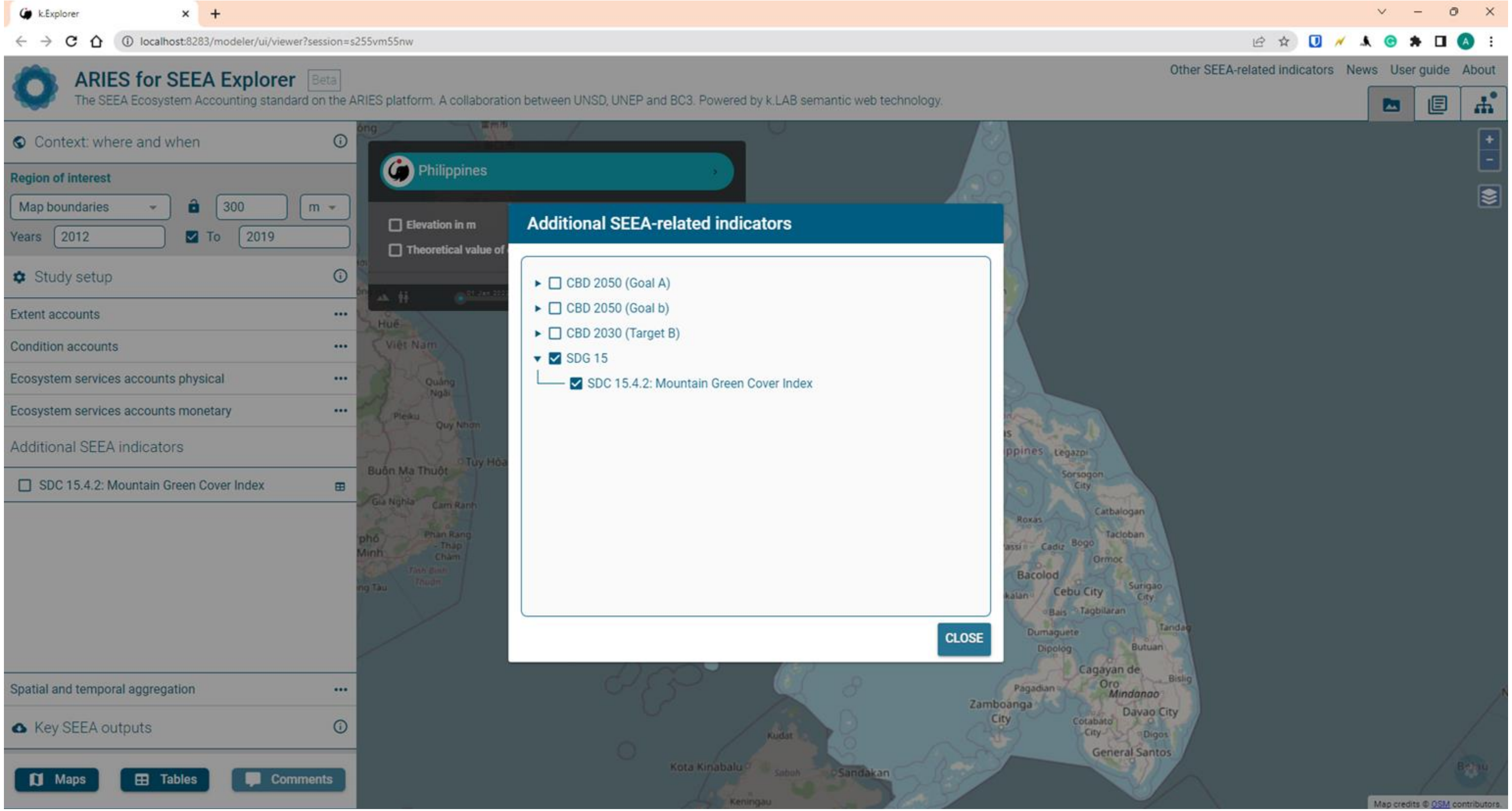

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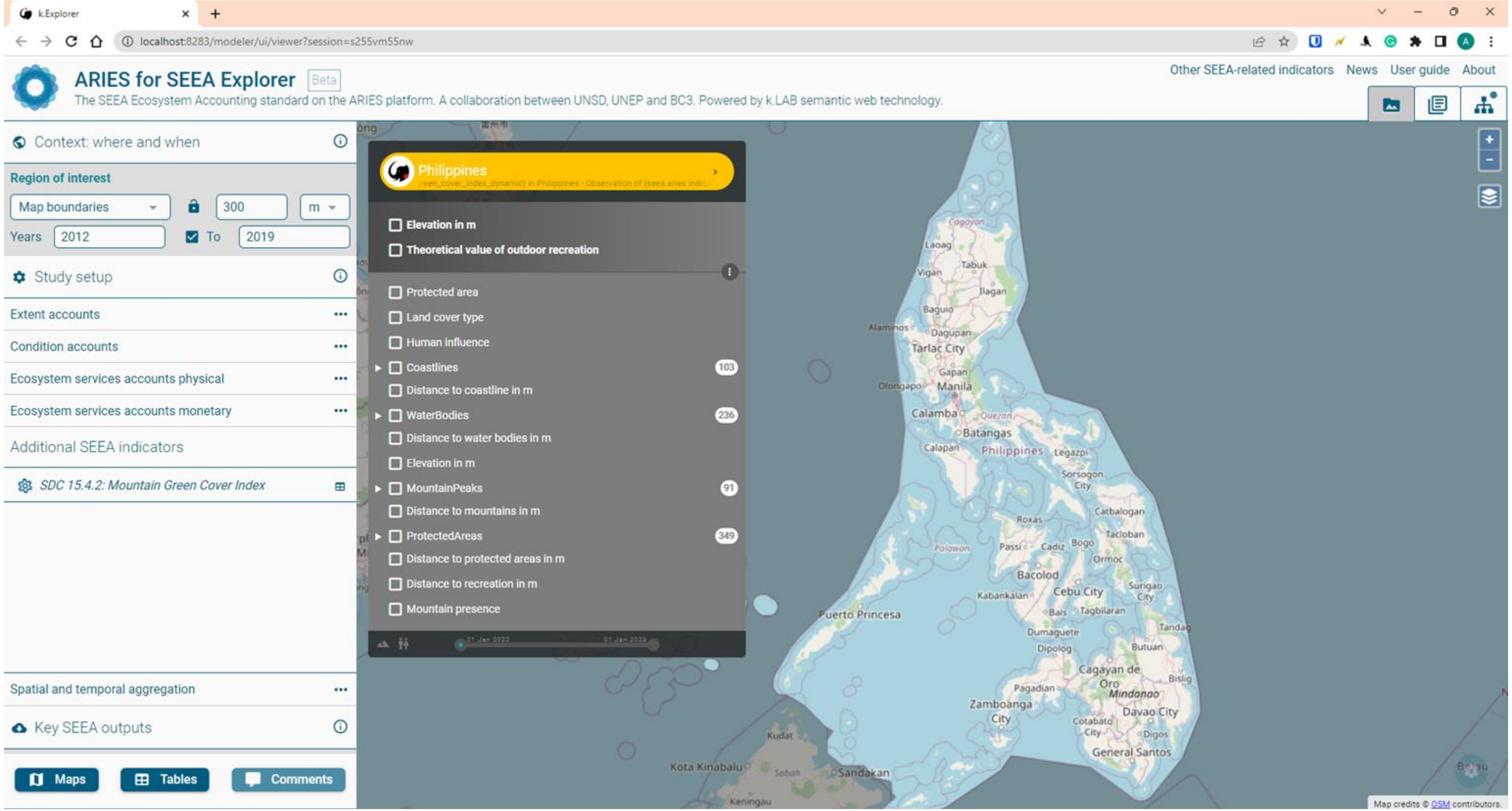

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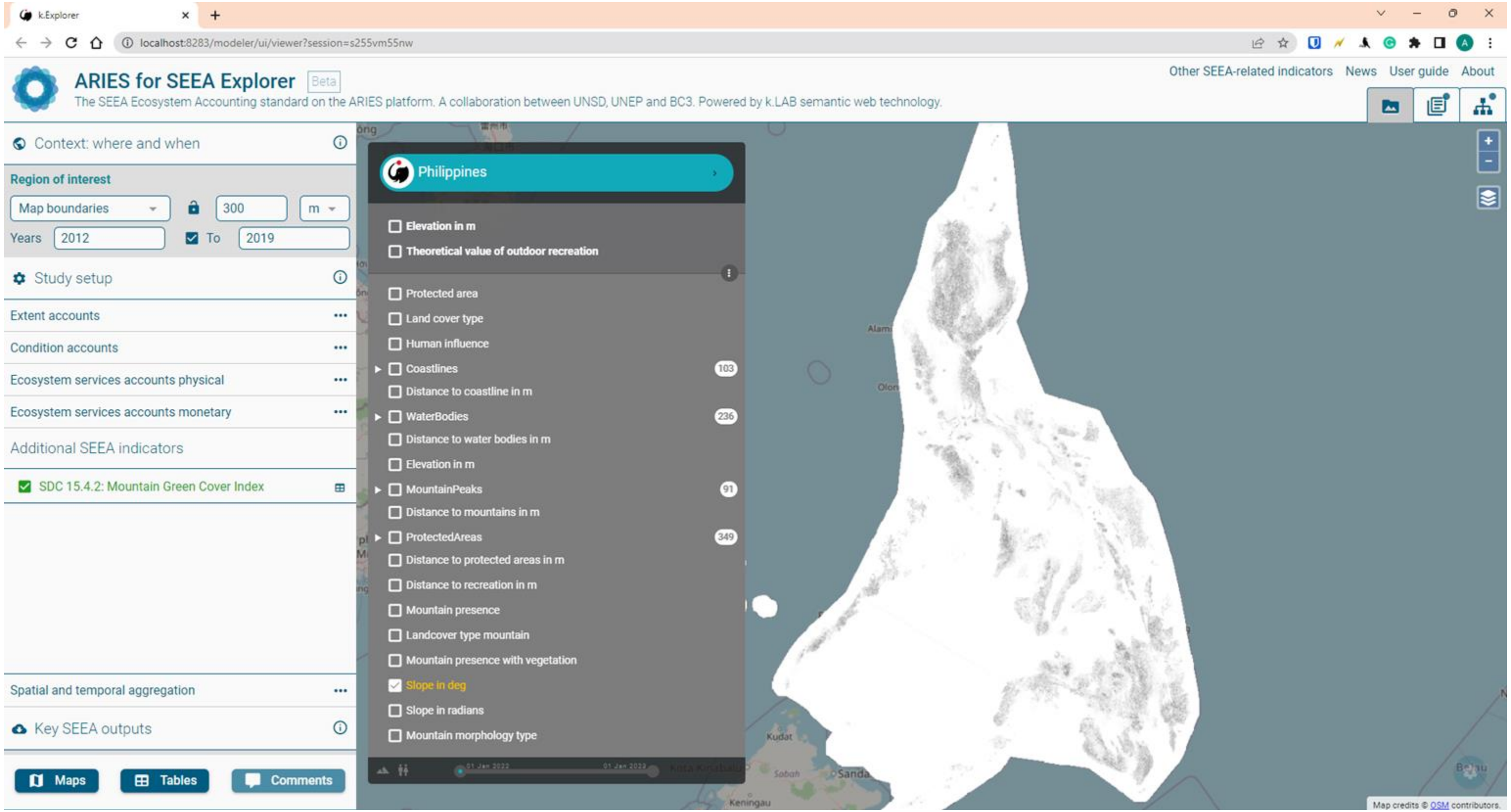

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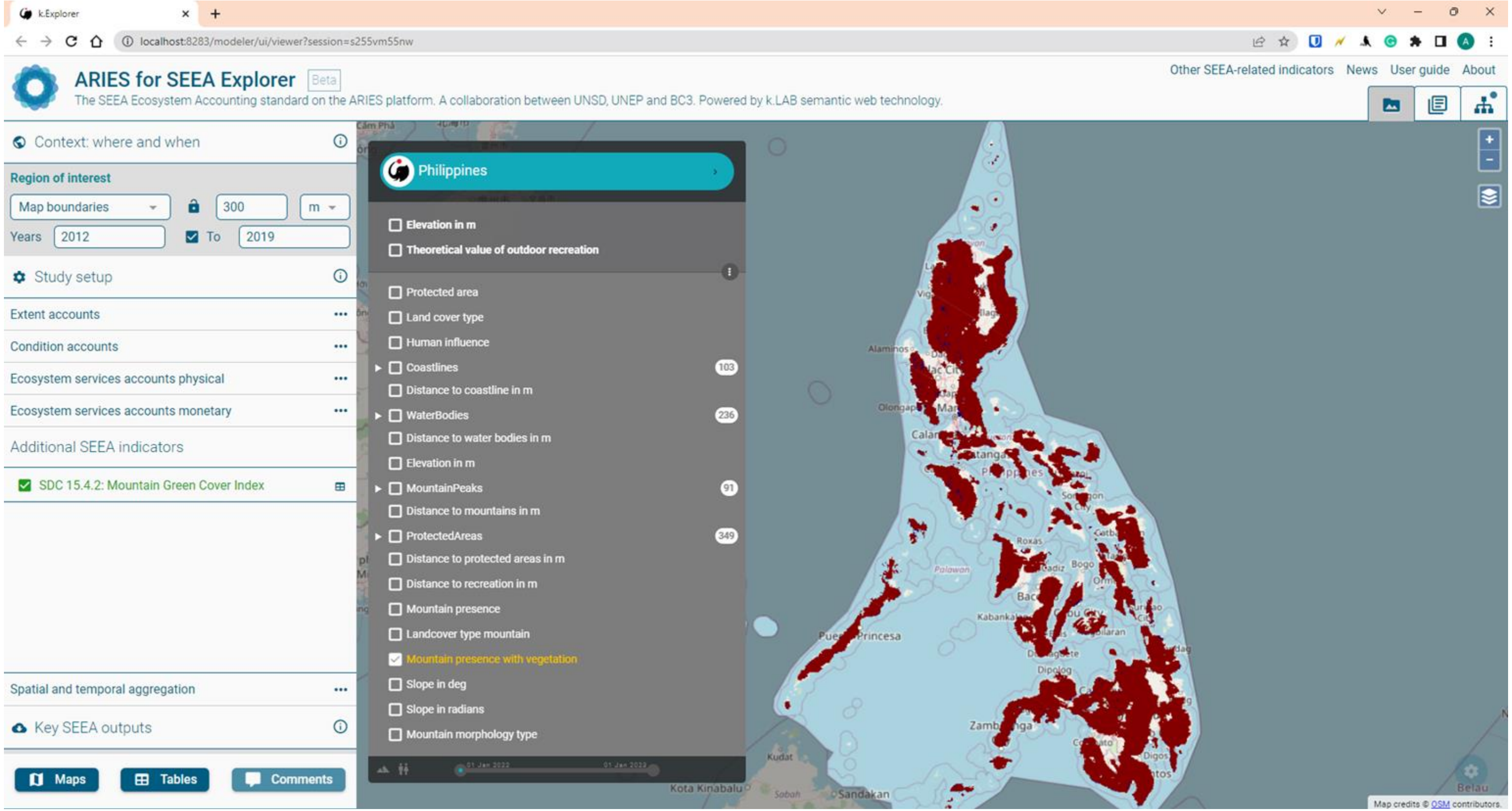

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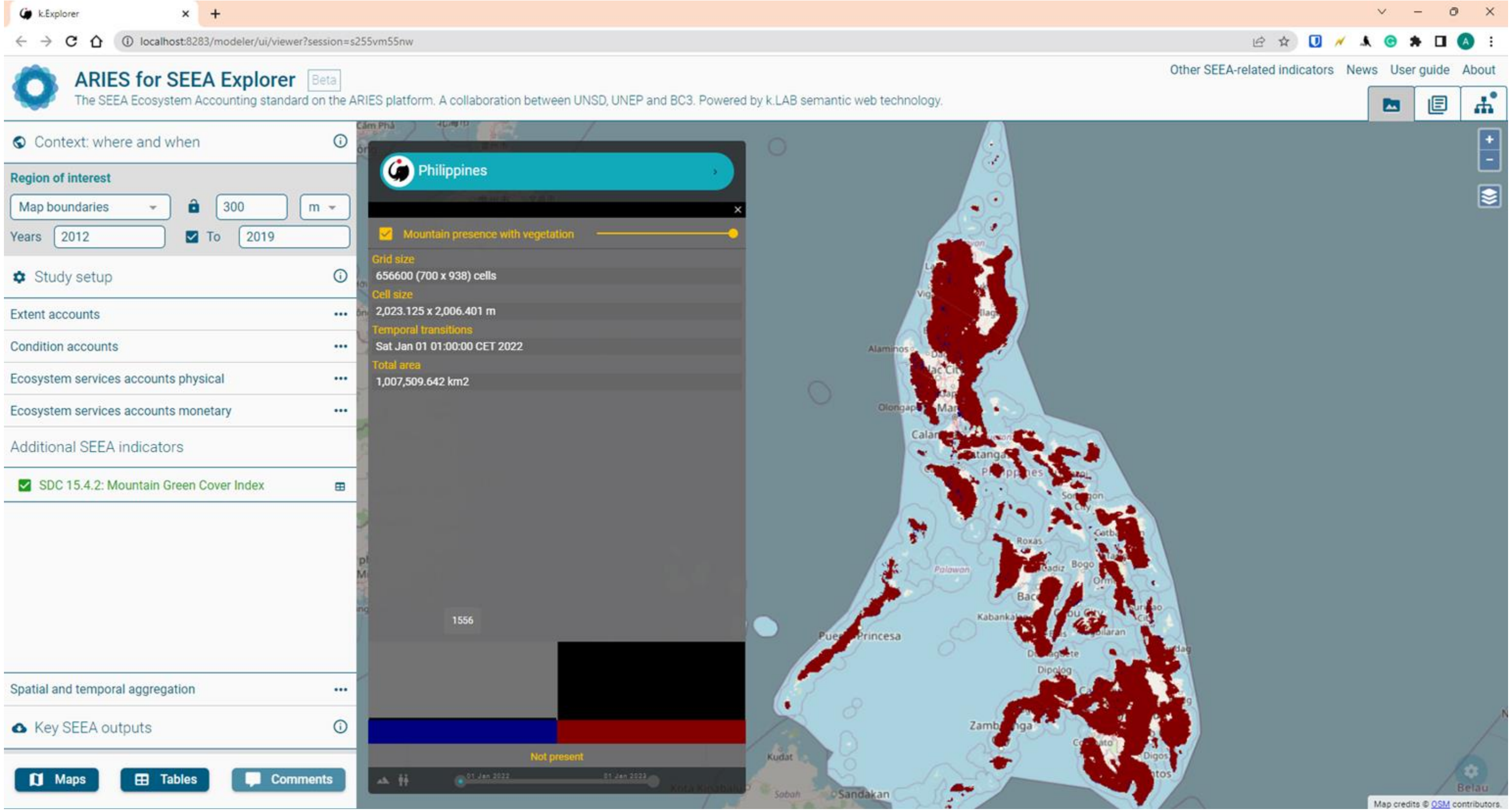

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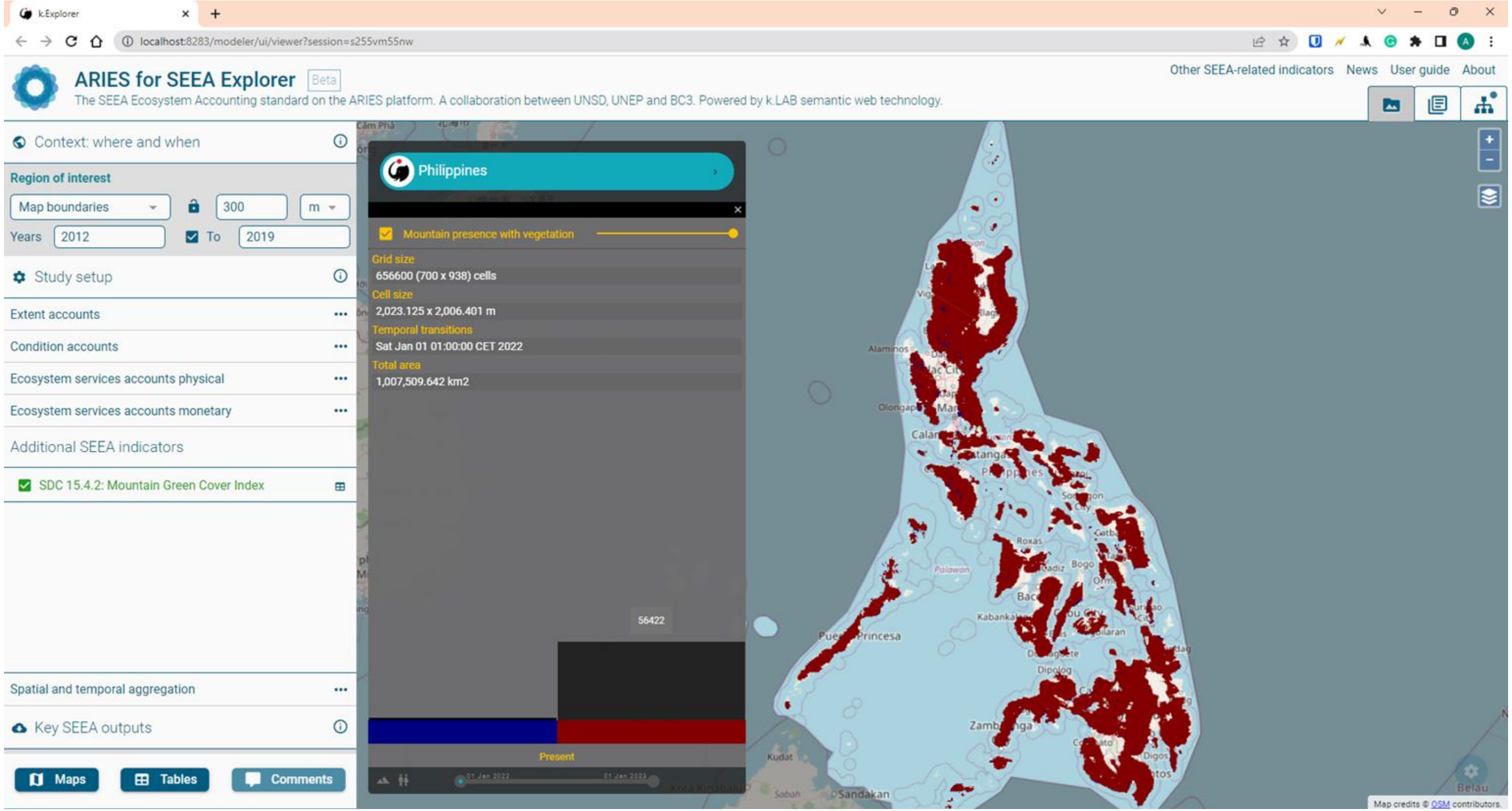

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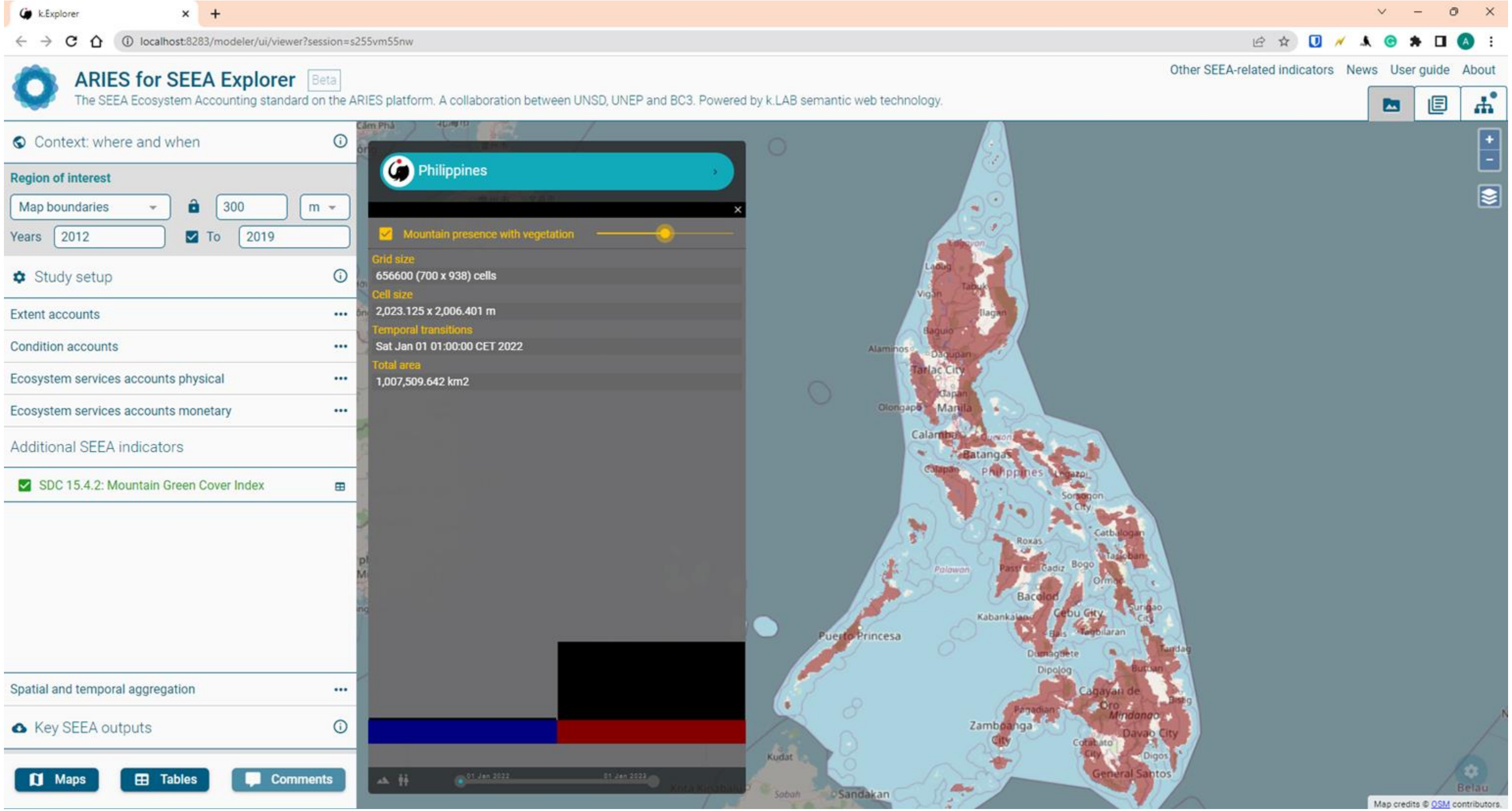

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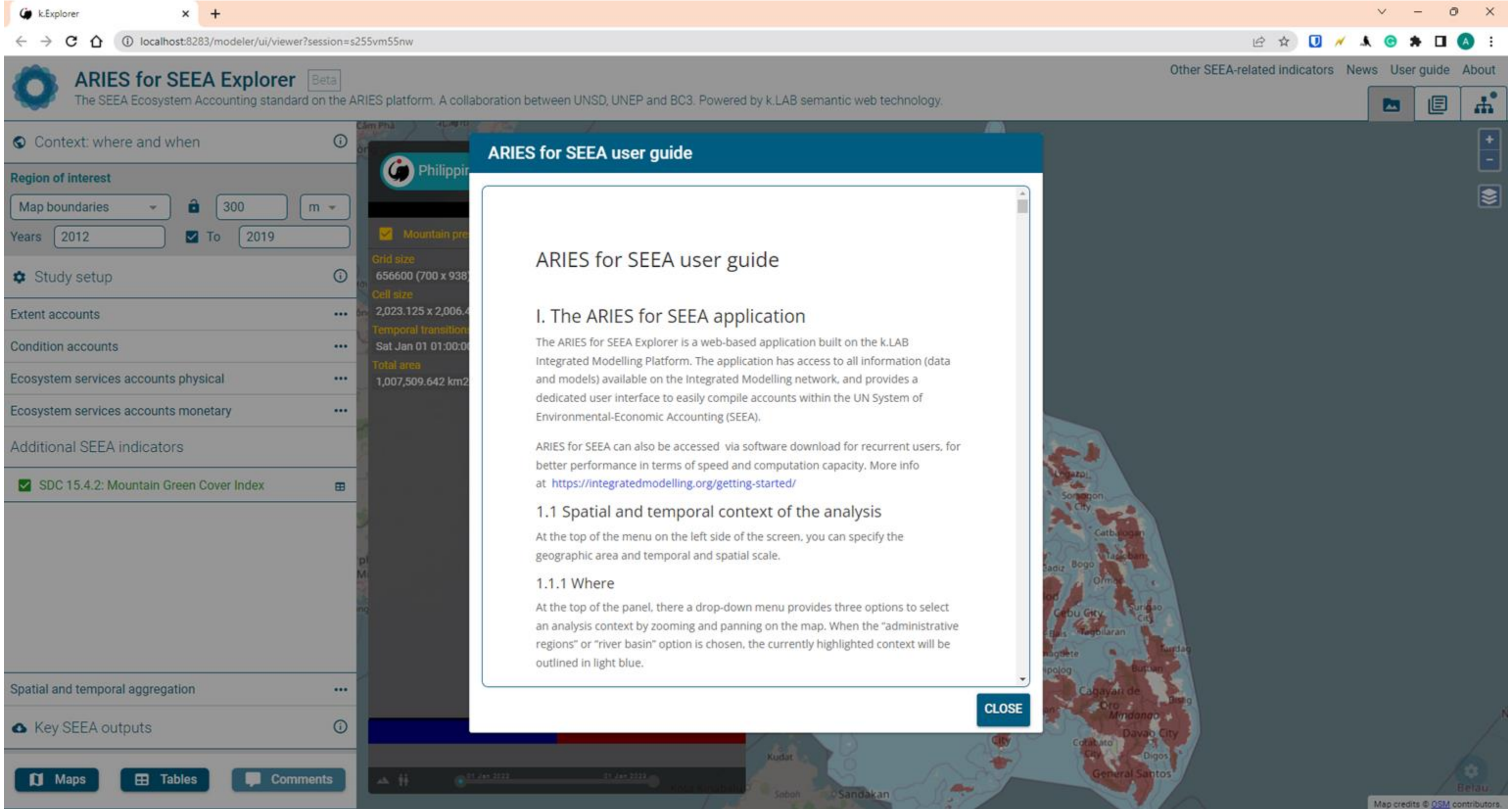


SEEA EA Framework – Illustrative Example

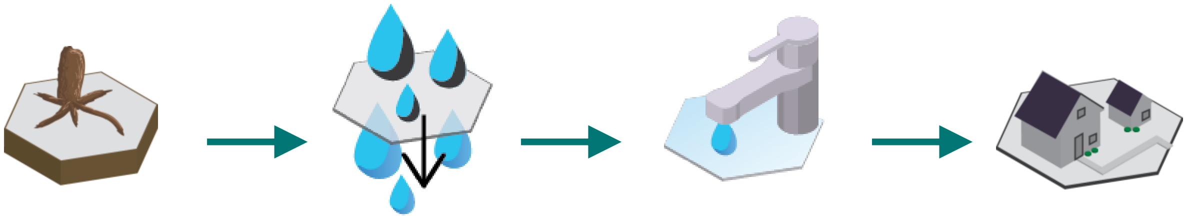
1 Asset – **forest**

2 **Condition**

3 **Services**

4 **Benefits**

5 **Beneficiaries**

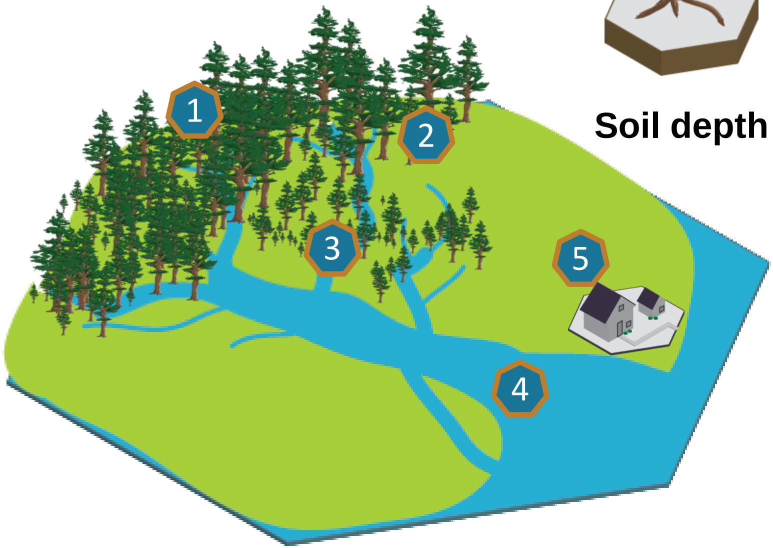


Soil depth

Water filtration

Clean water

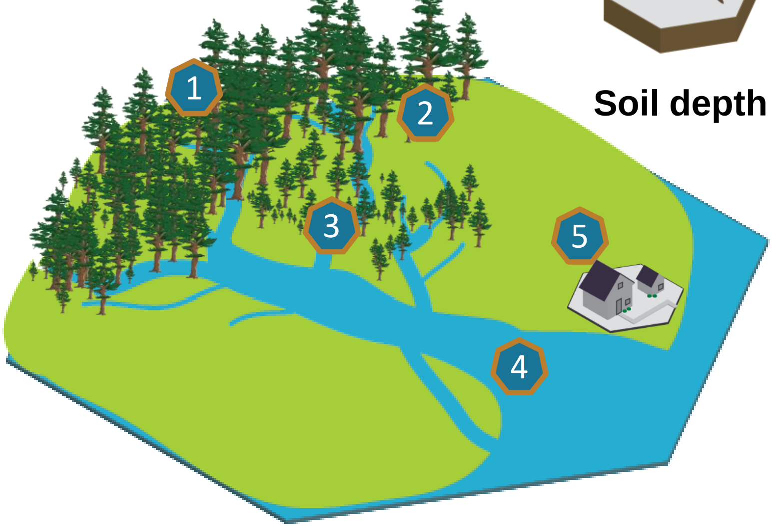
People



SEEA EA Framework – Illustrative Example

1

Asset – **forest**



2

Condition

Soil depth

3

Services

Water filtration

Run-off (or Quickflow), which occurs when there is more water than the land can absorb and the excess liquid flows across the surface of the ground

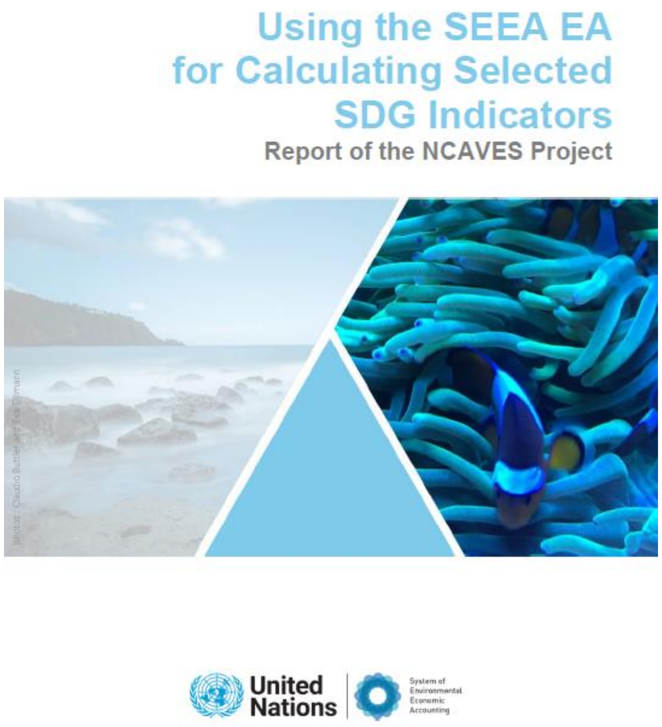
Baseflow, which is water seeping into the stream from groundwater

SEEA EA and SDGs

- SDG 15.1.1: Forest area as a proportion of total land area
- SDG 15.3.1: Proportion of land that is degraded over total land area

- SDG 6.6.1: Change in the extent of water related ecosystems over time

- SDG 11.7.1: Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities



ARIES
ARtificial Intelligence for Environment & Sustainability

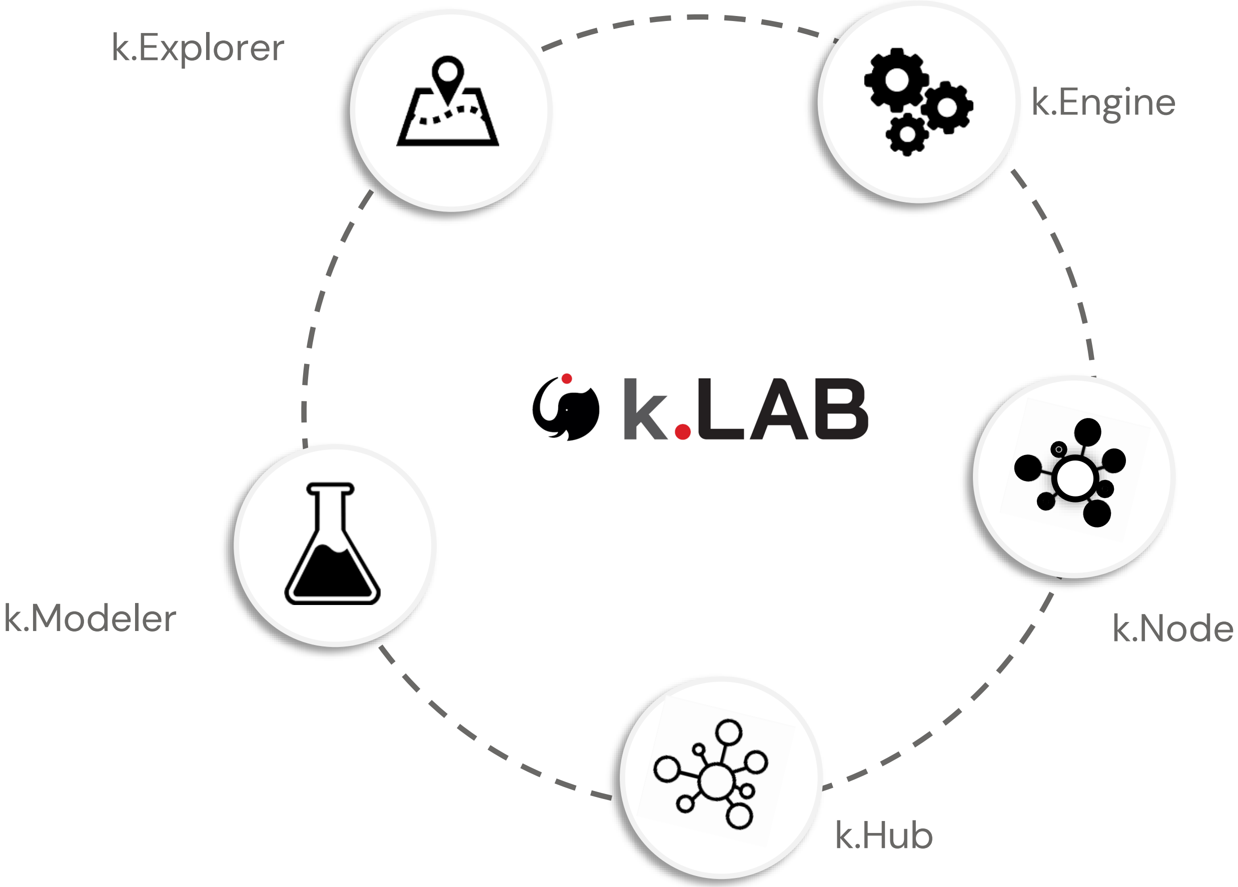
k.LAB

The knoweldge laboratory

A semantic web for sustainability: revolutionizing how we write, find, link and reuse data and models.

The k.LAB platform supports observations made in the semantic web

Include its own semantic language, **k.IM**, used to program in this context



The k.LAB platform supports observations made in the semantic web

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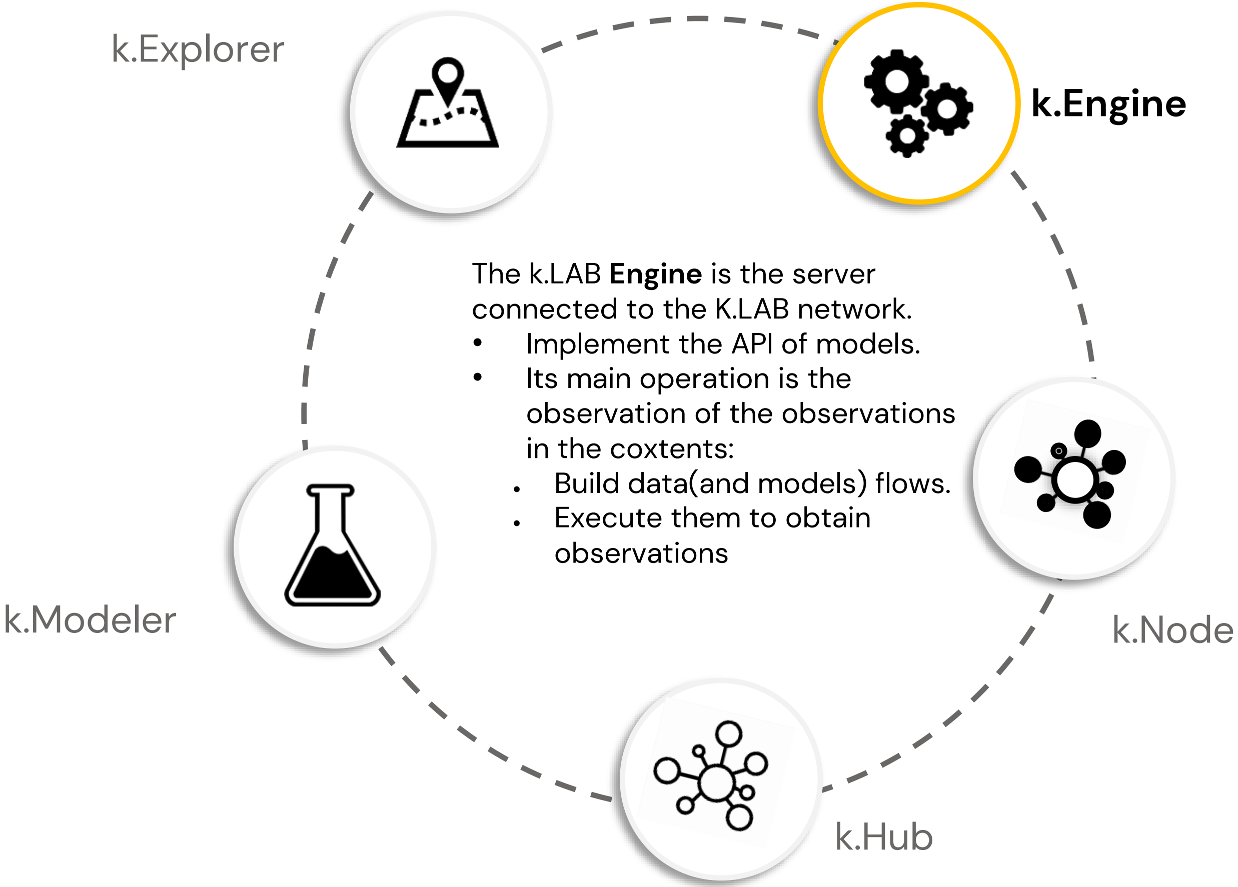
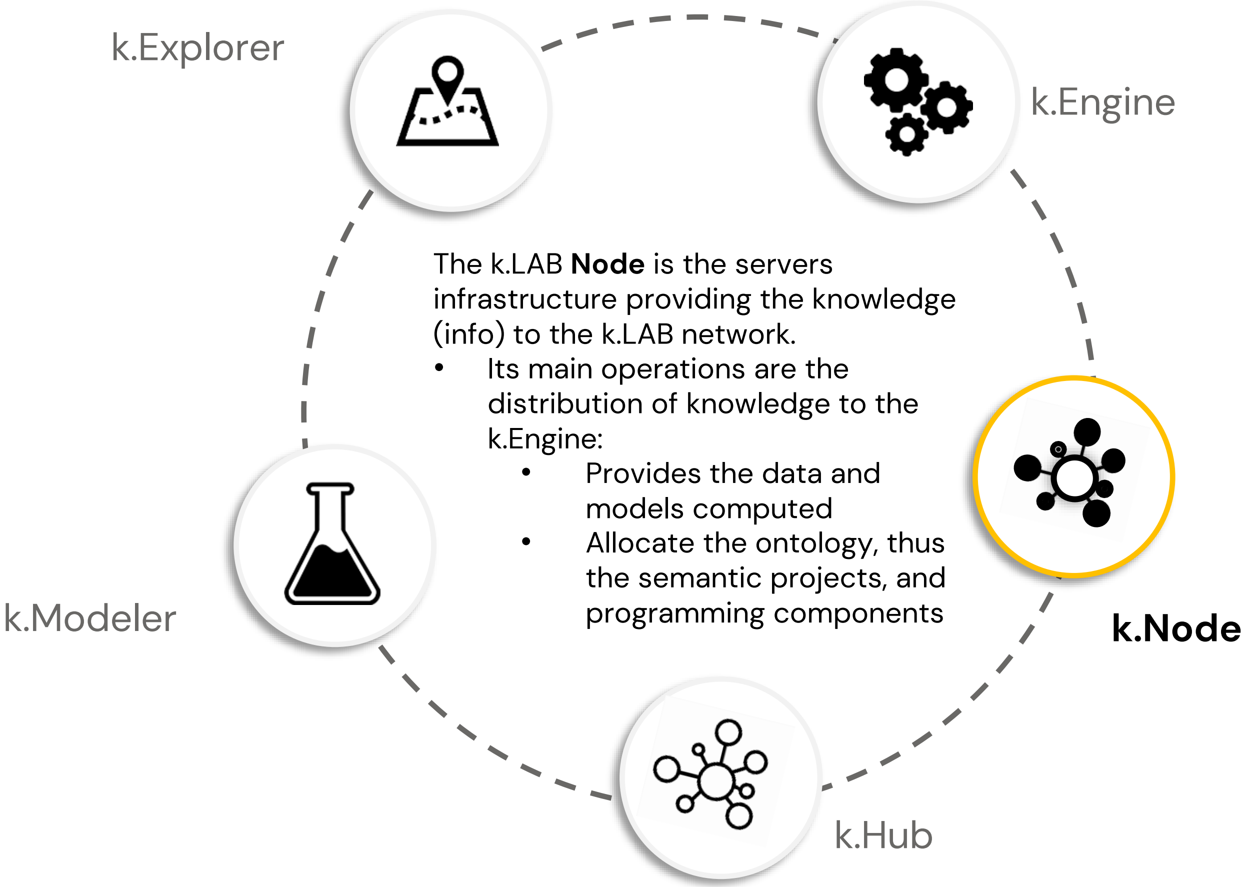


La plataforma k.LAB: soporte para una web semántica de observaciones

Incluye el lenguaje semántico de programación **k.IM**

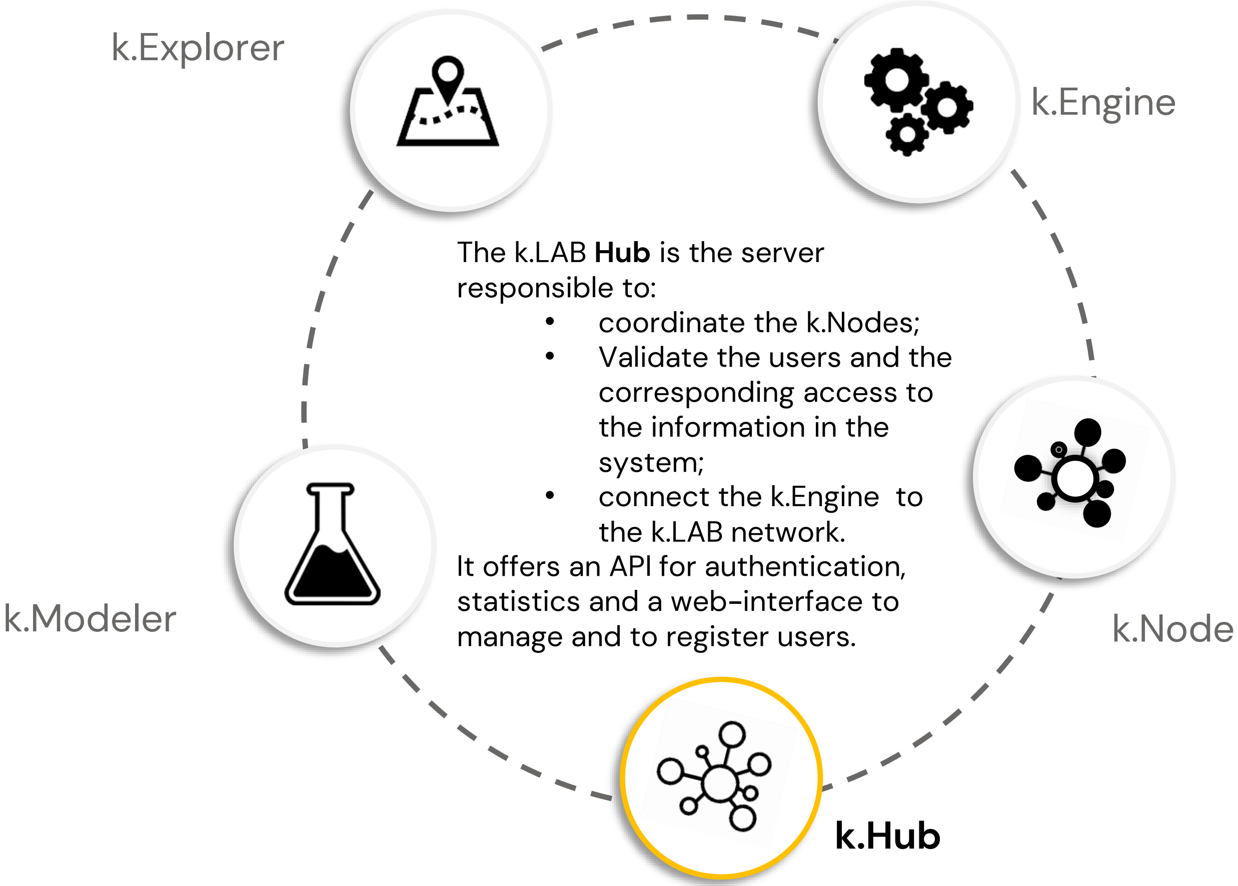


The k.LAB **Node** is the servers infrastructure providing the knowledge (info) to the k.LAB network.

- Its main operations are the distribution of knowledge to the k.Engine:
  - Provides the data and models computed
  - Allocate the ontology, thus the semantic projects, and programming components

The k.LAB platform supports observations made in the semantic web

Include its own semantic language, **k.IM**, used to program in this context



The k.LAB **Hub** is the server responsible to:

- coordinate the k.Nodes;
- Validate the users and the corresponding access to the information in the system;
- connect the k.Engine to the k.LAB network.

It offers an API for authentication, statistics and a web-interface to manage and to register users.

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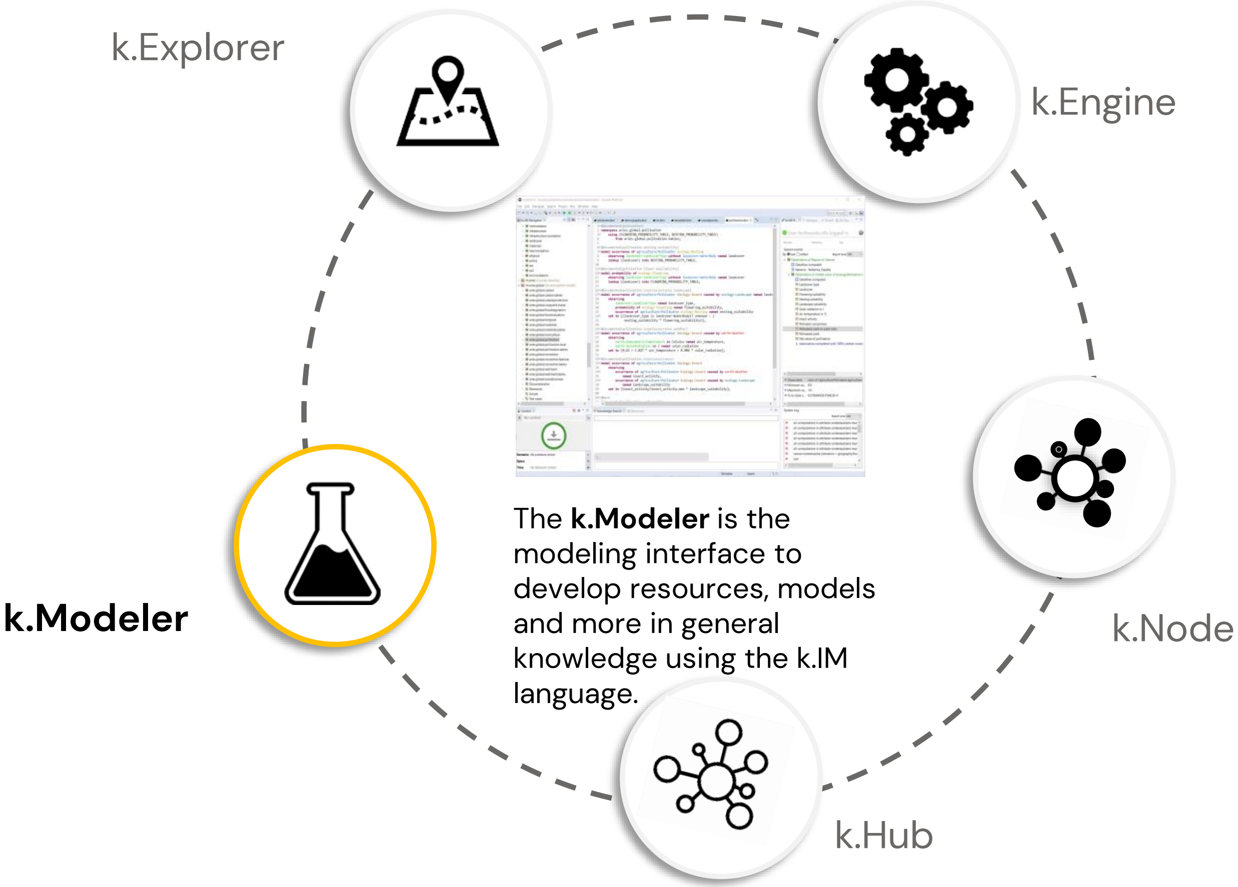

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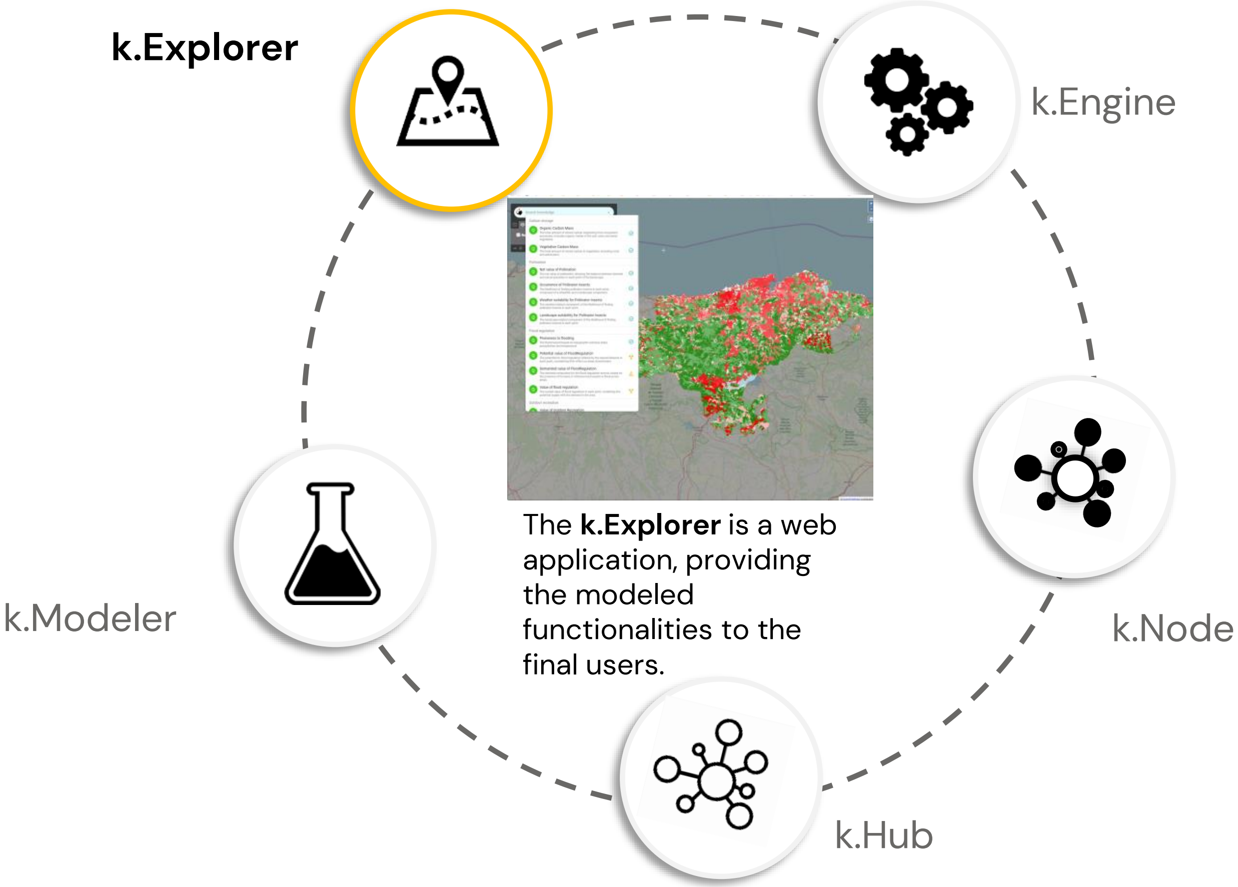

The key is a technology built for INTEROPERABILITY, developed on FAIR[1] data/models principles

Semantic web modelling

ARIES is connected to a library in which each component of a model is break down into in **modular** components, which allows and greatly simplify the use (and reuse) or the substitution of a certain input in the model composition when a more appropriate element becomes available in the system (i.e. local vs global data)

AI: machine reasoning

As each component of a model or data is connected to a concept through its semantic, the best combination of data and models available in the system is **automatically integrated** to answer the query posed by user (methodological, spatial and temporal dimensions are all considered).

Which algorithms are used to prioritize resources?

A de-centralised system with real democratic access to the knowledge produced

The system is built to can interconnect information hosted on a network of individual nodes (k.IM), based on open-source software language and always free to use for non-profit purposes. The language used to model and integrate data is **universal** because readable by machines as well as humans; being this very similar to English, it is also very **intuitive** for non-expert modelers. As more data and models are integrated in the system, the quality and the variety of those increases, not with a simple additional but a **multiplicative effects.** Each expert can contribute with new knowledge, and leverage on the knowledge created by others. This allows to find better answer to the questions posed to the system.
ARIES also generates very detailed report(s) and a visual diagram of the data and model(s) used to guarantee **full transparency and traceability** of each individual result.

1: **F**indable, **A**ccessible, **I**nteroperable and **R**eusable data and models

Machine reasoning: How do can a machine pick the “best” data/model under which circumstances?

Initial prioritization, adjustable by advanced users:

1. Lexical scope (how “close” are the data/model to the namespace, project, within k.LAB repositories);
2. Trait concordance (shared attributes with concept requested);
3. Scale coverage (data with more complete coverage chosen preferentially);
4. Scale specificity (local models chosen over national, over global);
5. Inherency (models specified for location/scale-specific use chosen over generalized models);
6. Subjective concordance (user-specified metadata & weightings);
7. Evidence (data models chosen over computed models)
8. Reliability (human input that affects the reliability of a source of information)