



BIOFIN-EU

# Biodiversity Risk Assessment for Europe

Hosted by: UM, WP4  
Siham Eddamiri  
Lea Hiebel



Funded by  
the European Union

[biofin-project.eu](https://biofin-project.eu)



*Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency (REA) (granting authority). Neither the European Union nor the granting authority can be held responsible for them.*



# Table of Contents

- A brief introduction to Machine Learning
- Step 1 : Species Projection
- Step 2 : Land Use Land Cover Forecasting
- Step 3 : Risk Assessment
- Discussion with audience on **Indicator Species** and **Risk Factors**



# Machine Learning

- **Herbert Alexander Simon:**  
“Learning is any process by which a system improves performance from experience.”
- “Machine Learning is concerned with computer programs that automatically improve their performance through experience.”



**Herbert Simon**  
[Turing Award](#) 1975  
[Nobel Prize in Economics](#) 1978

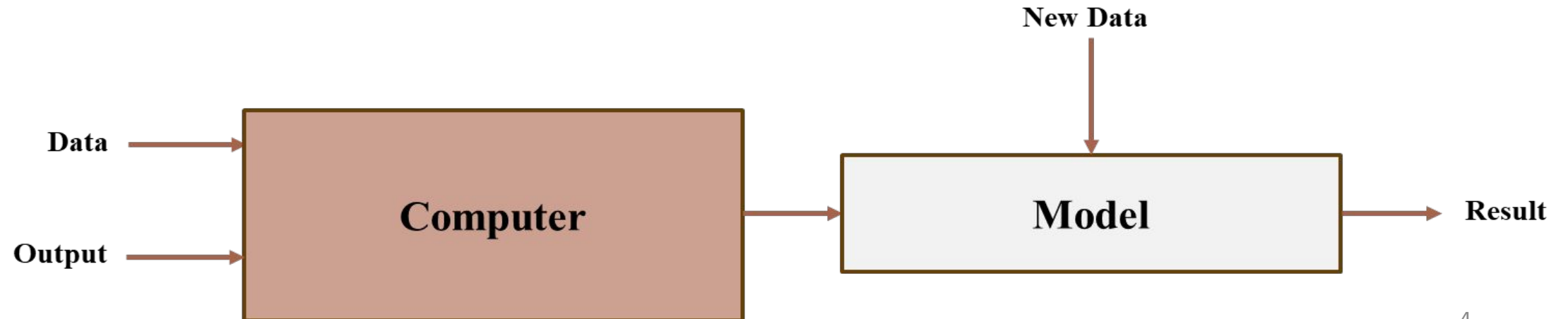
# Machine Learning



## Traditional Programming:



## Machine Learning:

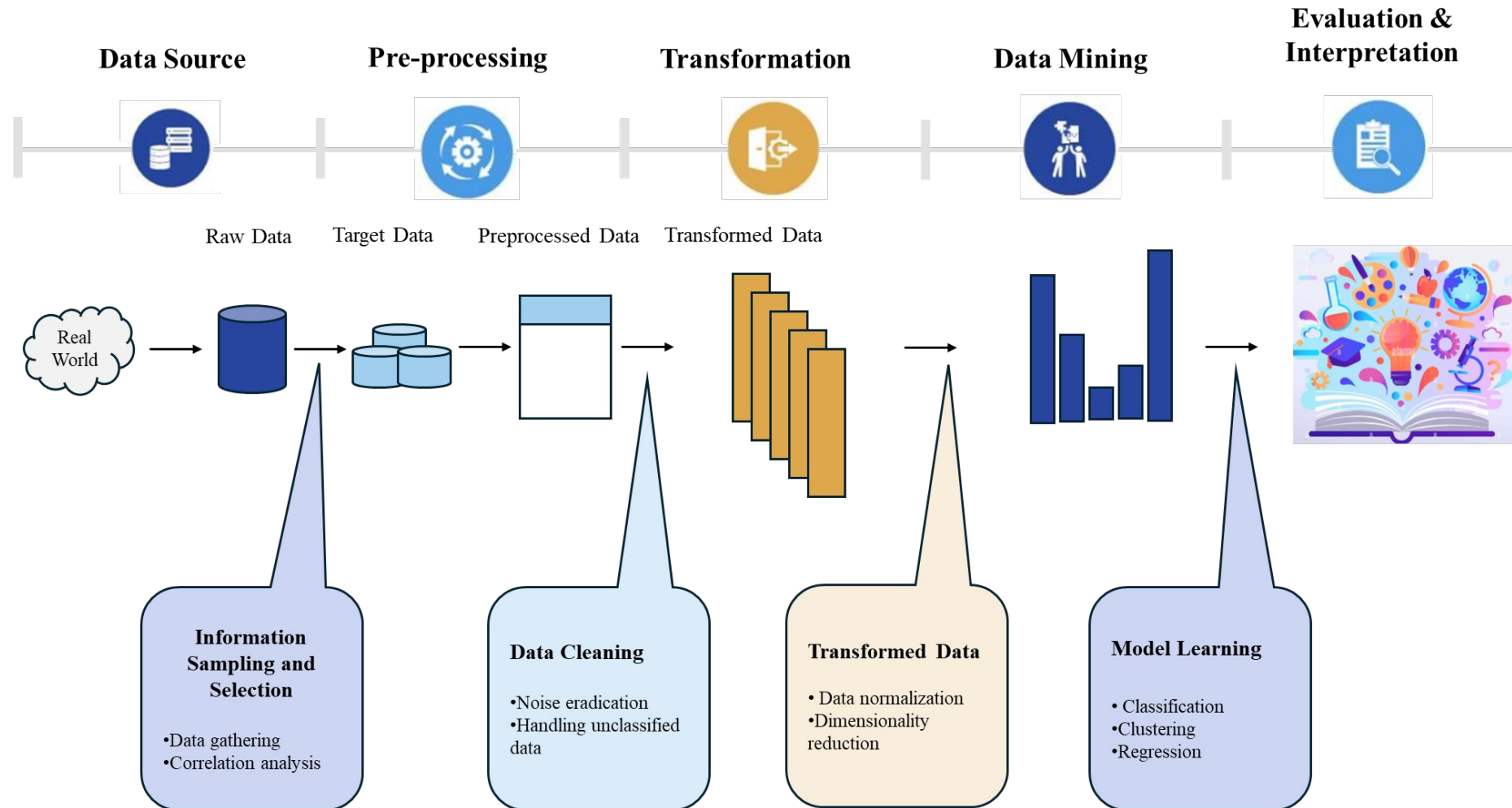






# Machine Learning

## The Learning Process:

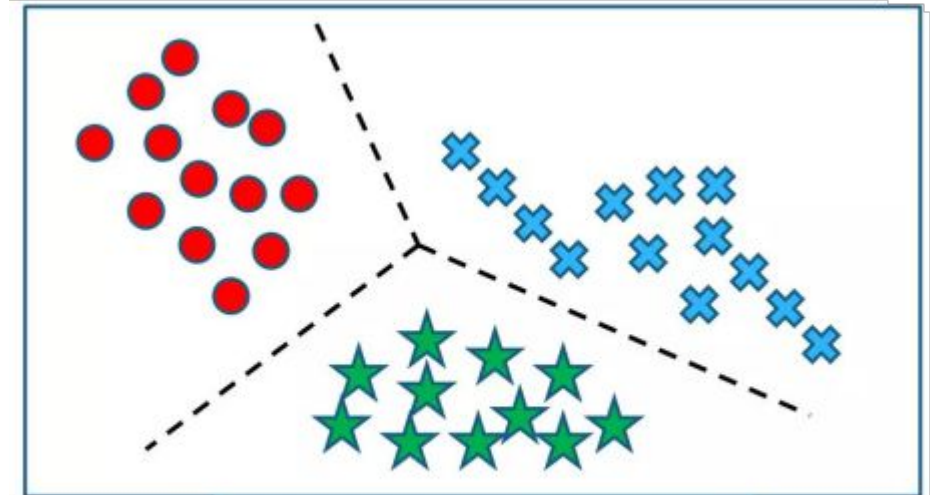




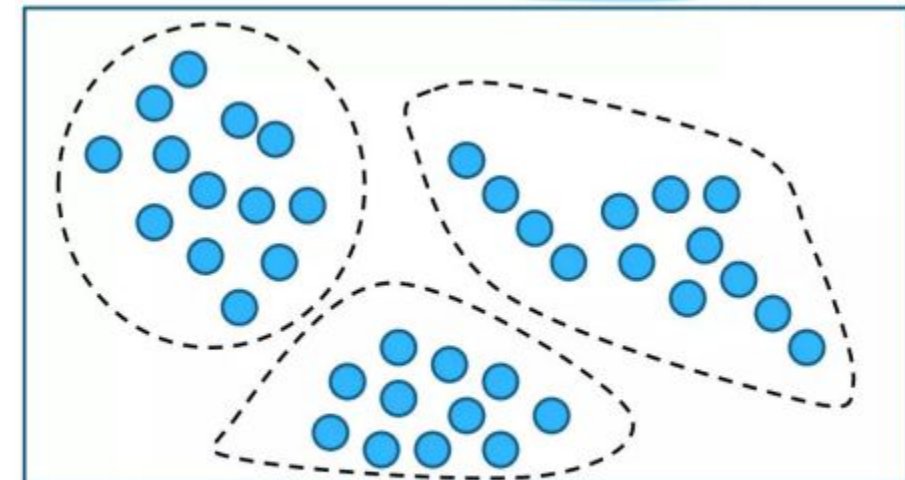
# Machine Learning

## Type of algorithm in Machine Learning:

- ❑ **Supervised learning**
  - Prediction
  - Classification (discrete labels), Regression (real values)
- ❑ **Unsupervised learning**
  - Clustering
- ❑ **Reinforcement learning**
  - Decision making (robot, chess machine)



Supervised learning



Unsupervised learning

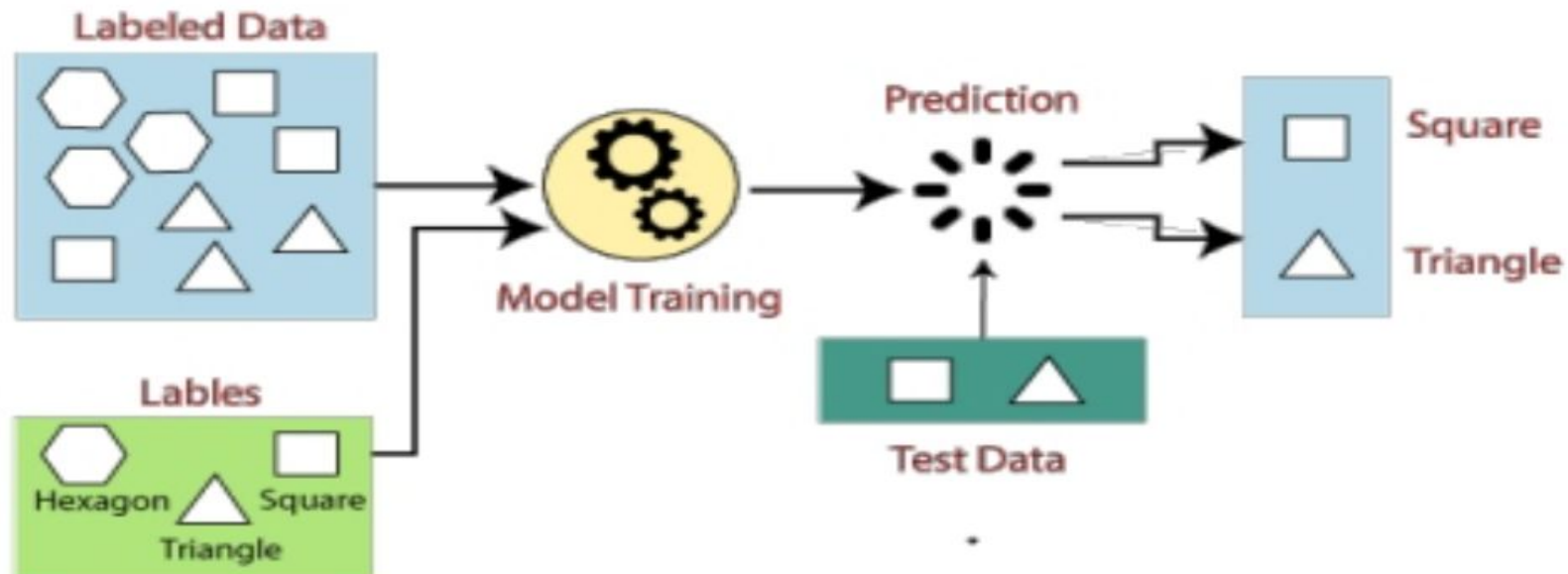


# Machine Learning

## Type of algorithm in Machine Learning:

- ❑ **Supervised learning**
  - Prediction
  - Classification (discrete labels), Regression (real values)

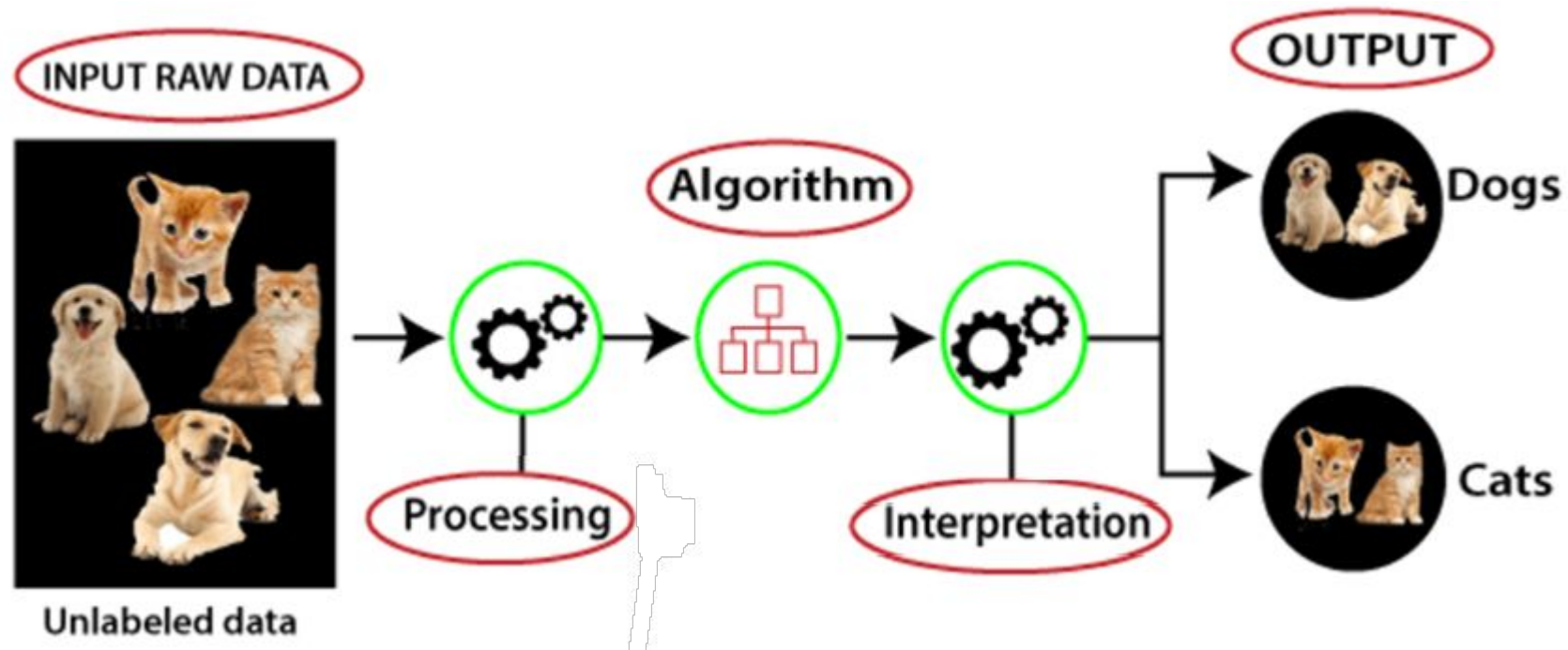
### ❑ Example



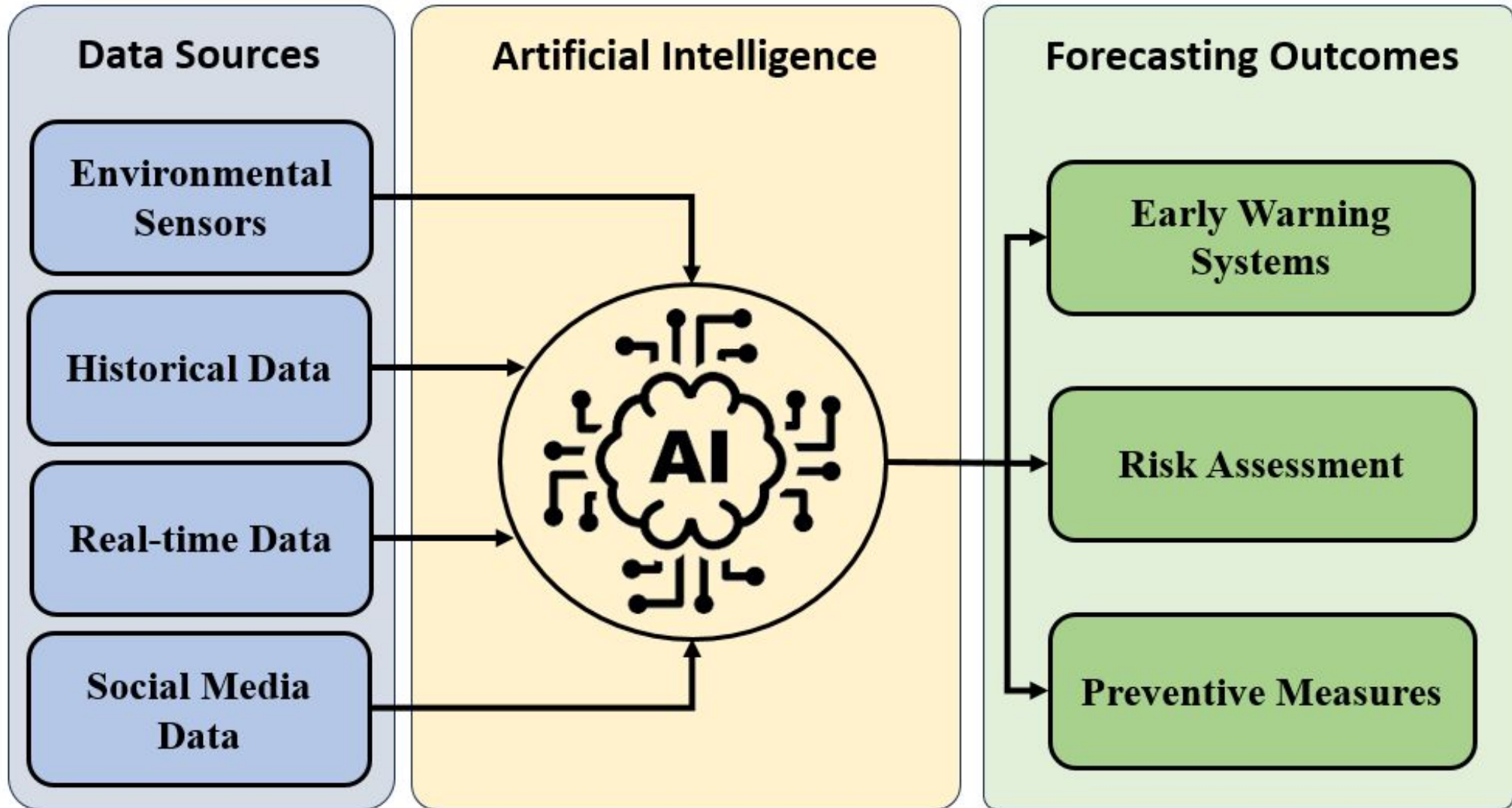
# Machine Learning

## Type of algorithm in Machine Learning:

- ❑ **Unsupervised learning**
  - Clustering
  
- ❑ **Example**



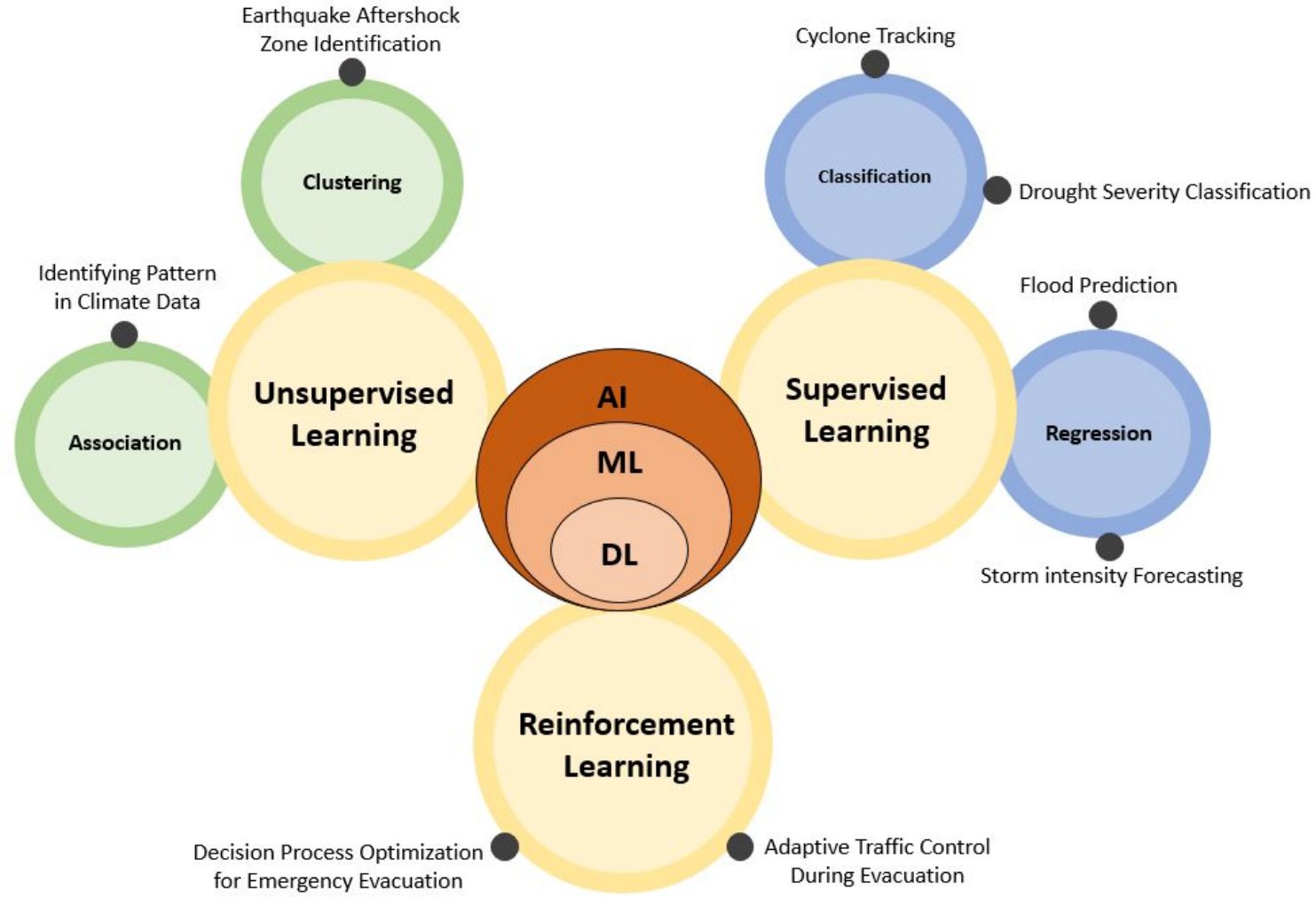
# Machine Learning



*Figure 1: Process of Artificial Intelligence adoption in Forecasting Outcomes*



# Machine Learning Applications



*Figure 2: Artificial Intelligence paradigms and their applications in extreme events*

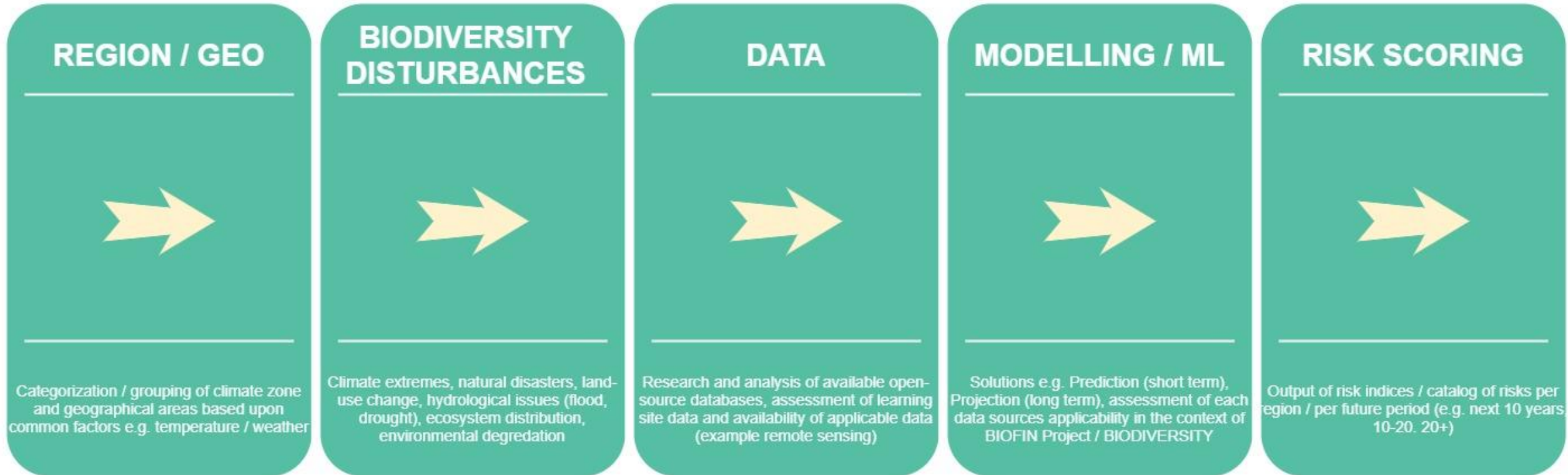


# Methodology For BioFIN



# Methodology

This process outlines the steps for identifying and scoring biodiversity-related risks by integrating region-specific data, disturbances, open-source databases, and machine learning models to predict short- and long-term biodiversity risks. The goal is to develop risk indices for future scenarios across various regions, supporting strategic decision-making for biodiversity finance.



*Figure 3 :Integrated Biodiversity Risk Assessment Framework for the BioFIN Project*



# Methodology

Step 1

Step 2

Step 3

## **Projection of species**

Identify indicator species and model their current and future distributions using environmental data and Species Distribution Models (SDMs).

## **Land Use and Land Cover Changes**

Analyze past land cover trends and forecast future changes to assess potential impacts on species habitats and ecosystem dynamics.

## **Risk Assessment**

Combine ecological risk factors into a spatial index to identify high-risk areas and support biodiversity-positive investment decisions.



## Step 1: Projection of species





# Projection Species

## ❑ Objective:

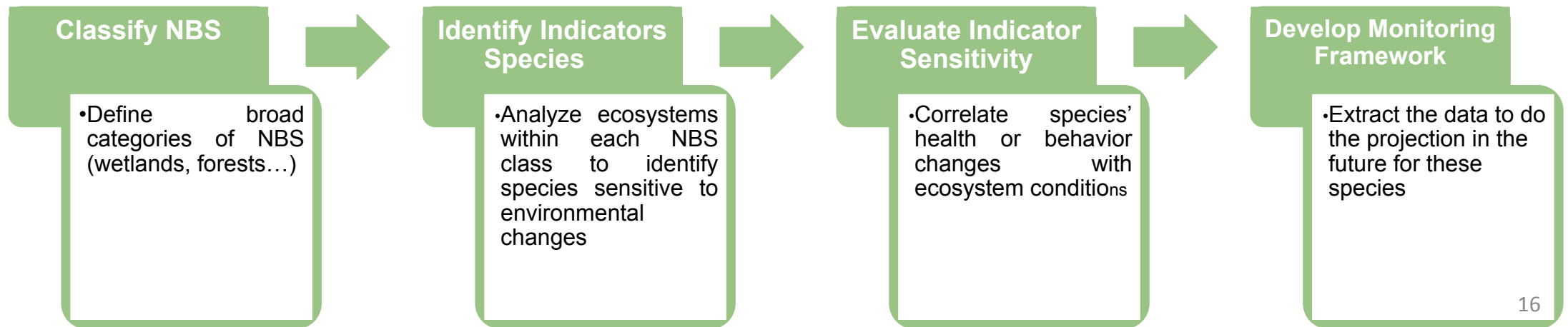
- Classify NBS into clear, actionable classes.
- Identify **sensitive species** within each NBS that act as **early-warning indicators** for ecosystem health.

## ❑ Why This Approach?

- Enhance monitoring and management of NBS by leveraging biological signals.
- Improve understanding of ecosystem resilience and risks.

## ❑ Key Questions:

- What are the main NBS classes?
- Which species are most sensitive to changes in these systems?
- How can we use these indicators as early-warning systems?





# Projection Species

## What are Indicator Species?

Indicator species (IS) are used to monitor environmental changes, assess the efficacy of management, and provide warning signals for impending ecological shifts.

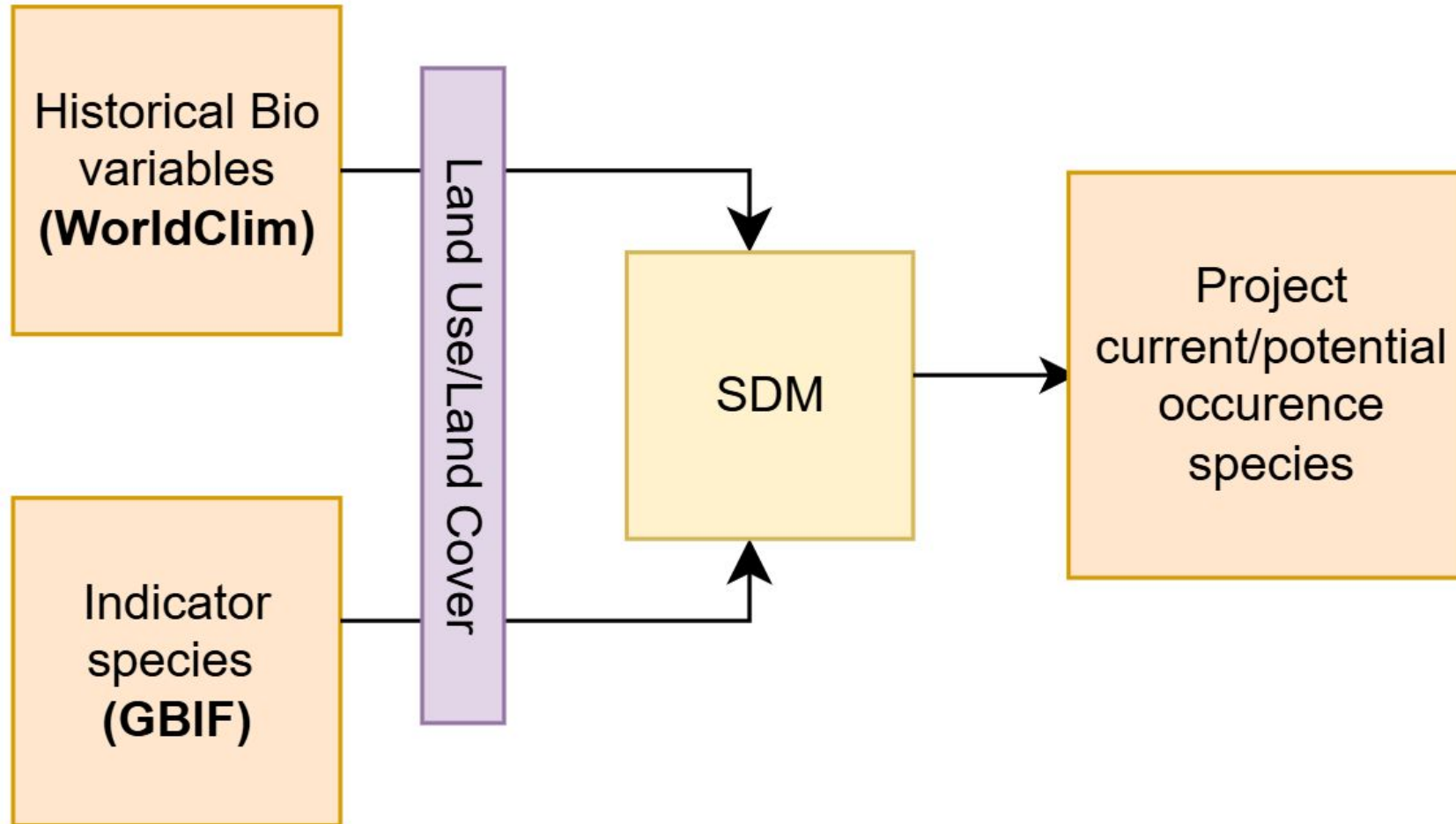
Though widely adopted in recent years by ecologists, conservation biologists, and environmental practitioners, the use of IS has been criticized for several reasons, notably the lack of justification behind the choice of any given indicator. (Siddig, A. A., Ellison, A. M., Ochs, A., Villar-Leeman, C., & Lau, M. K. (2016). *How do ecologists select and use indicator species to monitor ecological change? Insights from 14 years of publication in Ecological Indicators. Ecological Indicators, 60, 223-230.*)

## How We Use Indicator Species in BIOFIN-EU

- Selection Criteria:** Species are chosen based on sensitivity to habitat changes, ecological relevance, and availability of distribution data.
- Purpose in WP4:** Serve as biological indicators to model ecosystem responses under land use and climate change scenarios.
- Application:** Integrated into Species Distribution Models (SDMs) to project future presence/absence and support risk assessment.
- Outcome:** Help identify areas of high biodiversity vulnerability to guide nature-positive investments and inform policy tools.



# Projection Species





# Projection Species

Classify NBS



Identify Indicator Species

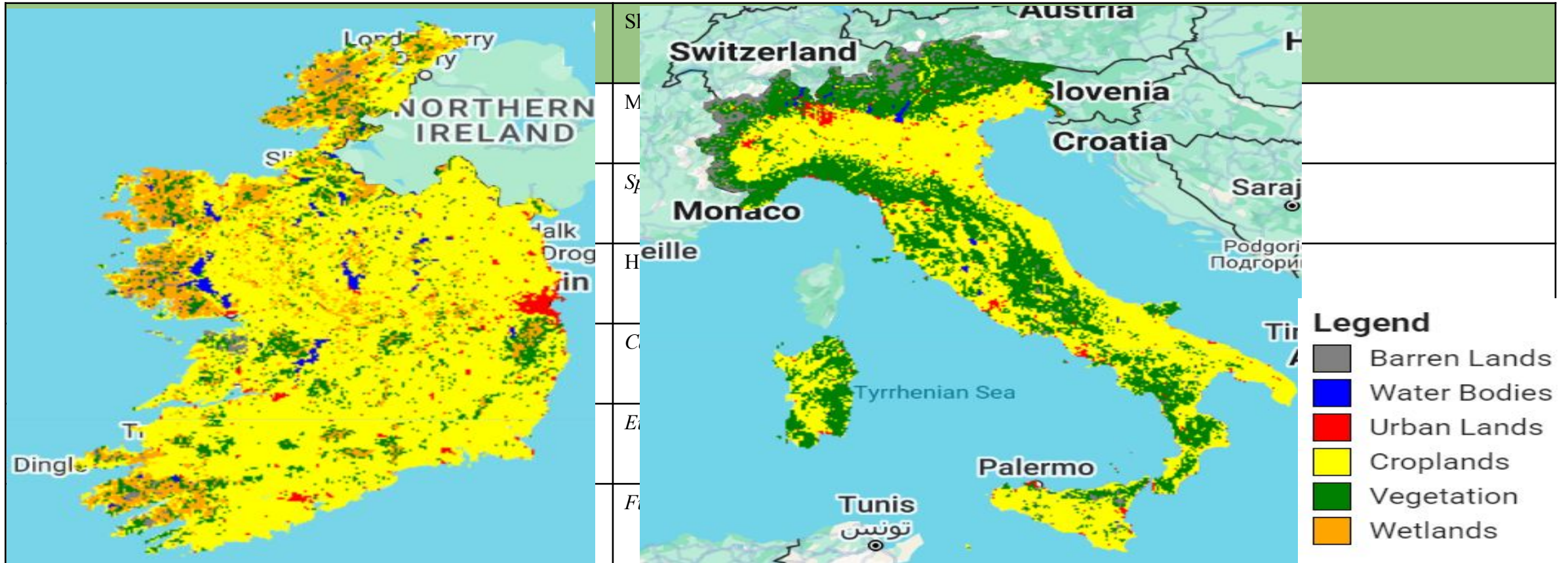


Evaluate Indicator Sensitivity



Develop Monitoring Framework

## NBS Classification and Indicator Species Found in Italy and Ireland:





# Projection Species

Classify  
NBS



Identify  
Indicators  
Species



Evaluate  
Indicator  
Sensitivity



Develop  
Monitoring  
Framework

## Climate Variables

- ❖ Bioclimatic variables (BIOs) are derived from the monthly temperature and rainfall values in order to generate more biologically meaningful variables.

BIO1 = Annual Mean Temperature

BIO2 = Mean Diurnal Range (Mean of monthly (max temp - min temp))

BIO3 = Isothermality (BIO2/BIO7) ( $\times 100$ )

BIO4 = Temperature Seasonality (standard deviation  $\times 100$ )

BIO5 = Max Temperature of Warmest Month

BIO6 = Min Temperature of Coldest Month

BIO7 = Temperature Annual Range (BIO5-BIO6)

BIO8 = Mean Temperature of Wettest Quarter

BIO9 = Mean Temperature of Driest Quarter

BIO10 = Mean Temperature of Warmest Quarter

BIO11 = Mean Temperature of Coldest Quarter

BIO12 = Annual Precipitation

BIO13 = Precipitation of Wettest Month

BIO14 = Precipitation of Driest Month

BIO15 = Precipitation Seasonality (Coefficient of Variation)

BIO16 = Precipitation of Wettest Quarter

BIO17 = Precipitation of Driest Quarter

BIO18 = Precipitation of Warmest Quarter

BIO19 = Precipitation of Coldest Quarter



# Projection Species

Classify  
NBS



Identify  
Indicators  
Species



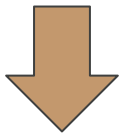
Evaluate  
Indicator  
Sensitivity



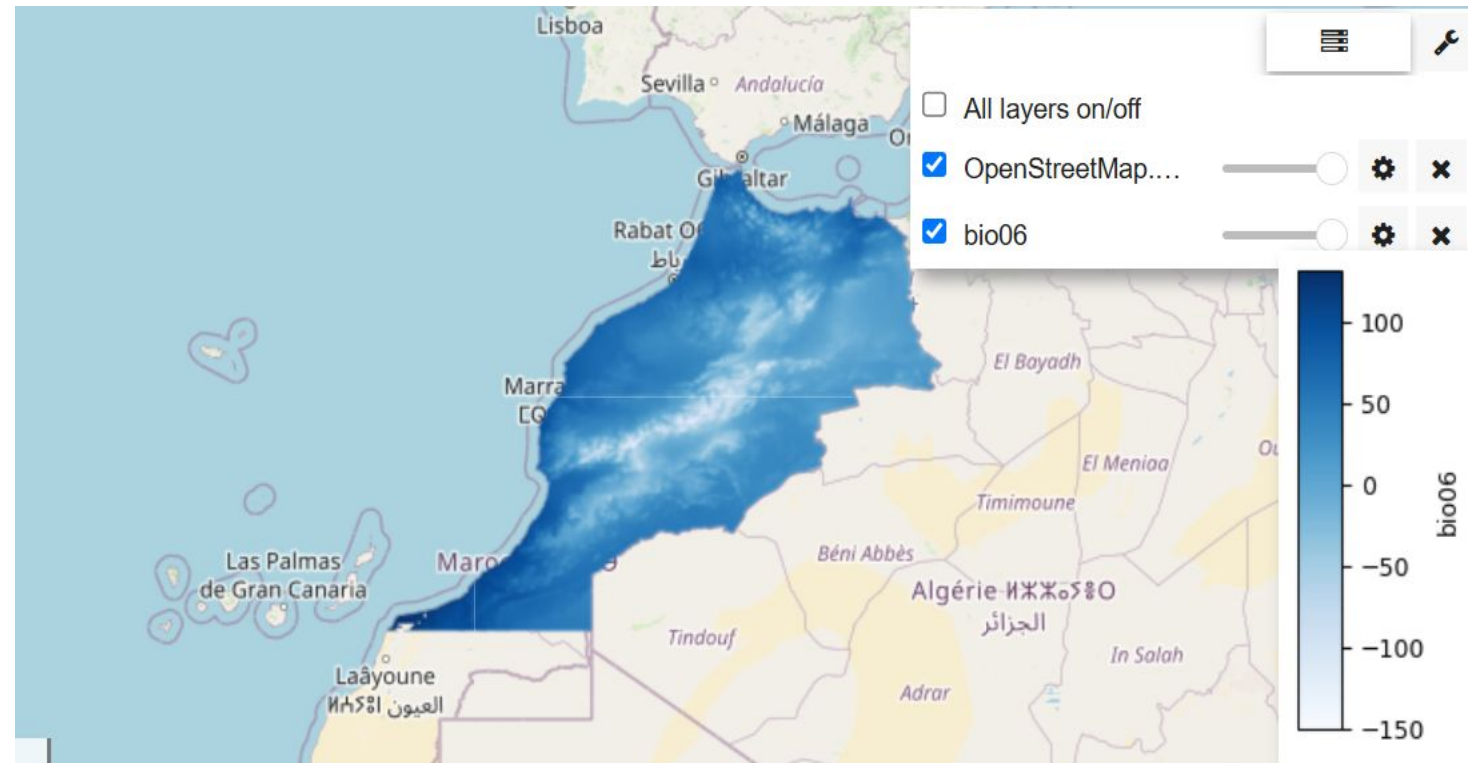
Develop  
Monitoring  
Framework

## Climate Variables

**All the bands:** ['TCC', 'aspect', 'bio01', 'bio02', 'bio03', 'bio04', 'bio05', 'bio06', 'bio07', 'bio08', 'bio09', 'bio10', 'bio11', 'bio12', 'bio13', 'bio14', 'bio15', 'bio16', 'bio17', 'bio18', 'bio19', 'elevation', 'hillshade', 'slope'].



**Selected Bands:** ['TCC', 'aspect', 'bio06', 'bio08', 'bio14', 'bio19', 'slope']





# Projection Species

Classify  
NBS



Identify  
Indicators  
Species



Evaluate  
Indicator  
Sensitivity



Develop  
Monitoring  
Framework

## Projection of Bioclimatic Variables

Model: ACCESS-CM2

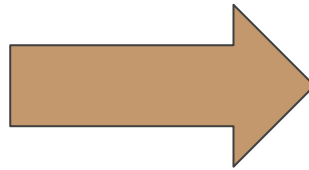
Scenario: ssp245

Country: Italy

Year: 2030

Bioclimatic ... BIO1 (Annual Mean Temperatur

Execute





# Projection Species

Classify  
NBS



Identify  
Indicators  
Species



Evaluate  
Indicator  
Sensitivity



Develop  
Monitoring  
Framework

## Species Distribution Modeling

Species:  ▼

Country:  ▼

Land Cover:  ▼

Run Training

Model:  ▼

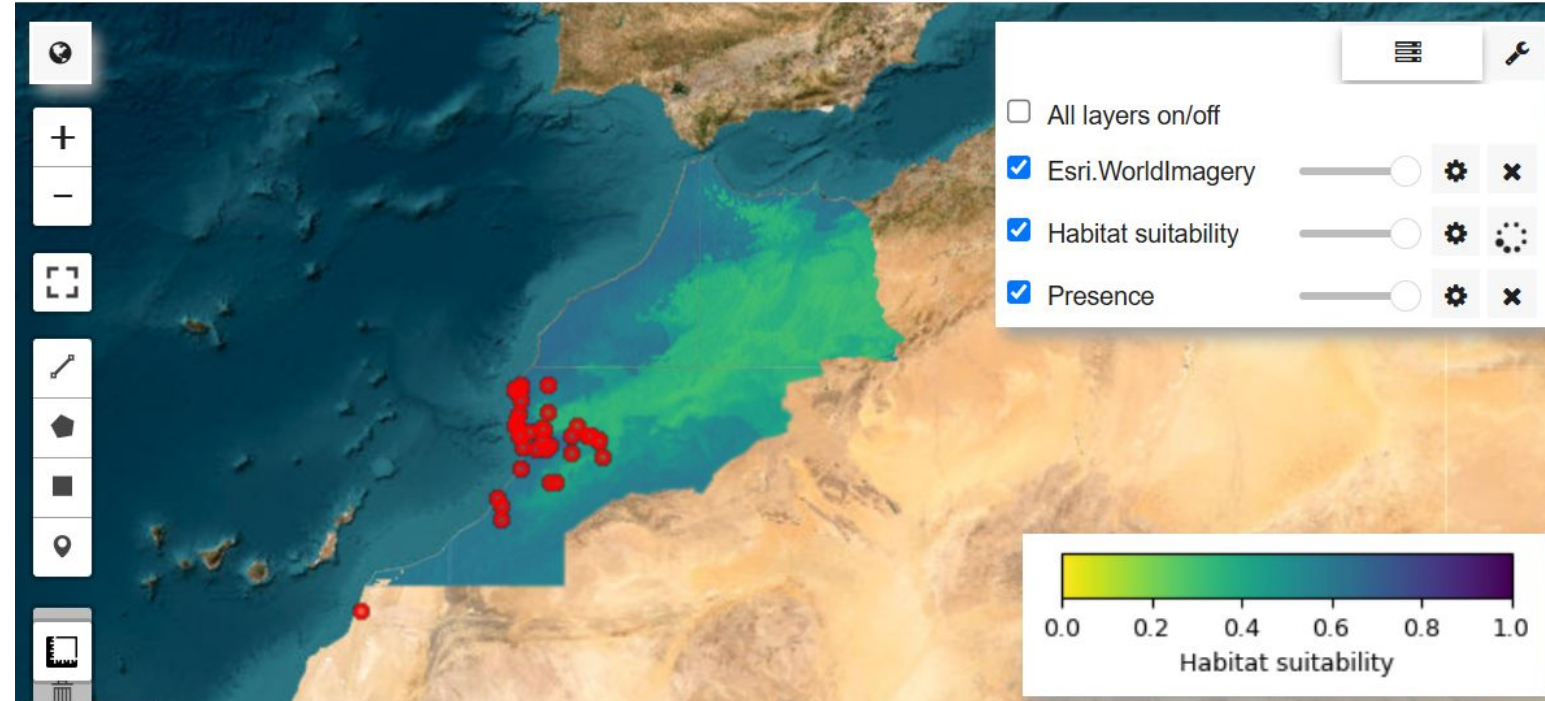
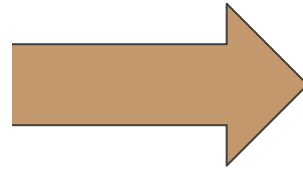
Scenario:  ▼

Country:  ▼

Year 1:  ▼

Year 2:  ▼

Run Projection





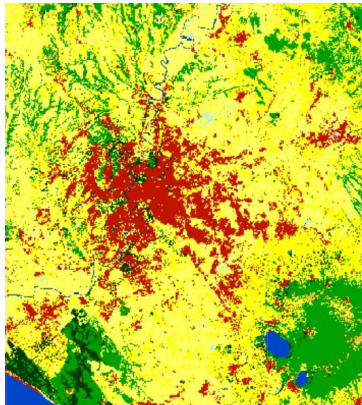
## Step 2: Land Use and Land Cover Forecasting





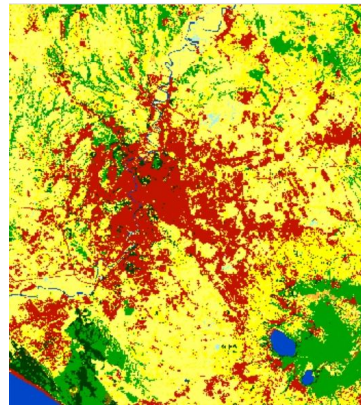
# Forecast future LULC

every year (2000-2022)



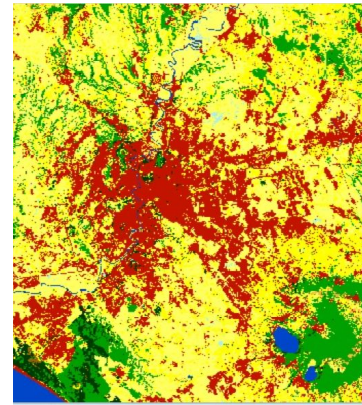
**LULC 2000**

...

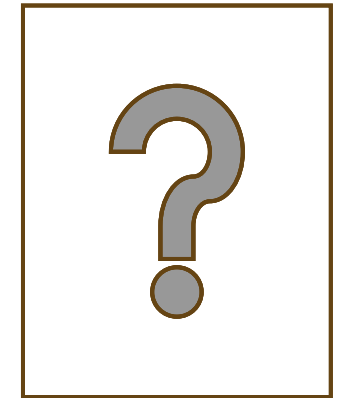


**LULC 2010**

...



**LULC 2022**



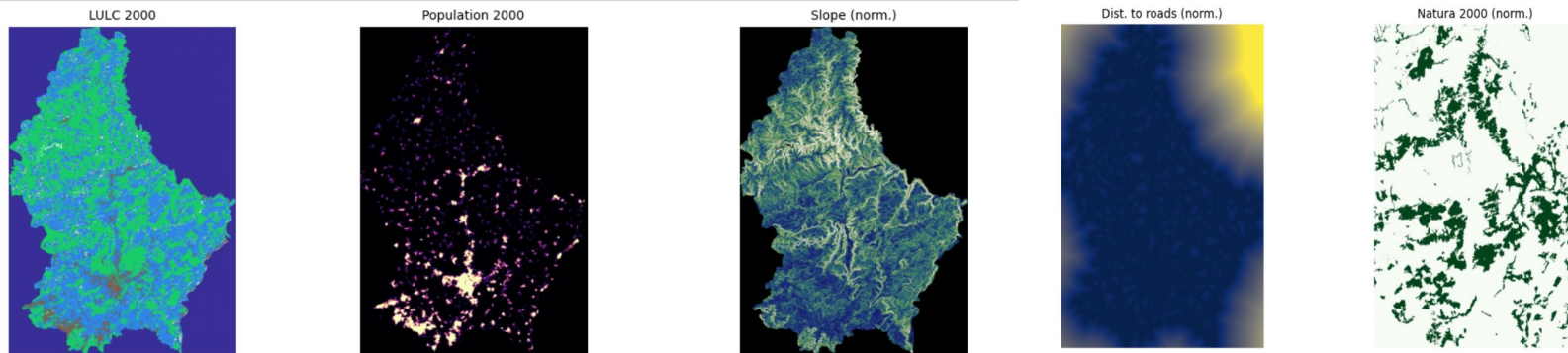
**LULC 2030 / 2040**

- |   |  |
|---|--|
|  Open evergreen broadleaved forest   |  Rainfed cropland                       |
|  Closed evergreen broadleaved forest |  Herbaceous cover cropland              |
|  Water body                          |  Tree or shrub cover (Orchard) cropland |
|  Impervious surfaces                 |  Irrigated cropland                     |

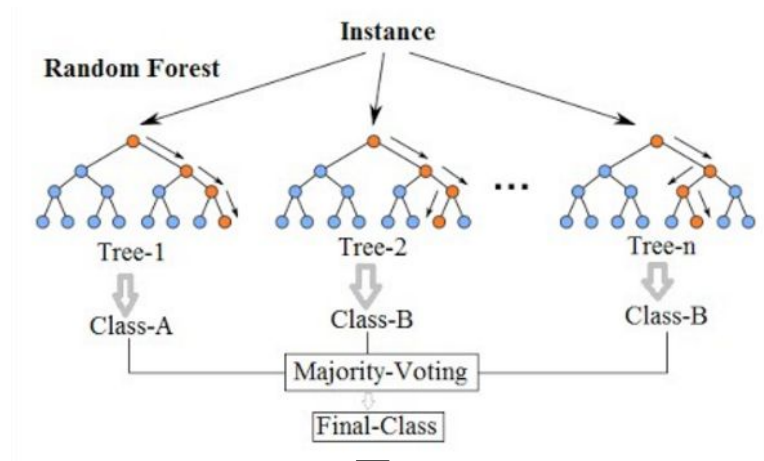
# Forecast future LULC



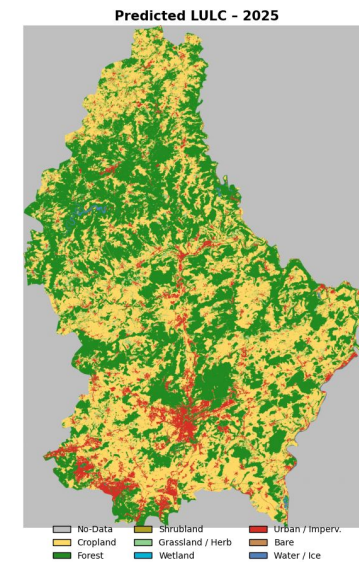
Input data



Model



Output



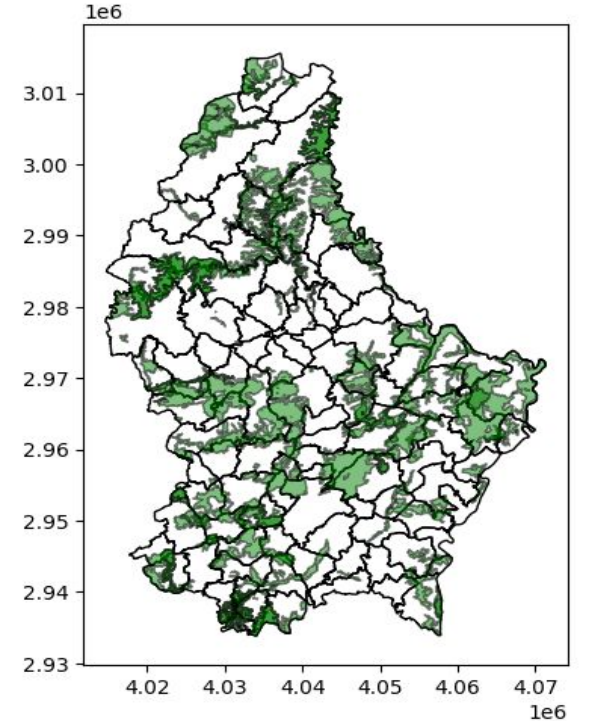


# Forecast future LULC

## □ Key questions :

- Analyse historical LULC changes (2000-2022)
- Investigate urban cover and urban growth inside vs outside Natura 2000 Network

Natura 2000 Sites Over Communal Boundaries - Luxembourg



**Natura 2000 Network** : network of protected areas covering Europe's most valuable and threatened species and habitats. It is the largest coordinated network of protected areas in the world, extending across all 27 EU Member States, both on land and at sea.



# Forecast future LULC

Table 1: Land use/cover Change Matrix from 2000 to 2022 (area in Ha)

	Cropland	Forest	Shrubland	Grassland/Herb	Wetland	Urban/Imperv	Bare	Water/Ice
Cropland	107623.71	2885.22	455.76	1073.25	5.76	3290.31	0.45	2.43
Forest	4350.42	114086.52	175.68	181.35	8.64	605.70	0.90	33.57
Shrubland	539.37	170.46	1667.25	30.33	0.27	14.31	0.00	0.00
Grassland/Herb	1519.20	244.98	46.44	4820.58	0.45	74.34	0.00	0.09
Wetland	0.90	6.93	0.27	0.45	50.13	3.06	0.18	36.81
Urban/Imperv	960.48	334.44	11.56	36.54	10.17	13982.49	1.26	2.07
Bare	0.63	0.45	0.00	0.00	0.27	1.62	10.26	2.16
Water/Ice	1.35	6.12	0.63	0.45	20.61	2.16	0.63	564.84

Table 2: Gain/Loss Summary between 2000 and 2022 (area in Ha)

Land use/cover class	Area in 2000	Area in 2022	Net change
Cropland	115336.89	114996.06	-340.83
Forest	119442.78	117735.12	-1707.66
Shrubland	2421.99	2357.19	-64.80
Grassland/Herb	6706.08	6142.95	-563.13
Wetland	98.73	96.30	-2.43
Urban/Imperv	15338.61	17973.99	2635.38
Bare	15.39	13.68	-1.71
Water/Ice	596.79	641.97	45.18

- Urban/Impervious surfaces experienced significant expansion (+13,892.49 ha), primarily by converting large areas of Cropland (3,290.31 ha)
- Forest (605.70 ha). Cropland also saw substantial gains, mostly at the expense of Forest (4,350.42 ha) and Grassland/Herbaceous areas (1,519.20 ha).



# Forecast future LULC

Table 5: Urban Cover (Inside vs. Outside) of the Natura 2000 Network per Year

Year	Inside (ha)	Outside (ha)	Prop Inside (%)	Prop Outside (%)
2000	188.55	15150.06	0.27	3.37
2005	213.57	16483.32	0.31	3.67
2010	226.35	17052.57	0.32	3.79
2015	251.82	17551.44	0.36	3.90
2020	263.52	17938.35	0.38	3.99
2022	253.26	17720.73	0.36	3.94

Table 6: Urban Growth Rates (Inside vs. Outside) of the Natura 2000 Network

Time Interval	Inside Growth (%)	Outside Growth (%)
2000-2005	13.27	8.80
2005-2010	5.98	3.45
2010-2015	11.25	2.93
2015-2020	4.65	2.20
2020-2022	-3.89	-1.21

- Urban cover inside Natura 2000 was 9-10 times lower than outside (0.33% vs. 3.77%) in average, in Luxembourg
- However, the rates of urban growth were higher inside than outside Natura 2000 (6.252% vs. 3.234%), which indicates an incipient urban sprawl inside the network



## Step 3: Risk Assessment





# Risk Assessment

## ❖ Development Finance and Biodiversity Risks:

- China's Belt and Road Initiative: Large-scale infrastructure development.
- Key Risks: Habitat destruction, species loss, and Indigenous land encroachment.

## ❖ Original Study Objective:

- Quantify biodiversity risks posed by China's Development Finance Institutions (DFIs).
- Develop a **spatially explicit risk assessment framework** to identify and mitigate risks.

## ARTICLES

<https://doi.org/10.1038/s41559-021-01541-w>

nature  
ecology & evolution



## Risks to global biodiversity and Indigenous lands from China's overseas development finance

Hongbo Yang<sup>1,3</sup>, B. Alexander Simmons<sup>1,3</sup>, Rebecca Ray<sup>1</sup>, Christoph Nolte<sup>2</sup>, Suchi Gopal<sup>2</sup>, Yaxiong Ma<sup>2</sup>, Xinyue Ma<sup>1</sup> and Kevin P. Gallagher<sup>1</sup>✉

China has become one of the world's largest lenders in overseas development finance. Development projects, such as roads, railways and power plants, often drive biodiversity loss and infringe on Indigenous lands, yet the risks implicit in China's overseas development finance are poorly understood. Here we examine the extent to which projects financed by China's policy banks between 2008 and 2019 occur within and adjacent to areas where large-scale investment can present considerable risks to biodiversity and Indigenous peoples. Further, we compare these risks with those posed by similar projects financed by the World Bank, previously the world's largest source of development finance. We found that 63% of China-financed projects overlap with critical habitats, protected areas or Indigenous lands, with up to 24% of the world's threatened birds, mammals, reptiles and amphibians potentially impacted by the projects. Hotspots of the risks are primarily distributed in northern sub-Saharan Africa, Southeast Asia and parts of South America. Overall, China's development projects pose greater risks than those of the World Bank, particularly within the energy sector. These results provide an important global outlook of socio-ecological risks that can guide strategies for greening China's development finance around the world.

# Risk Assessment



## ❖ **Key Goals:**

- Align methodology with Europe's ecological and policy context.
- Integrate additional components such as landscape fragmentation and climate resilience.

## ❖ **Components of the New Formula:**

- Critical Habitats (CH)
- Protected Areas (PA)
- Species Richness Index (SRI)
- Landscape Fragmentation (LF)
- Climate Vulnerability (CV)



# Risk Assessment

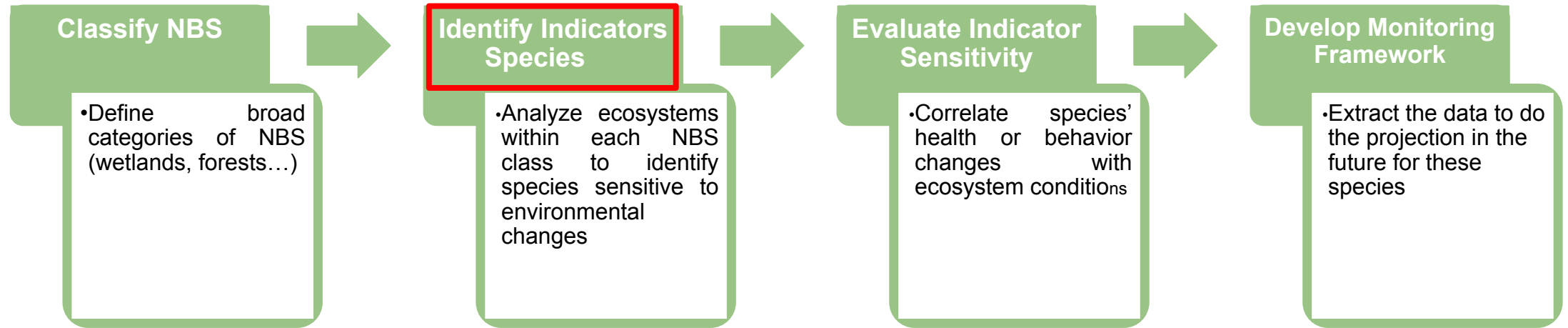
## ❖ The Biodiversity Risk Formula:

$$R_b = \frac{w_1 \cdot CH + w_2 \cdot PA + w_3 \cdot SI + w_4 \cdot LF + w_5 \cdot CV}{w_1 + w_2 + w_3 + w_4 + w_5} \quad (\text{with: } w_1 + w_2 + w_3 + w_4 + w_5 = 1)$$

- **Weights example:**  $w_1 = 0.3$ ;  $w_2 = 0.2$ ;  $w_3 = 0.3$ ;  $w_4 = 0.1$ ;  $w_5 = 0.1$
- **Critical Habitats (CH):** Prioritize habitats in Natura 2000 based on conservation value (high, medium, low).
- **Protected Areas (PA):** Score based on overlap with Natura 2000 and national parks.
- **Species Richness Index (SRI):** Use EU Red List data weighted by human footprint:  $SI_i = SRI_i + HFI_i$
- **Landscape Fragmentation (LF):** Connectivity metrics using Effective Mesh Size or equivalent.
- **Climate Vulnerability (CV):** Proportion of project buffer zones identified as climate-sensitive.



# Projection Species



## How to identify the Indicator Species





# Conclusion

- ❑ **Step 1:** Projections to assess ecosystem health and guide Nature-Based Solutions.
  - Indicator Species
- ❑ **Step 2:** Assessing and Forecasting Land Use and Land Cover Changes
  - Habitat Types / Ecosystem Classes
- ❑ **Step 3:** Risk Assessment
  - Risk Factors



Funded by  
the European Union

# Thank You!

## Let's Get in Touch!

website

[biofin-project.eu](http://biofin-project.eu)

e-mail

[info@biofin-project.eu](mailto:info@biofin-project.eu)

social media



Sarajevska regionalna razvojna agencija



Sarajevo Economic Region Development Agency



Dipartimento Territorio e Sistemi Agro-Forestali  
Università di Padova



A recognised college of UCD



UNIVERSIDADE

