A hybrid modelling approach for detecting seasonal variations in inland Green-Blue Ecosystems

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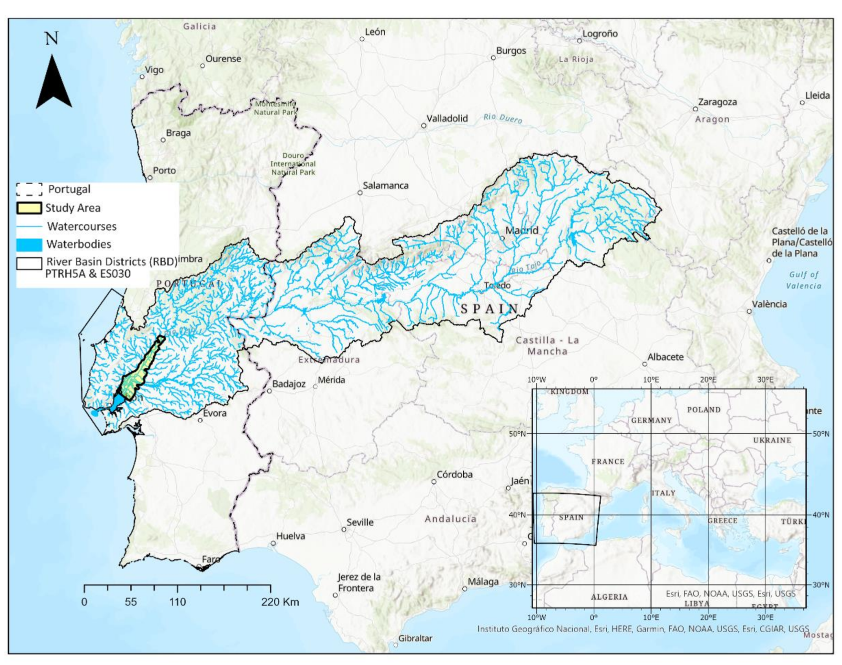
INTRODUCTION

Deforestation, environmental pollution, and the overexploitation of resources, in addition to the Earth's natural cycles, are scaling up the impacts of climate change in the provision of Ecosystem Services (ES) [1]. Green-Blue Ecosystems (GBE) are impacted by climatic conditions, topography, and water presence. In the context of climate change, Portugal is recognized as a hotspot among the most vulnerable European countries[2]. Recent studies have shown evidence of climatic changes, such as the long periods of drought recorded in 1990, 2004/2005 and 2012[3,4]. The more frequent occurrence of these events is increasing the severity of seasonality effects on GBE and compromising the provision of services such as freshwater supply, and consequently crop and wood production, and carbon storage and sequestration[5].

OBJECTIVES

The aim of this research is to investigate the seasonal influence, magnitude and relationships in mapping GBE. The rationale relies on what previous research noted concerning dealing with large datasets when building satellite-based climate-driven models. To overcome these concerns, we propose a two-step modelling strategy combining techniques to take advantage of each method to manage and analyze large geospatial datasets while enhancing overall efficiency in GBE mapping workflows.

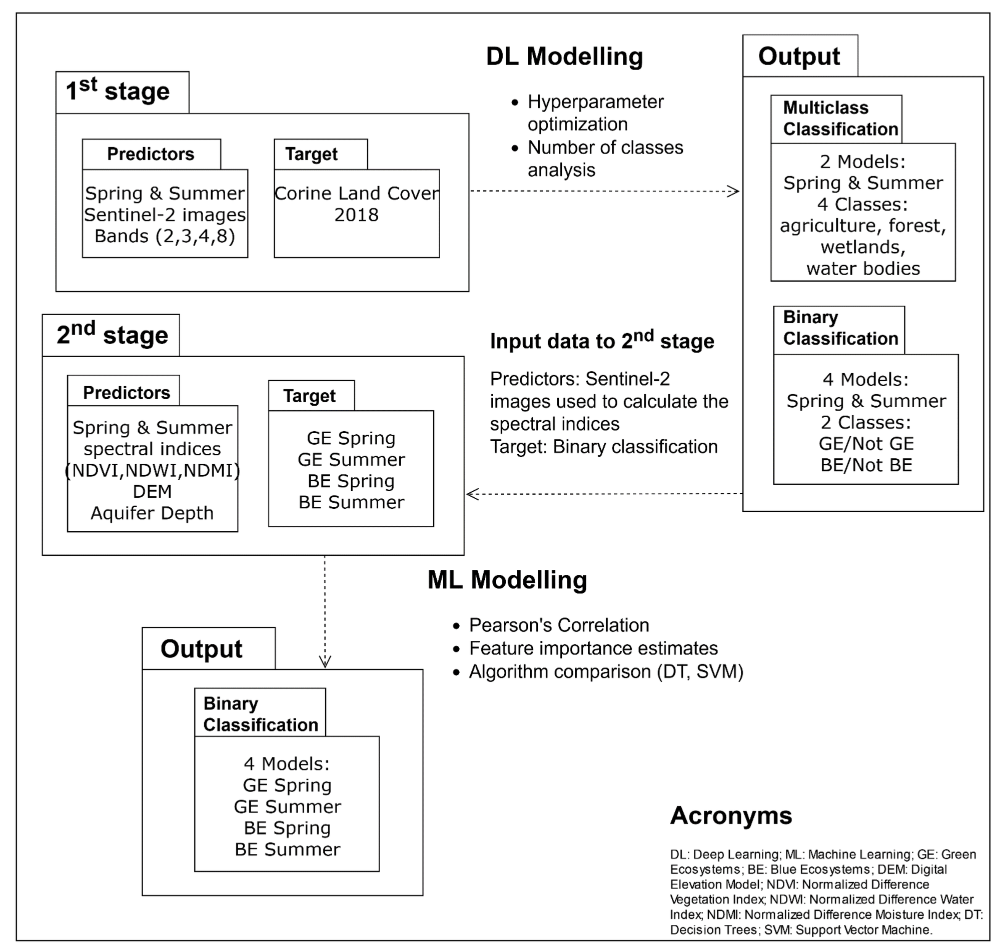
STUDY AREA



The Lower Tagus Aquifer system is a vulnerable groundwater body located in the surroundings of Lisbon, the most populated and dynamic area of mainland Portugal[2].

DATA & METHODS

Sentinel-2 bands (2, 3, 4 and 8), spectral indices (NDVI, NDWI and NDMI), topography and depth of groundwater (GD) were used as predictors, in a hybrid modelling strategy including ML/DL, hyperparameter optimization, sensitivity analysis, and Feature Importance Estimates (FIE) conducted through two modelling stages.



This strategy allows to work with subsets of the data, reducing memory usage, and improving processing speed, and overall efficiency.

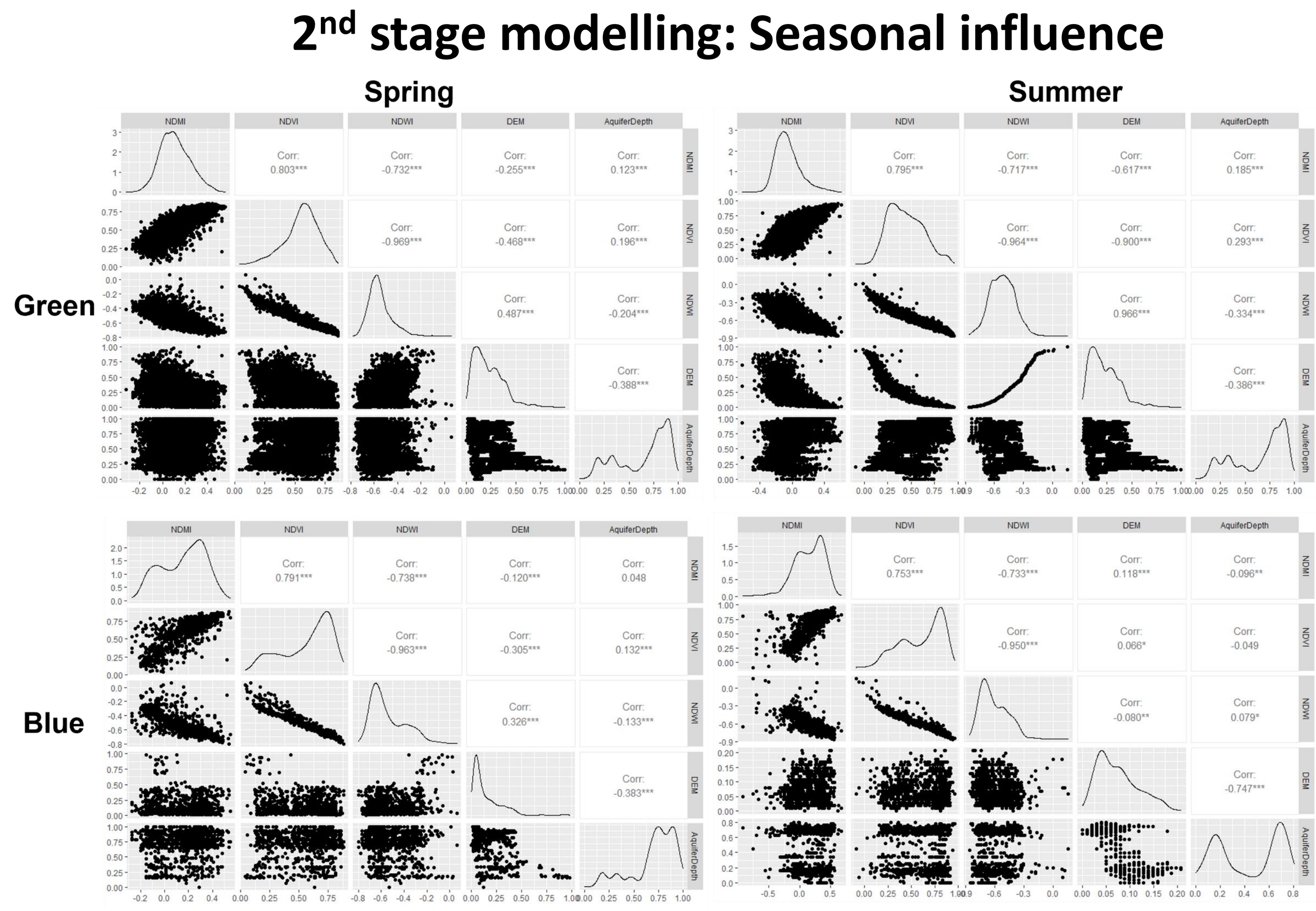
RESULTS & ANALYSIS

1st stage modelling: GBE Mapping

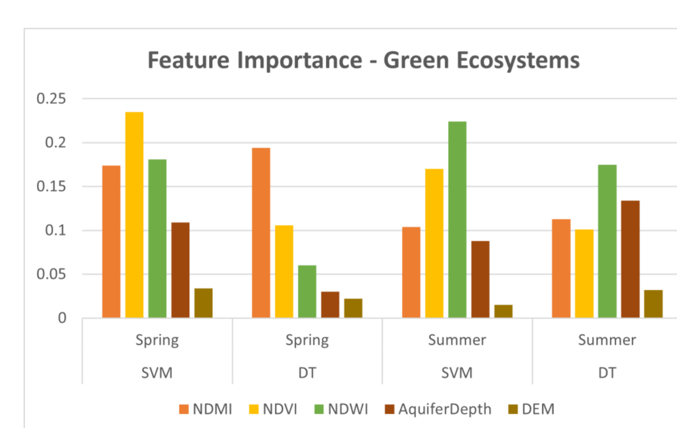
Type	Model (100; 64)	Class	Accuracy	F1-score	Recall	Precision	LR (low; high)
Multiclass	**Spring**	**242**	0.814	0.872	0.932	0.819	1.0965e-05; 1.0965e-04
		324		0.627	0.518	0.795	
		411		0.481	0.354	0.752	
		511		0.785	0.770	0.801	
	Summer	**242**	0.790	0.862	0.950	0.789	1.0965e-05; 1.0965e-04
		324		0.540	0.402	0.818	
		411		0	0	0	
		511		0.740	0.717	0.766	

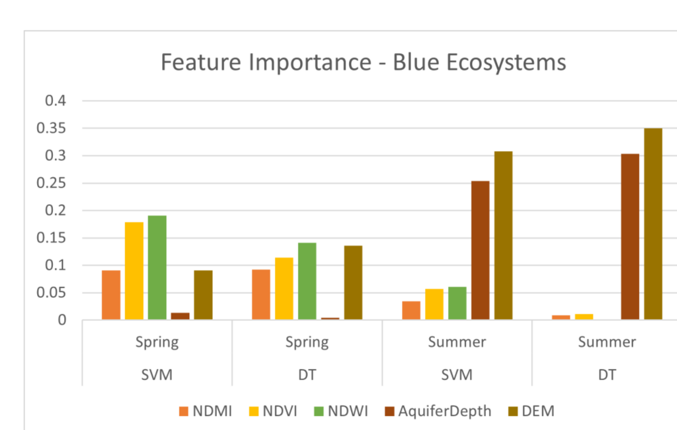
Type	Model	Accuracy	F1-score	Recall	Precision	LR (low; high)
Binary	Spring (100; 64)	0.876	0.650	0.576	0.740	9.120e-06; 9.120e-05
	Summer (100;64)	0.866	0.622	0.543	0.729	7.586e-06; 7.586e-05
	Spring (20; 8)	0.876	0.648	0.575	0.743	2.754e-05; 2.754e-04
	Summer (20;8)	0.846	0.529	0.434	0.677	7.586e-06; 7.586e-05

2nd stage modelling: Seasonal influence



FIE





CONCLUSIONS

The approach uses SEO products to detect seasonal climate variations and relationships in the implementation of seasonal satellite-based climate-driven models. The sensitivity analysis advanced the knowledge in applying DL models in complex landscapes using GIS tools. The sensitivity tests showed that the hyperparameter settings are key to building accurate models and maximizing the benefits of each technique. FIE demonstrated the novelty of applying satellite products with contextual data to empower the model's quality.

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