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Using Machine Learning to Analyze the Effects of Agricultural Practices on Ecosystem Services

Roxanne S. Lorilla - rslorilla@noa.gr

Vassilis Sitokonstantinou, Charalampos Kontoes, Alkiviadis Koukos, Ilias Tsoumas

National Observatory of Athens

BEYOND Centre of EO Research and Satellite Remote Sensing

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One Ecosystem

#LIFE4Nature

Monitoring Agricultural Practices and Food Security at various partial scales and resolutions

- Smart farming
- Monitoring of the CAP
- Food Security

Understanding the Earth system, its weather, climate, atmosphere, and natural/human-induced hazards to protect the global environment, reduce disaster losses, and achieve sustainable development.

Development of an Early Warning System that utilizes new and enhanced satellite EO sensors with the purpose of forecasting and risk mapping the mosquito-borne diseases outbreaks

Earth Observation (EO) services as it regards disaster and emergency management, and risk reduction

Development of a nowcasting system and short term forecasting system for solar energy exploitation using advanced technical capacities of EO

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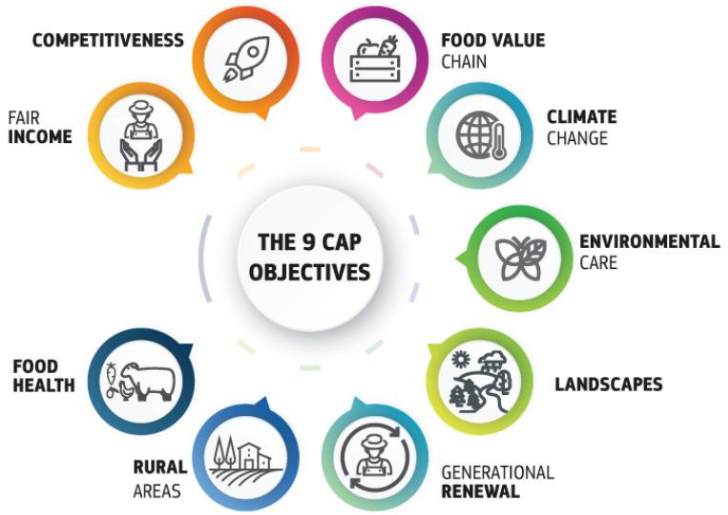
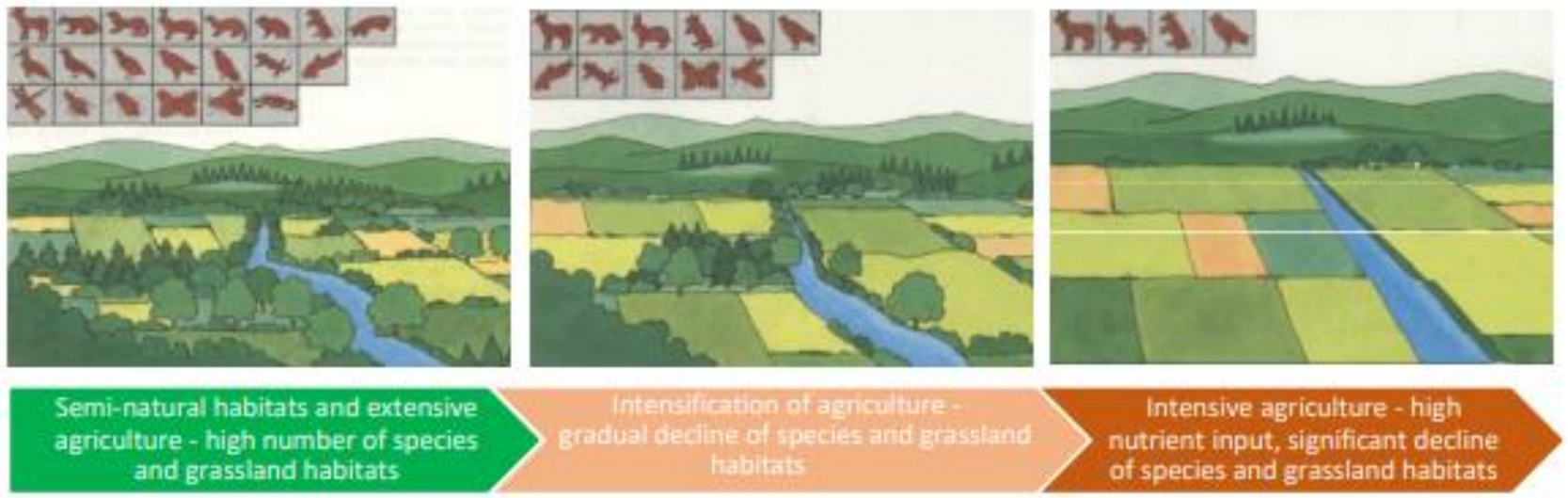
CAP, BIODIVERSITY & ECOSYSTEM SERVICES

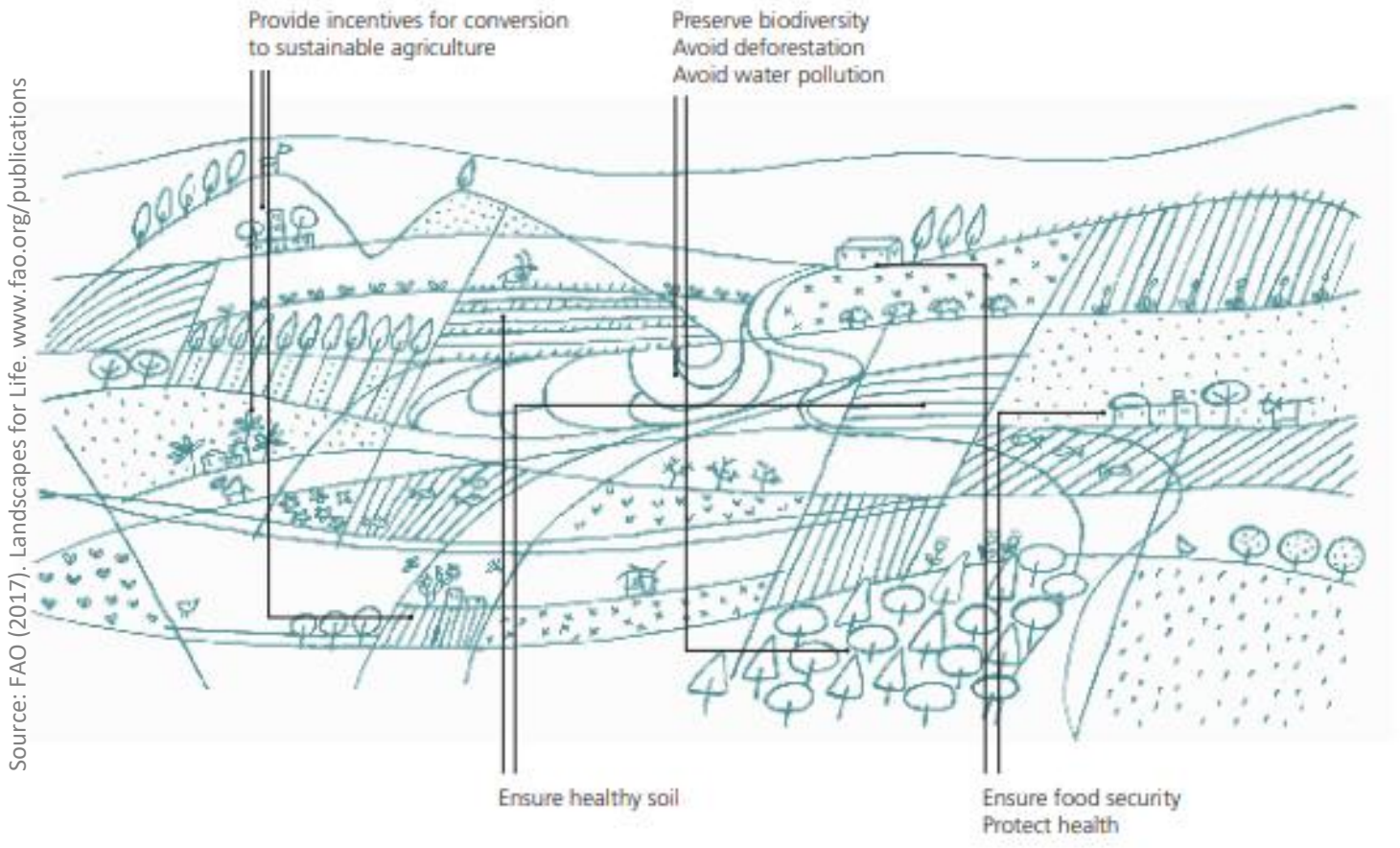
- The Common Agricultural Policy has facilitated agricultural intensification, leading to loss of farmland biodiversity and degradation of ecological processes
- National and farm-level flexibility in choices of greening measures resulted in the horizontal implementation of management rules (lack of spatial targeting of environmental measures)
- The increase of production efficiency has led to landscape homogenization.
- The post 2020 CAP brings to the table key elements for the environment and climate



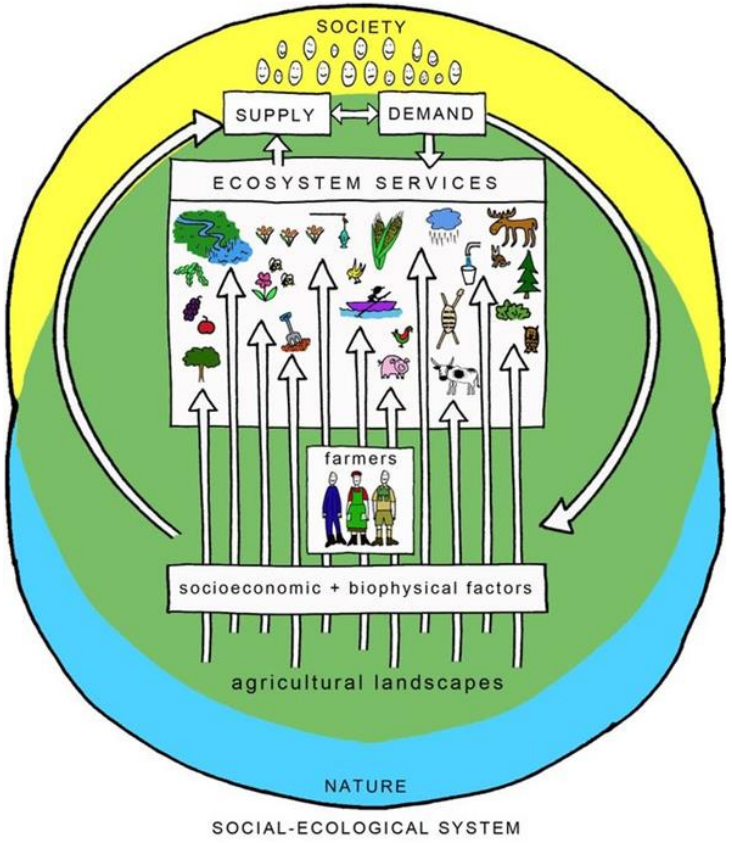


Source: EUROPEAN COURT OF AUDITORS (ECA). Audit preview: Biodiversity in farming. European Union 2019. https://www.eca.europa.eu/en/Pages/DocItem.aspx?did=50151

AGROECOSYSTEM SERVICES



Source: FAO (2017). Landscapes for Life. www.fao.org/publications



Malinga, Rebecka (2016). Ecosystem services in agricultural landscapes A study on farming and farmers in South Africa and Sweden. Stockholm University, ISBN 978-91-7649-506-3

WHY?

Reveal the specific conditions, in terms of agricultural management, that promote coexistence of multiple ecosystem services.

Increase the understanding of the complex dynamics between the human and ecological aspects of agricultural landscapes.

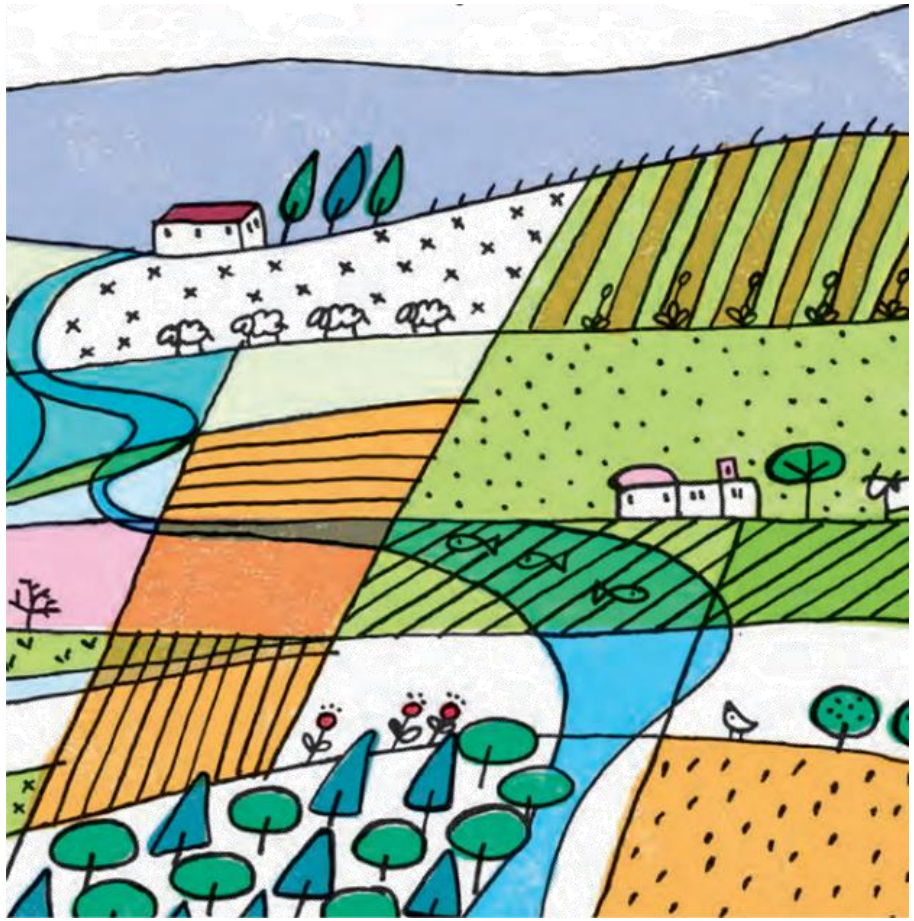
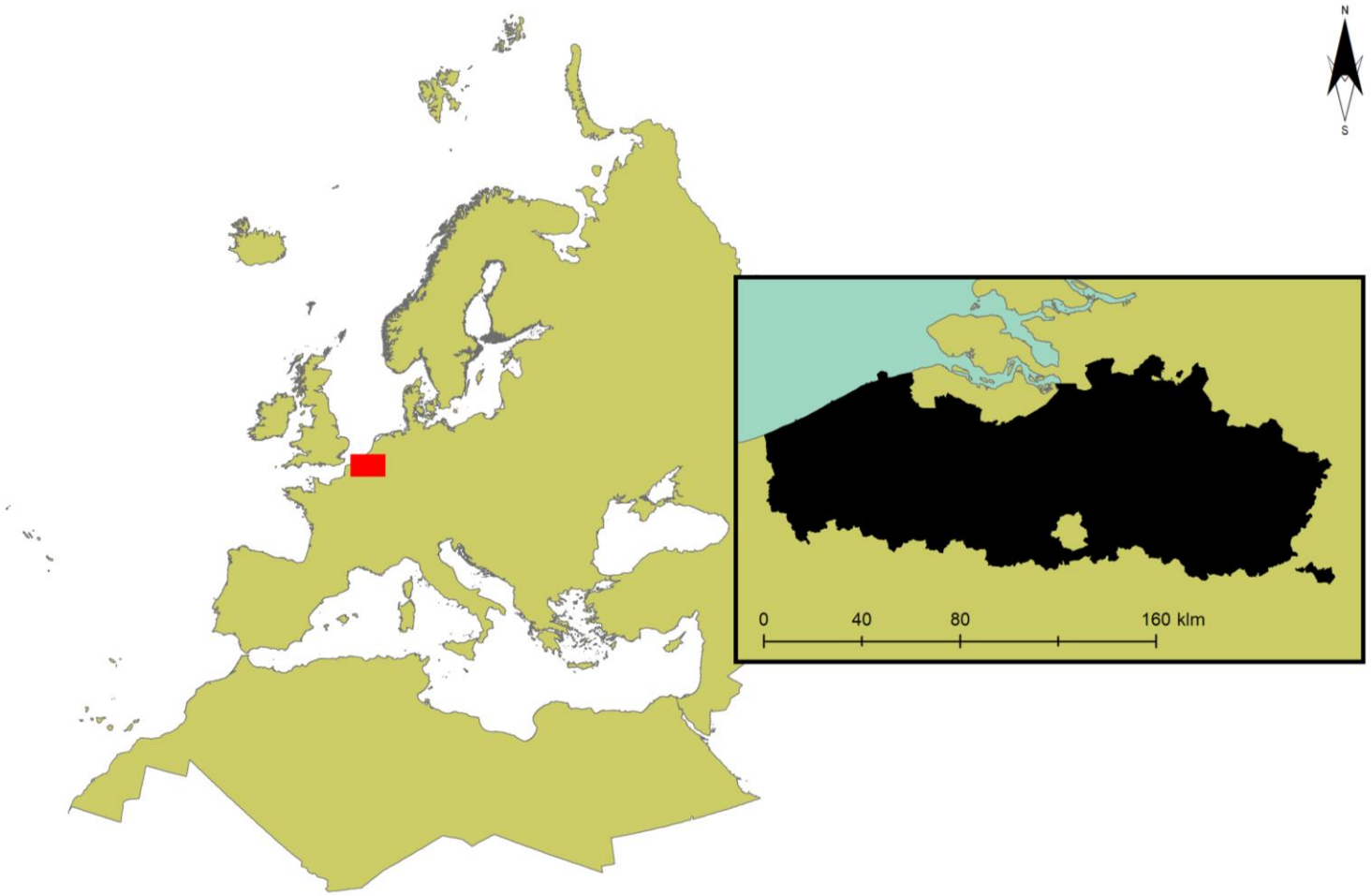
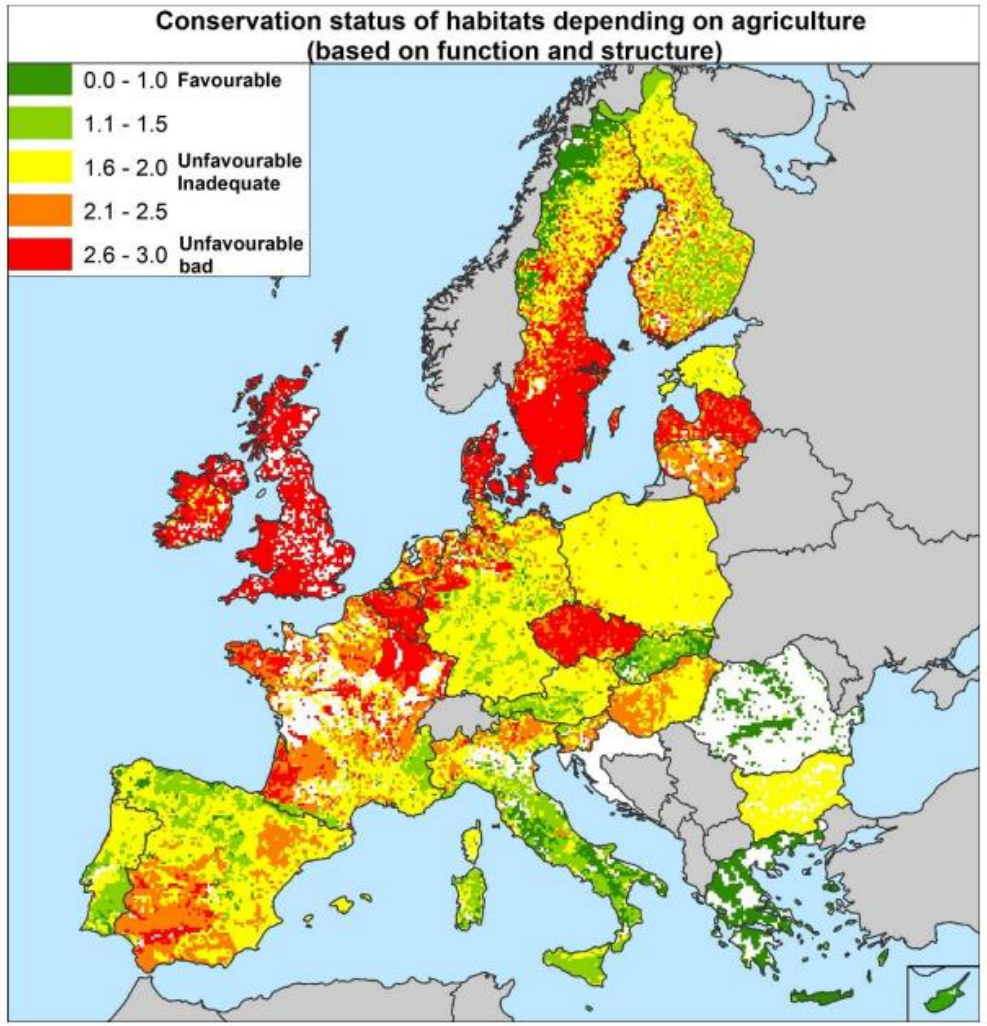


Illustration by Chiara Caproni (immagni&immaginej in: FAO (2017) - Landscapes for Life. www.fao.org/publications

STUDY AREA





Source: DG AGRI based on JRC. https://ec.europa.eu/agriculture/sites/agriculture/files/statistics/factsfigures/agriculture-environment.pdf

DATASETS

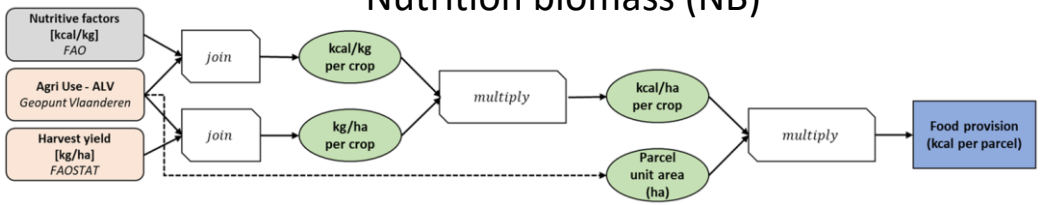
Datasets	Data type	Unit	Source
Agricultural Use - ALV	Vector	parcel	Agricultural Land Use http://www.geopunt.be/
Corine Land Use / Cover	Vector	25ha	Copernicus Land Monitoring (CLM) https://land.copernicus.eu/pan-european/corine-land-cover
Forest type	Raster	10m	CLM
Riparian zones	Vector	0.5ha; 10m	CLM
EU-DEM v1.1	Raster	25m	CLM
Inland water	Vector	Water body type (rivers and lakes)	Rivers and lakes http://www.geopunt.be/
Road network	Vector	Road type	OSM https://plugins.qgis.org/plugins/OSMDownloader/
Standard Nutritive Factors	Table	kcal per 100g	FAO http://www.fao.org/economic/
Crop statistics	Table	hg per ha	FAOSTAT http://www.fao.org/faostat/
Soil Erodibility (K- Factor)	Raster	500m	Joint Research Centre (2014) https://esdac.jrc.ec.europa.eu/
NDVI (produced from Sentinel 2)	Raster	10m	Copernicus https://scihub.copernicus.eu/ & https://sentinels.space.noa.gr/dhus/#/home
LSWI (produced from Sentinel 2)	Raster	10m	Copernicus
Precipitation	Raster	4km	CHRS https://chrsdata.eng.uci.edu/
Temperature	Raster	4km	ERA5 https://climate.copernicus.eu/
Solar radiation and irradiance	Point	40km	National Observatory of Athens
Floral availability (FA) and Nesting suitability (NS)	Table	Score (0-1)	FA and NS per ecosystem feature (Zulian, Paracchini, et al., 2013)
Rao's Q function	R code		Rocchini et al., (2017) https://doi.org/10.1016/j.ecolind.2016.07.039

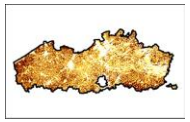
ECOSYSTEM SERVICES PROXIES

Ecosystem services	Indicators	Method	Related literature
Nutrition biomass	Nutrition value of crops	Quantification of per hectare caloric value for different crop types using harvest yield and nutritive factors	Haase et al. (2012); Kroll et al. (2012); Maes et al. (2016)
Erosion control	Actual soil erosion prevention	Assessment of the provision of soil erosion prevention using the RUSLE model	Guerra et al. (2016)
Climate regulation	Carbon sequestration	Calculation of the difference of annual net primary production using the CASA model	Braun et al. (2018); Raich et al. (2002)
Lifecycle maintenance	Functional diversity	Measuring Rao's Q (quadratic entropy) diversity index using remotely sensed vegetation indices as a biodiversity proxy	Rocchini et al. (2017; 2018; 2019)
Pollination	Relative pollination potential	ESTIMAP Pollination model	Lonsdorf et al. (2009); Stange et al. (2017); Zulian et al. (2013)

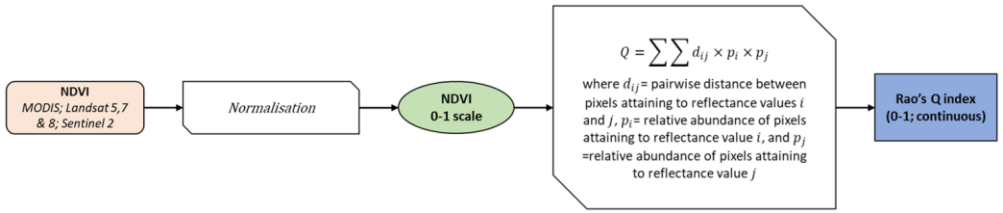
MAPPING ECOSYSTEM SERVICES

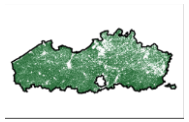
Nutrition biomass (NB)



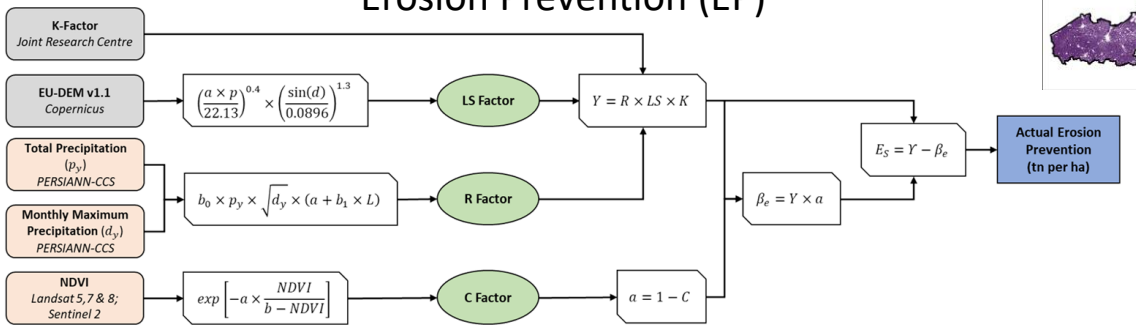


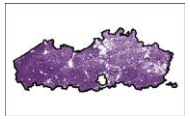
Lifecycle Maintenance (LP)



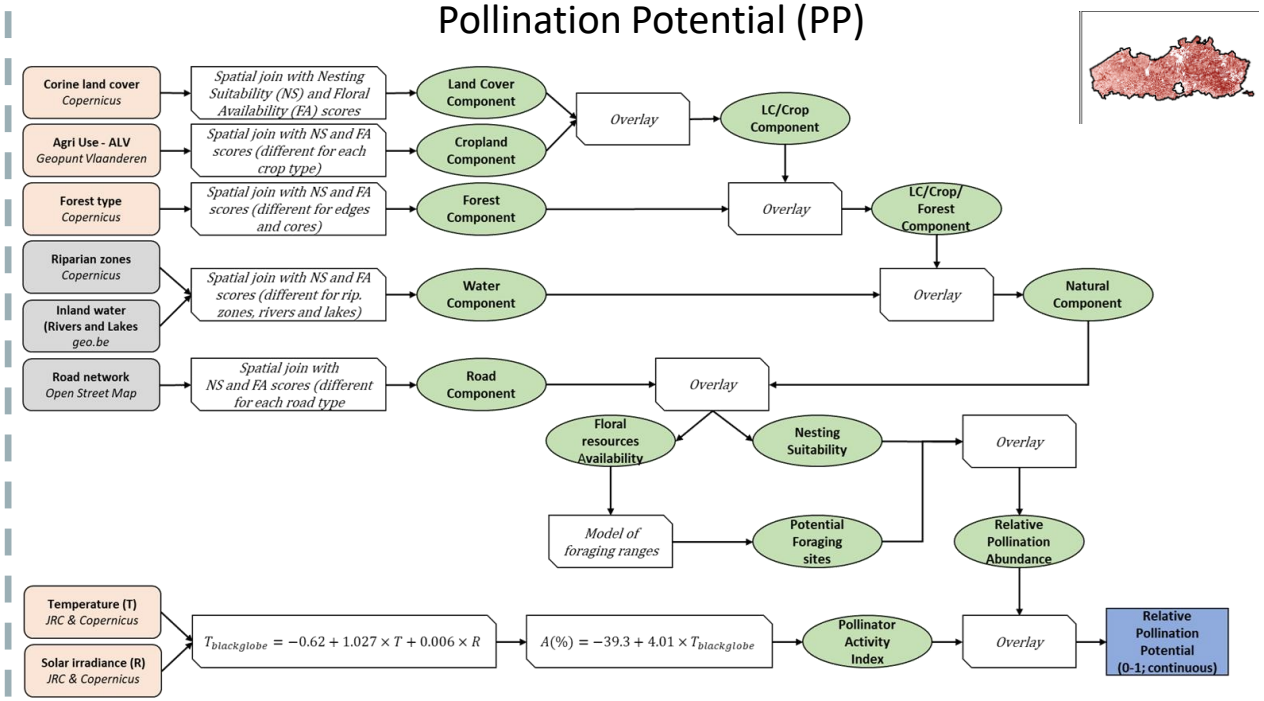


Erosion Prevention (EP)

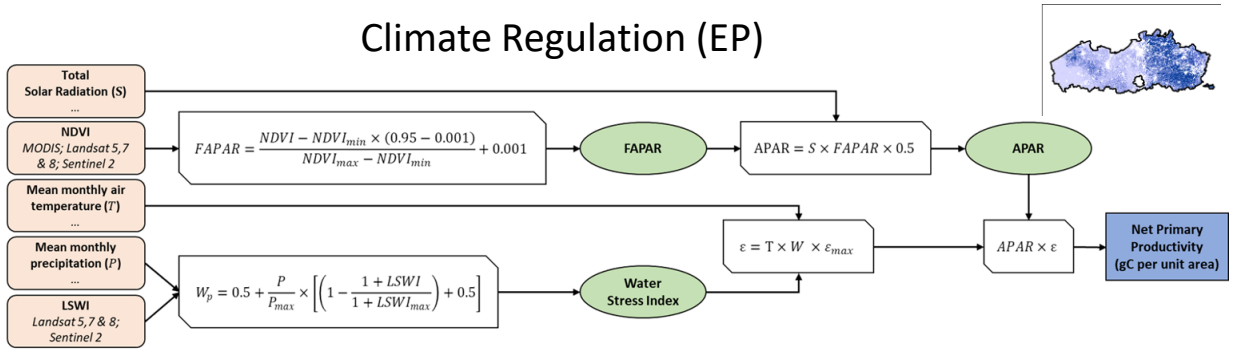




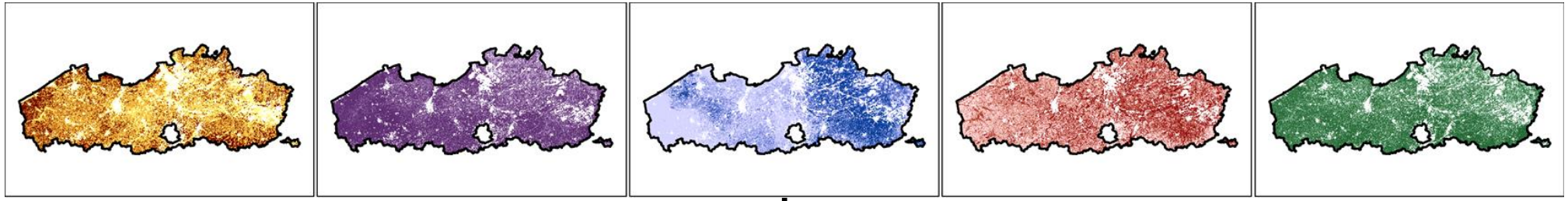
Pollination Potential (PP)



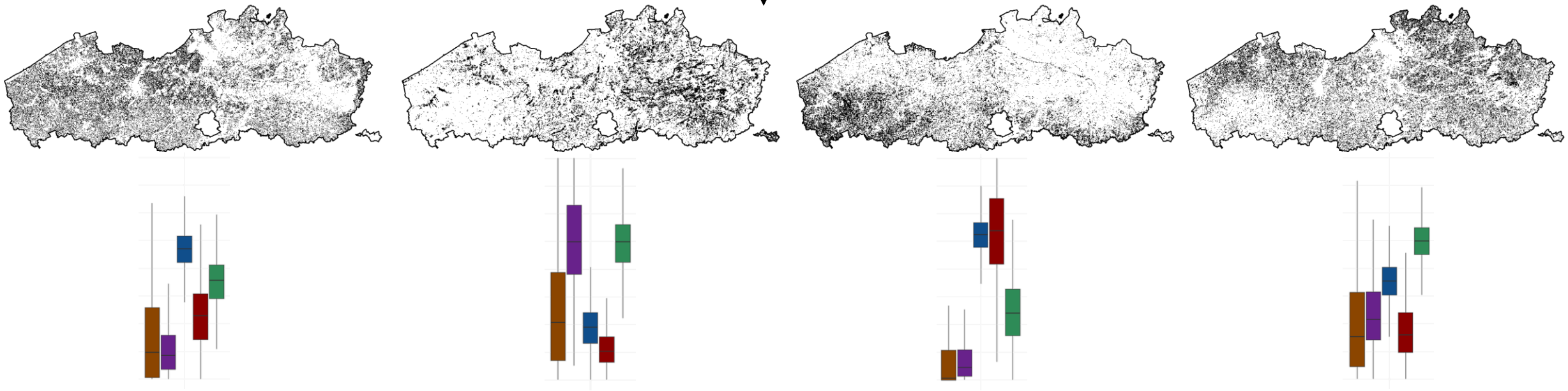
Climate Regulation (EP)



Define bundles of ecosystem services



Cluster analysis

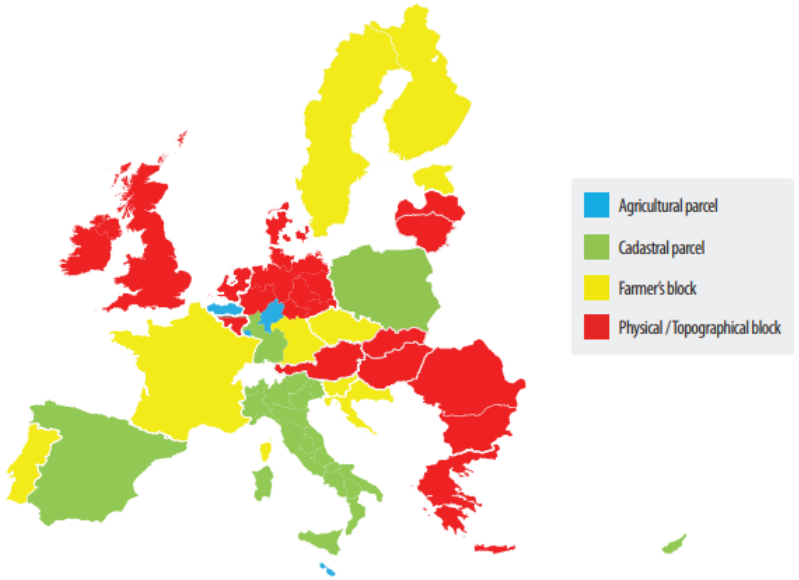


Land Parcel Identification System

- The farmers' declarations on the cultivated crop type in the year of inspection
- The LPIS operates on the basis of reference parcels*

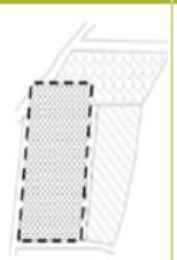
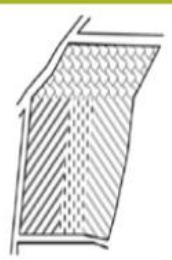
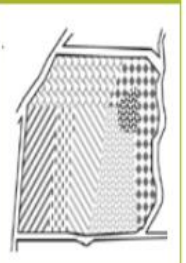
**A reference parcel is a uniquely identified and geographically delimited agricultural area*

LPISs by type across the EU



Source: European Court of Auditors based on the 2014 and 2015 LPIS Quality Assessment Reports

Characteristics of the reference parcel types

	Agricultural parcel	Cadastral parcel	Farmer's block	Physical / Topographical block
				
Main features	- Single crop group - Single farmer	- One or more farmers - Based on ownership - One or more crop groups	- Single farmer - One or more crop groups - No natural boundaries	- One or more farmers - Area bordered by certain features (ditches, hedges, walls, etc.) - One or more crop groups
Main data source	Farmer's application	Cadastre, land register	Farmer's application	Administrative classification

Source: European Court of Auditors and European Commission (JRC).

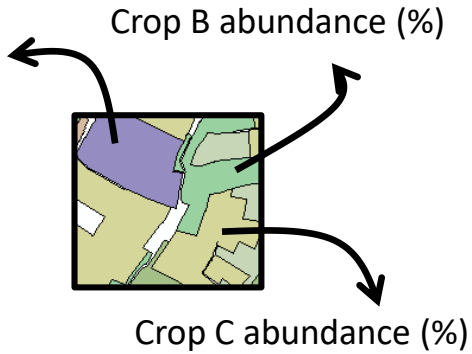
LPIS for Flanders

- 13 broad categories
- 312 parcel type classes (IDs)

AGRICULTURAL MANAGEMENT PROXIES

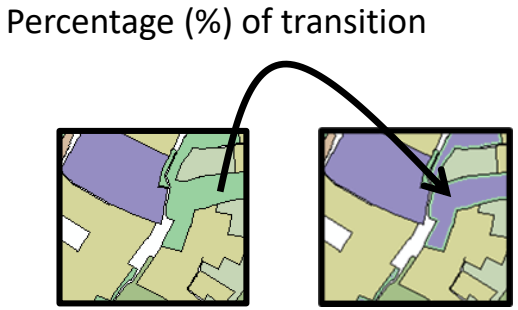
Crop Abundance (7 variables)

- Forage, Fruit, Maize, Potato, Sugarbeet, Tuber_Roots, Winter Wheat



Crop Transition (6 variables)

- Maize ***to*** Potato, Maize ***to*** Winter Wheat
- Potato ***to*** Maize, Potato ***to*** Winter Wheat
- Sugarbeet ***to*** Winter Wheat
- Winter Wheat ***to*** Maize



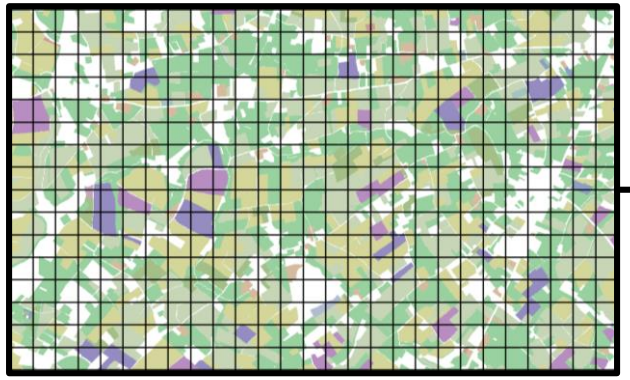
Spatial Diversification

- Shannon's diversity index

AGRICULTURAL MANAGEMENT PROXIES

Crop type at parcel level

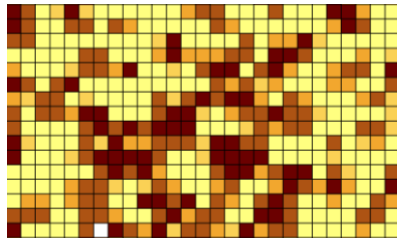
Grid features



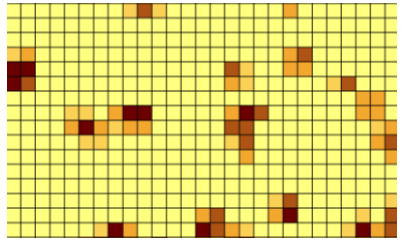
Abundance

Reference year

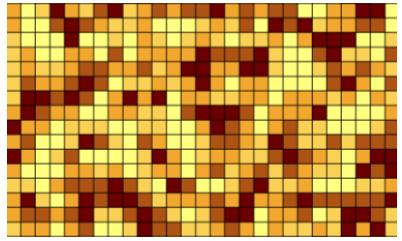
Winter Wheat



Potato



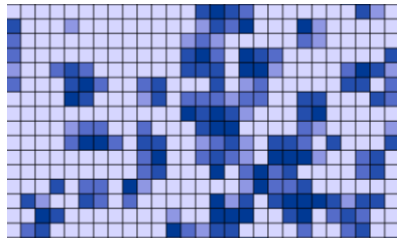
Maize



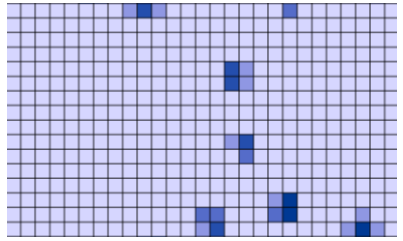
Transition

Previous year – Reference Year

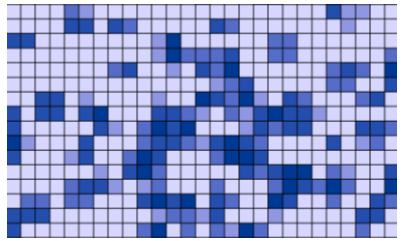
Winter Wheat to Maize



Maize to Potato



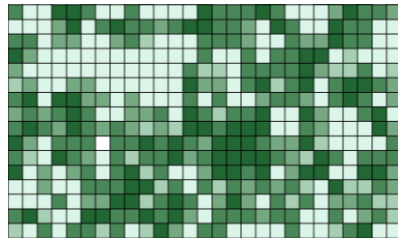
Maize to Winter Wheat



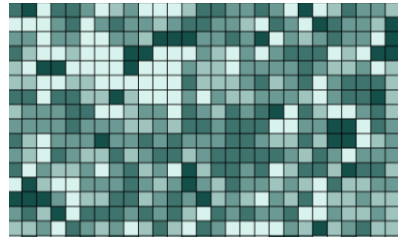
Diversification

Reference year

Shannon's diversity index



Simpson's diversity index



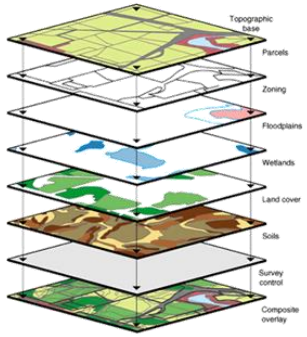
Random Forest Model

Crop parcels (LPIs)

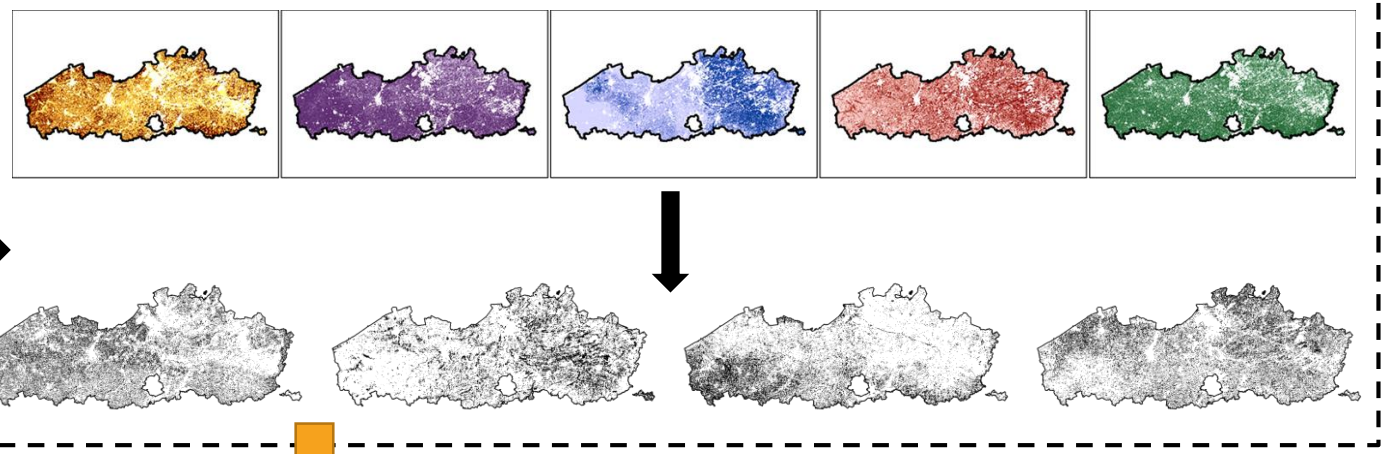
The farmers' declarations on the cultivated crop type in the year of inspection

EO Data

Satellite images, Soil data, LULC, climatic parameters

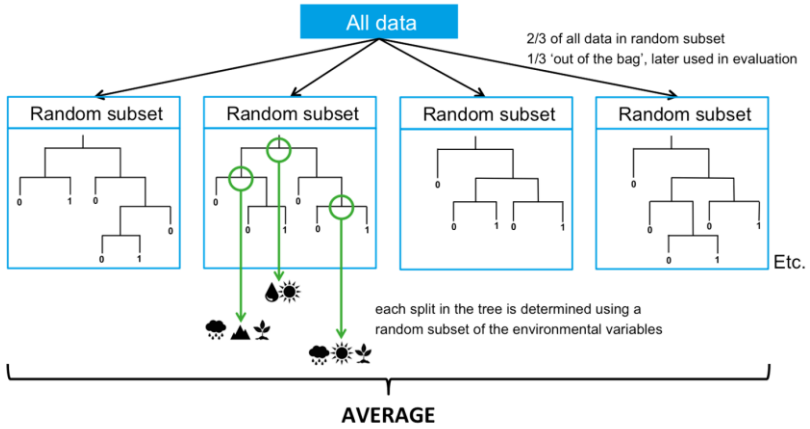


Input data



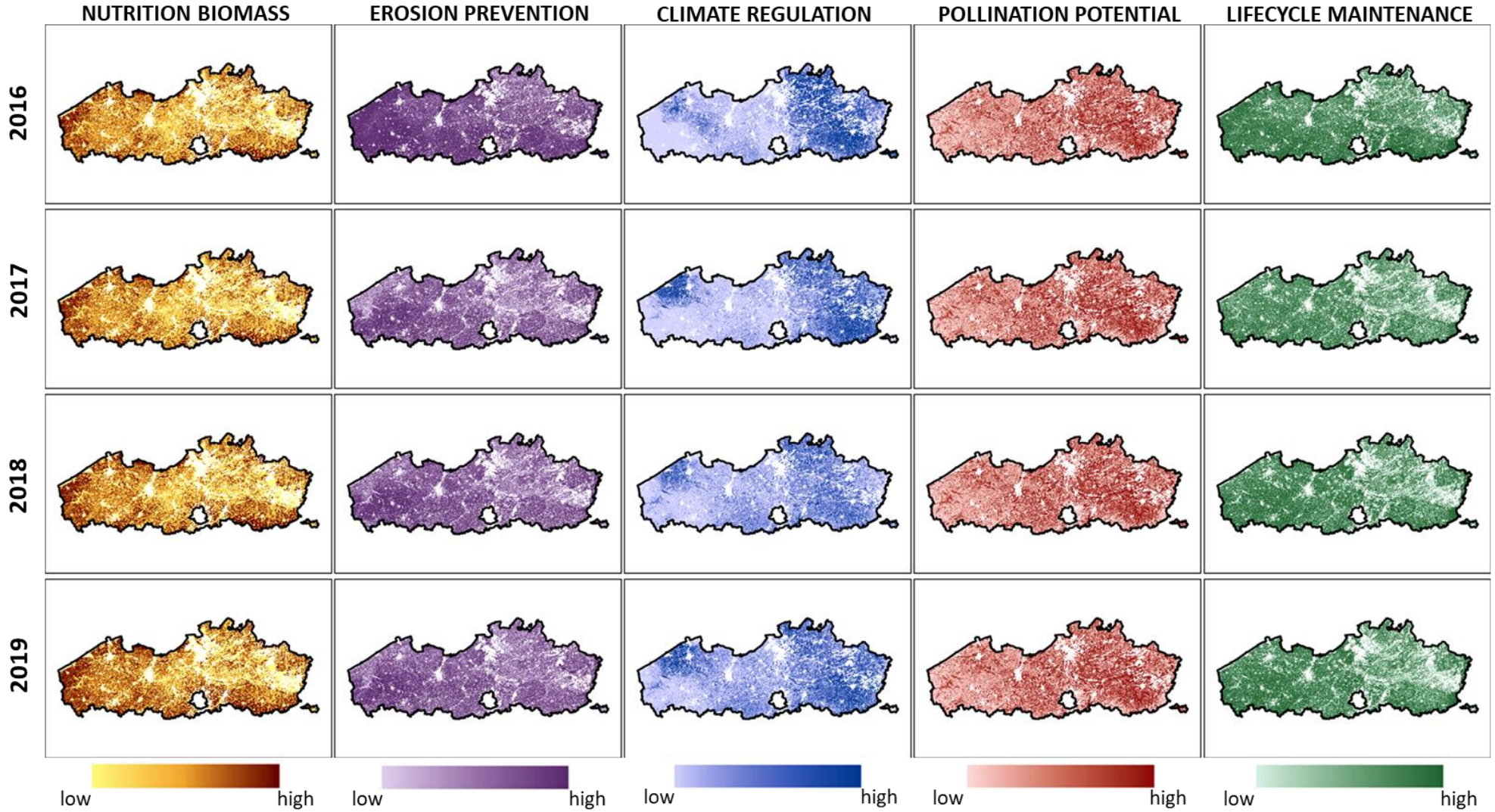
Agricultural management proxies

Explanatory variables

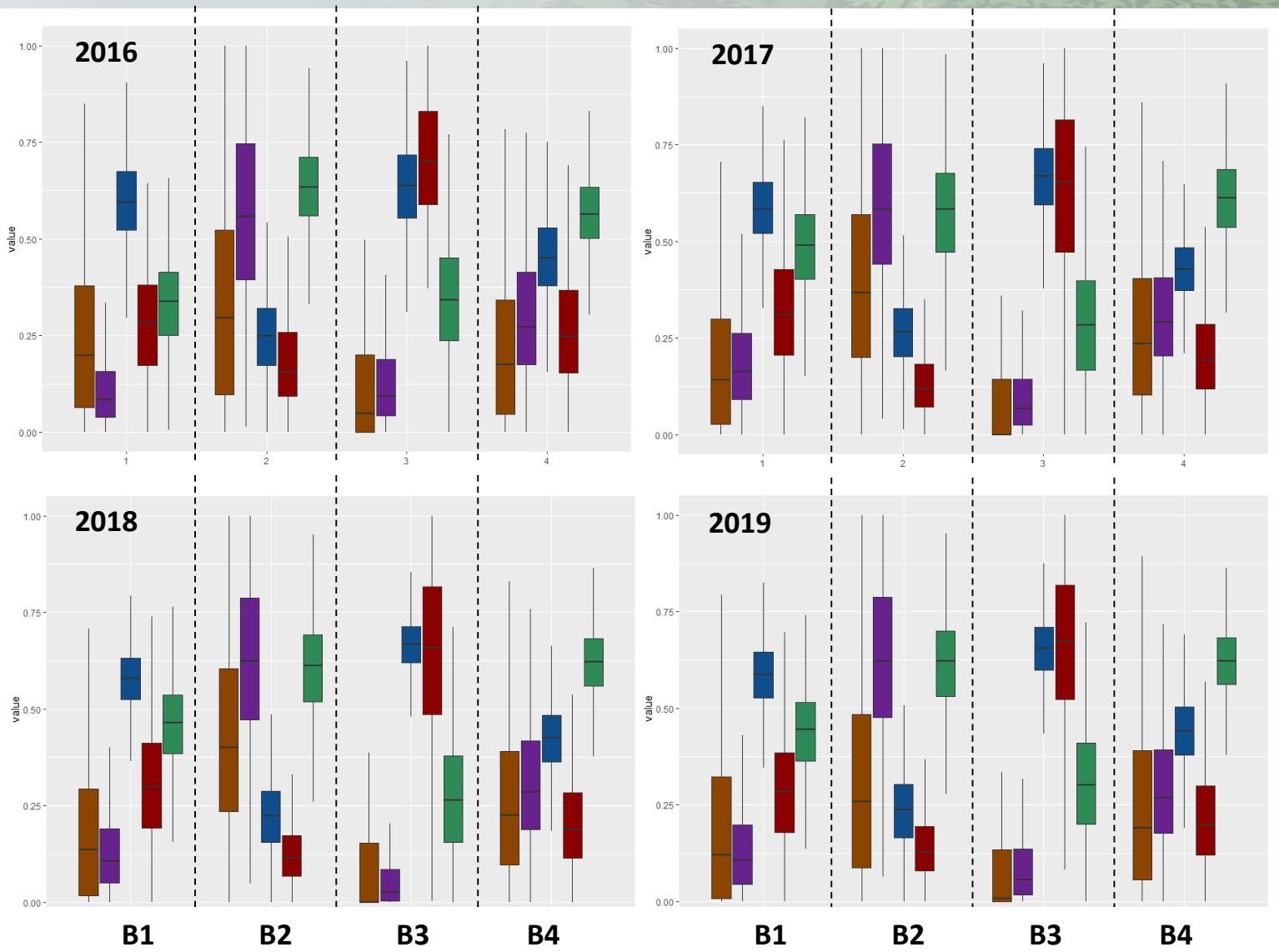


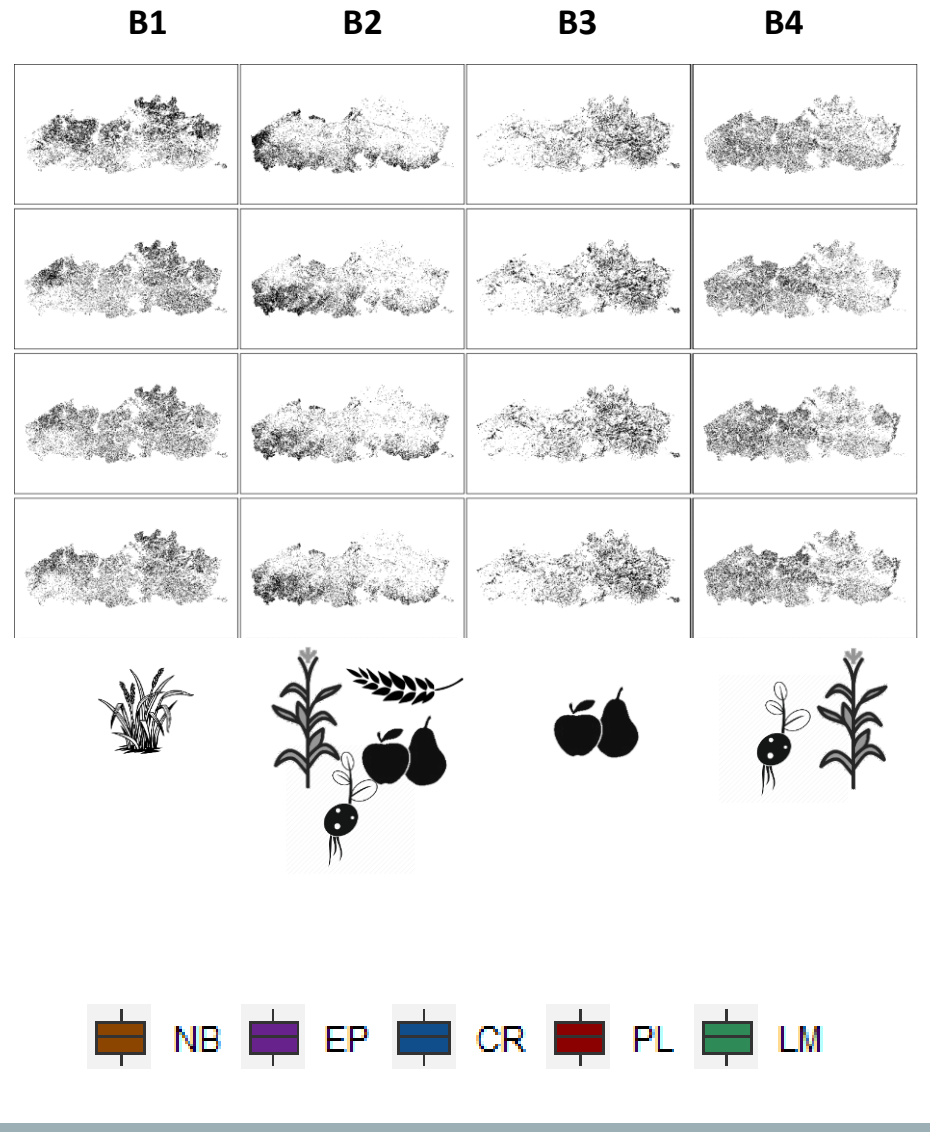
> find the set of predictor variables that produce the strongest classification model

ECOSYSTEM SERVICES IN FLANDERS

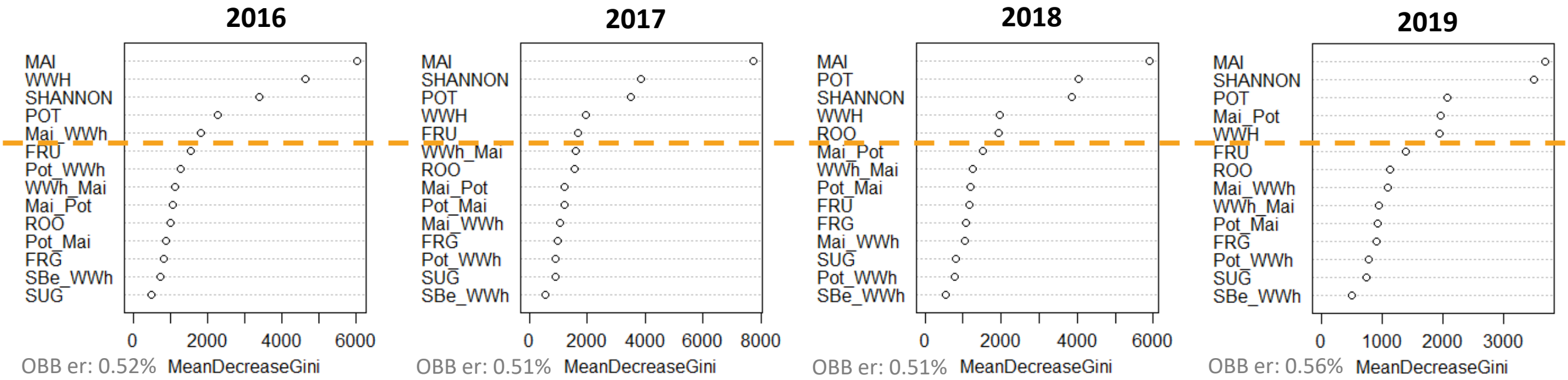


BUNDLES' DISTRIBUTION AND ECOSYSTEM SERVICE SUPPLY





ECOSYSTEM SERVICES AND AGRICULTURAL MANAGEMENT



WHAT NEXT?

Conclusions

- Size, in terms of abundance of crops, has contributed to the supply of ecosystem services
- Transition, as a proxy of rotation, has not shown significant results
- Diversification is among the most important management practices that influence the multifunctionality of agricultural landscapes.

Next steps

Include:

- agricultural practices (fertilization, tillage, cover cropping, livestock grazing)
- Crops' structure in the landscape (metrics at the class level to assess characteristics such as shape, edge density, connectivity)
- Landscape features (such green linear elements, riparian vegetation)

Assess these relationships across multiple scales (e.g. landscape character areas)

Thank you for your attention!

Dr Roxanne S. Lorilla

rslorilla@noa.gr

National Observatory of Athens