Hi!ckathon 3

Final Sprint: 13-15 January 2023

Group	28
Members of the team	Adrien Letellier - ENSAE Dmitri Lebrun - ENSAE Tilian Bourachot - ENSAE Augustin Gonand - HEC Come Campagnolo - HEC Zoe Boleslawski - HEC
Topic	d) We are a governmental institution attempting to implement a Water Trading Scheme modelled on the European Carbon Credit Scheme (ETS)

I. Overview

Water scarcity is a critical global issue, exacerbated by climate change, population growth, and unsustainable water use. Currently, water scarcity in France is not as severe as in some other regions, but climate trends suggest this will change. In 2024 already, several French departments are concerned with droughts and have implemented measures to limit the amount of water that can be used for agriculture, industry and even domestic use [1 2 3].

We, as a governmental institution, consider it our responsibility to balance the needs of private individuals, businesses, and ecosystems while ensuring sustainable access to water. Inspired by the European Trading Scheme (ETS) for carbon credits, our project addresses the missing market for water usage by establishing a robust, data-driven allocation system for water distribution and trading.

a) Problem statement

Water, as a common pool resource, often suffers from the "tragedy of the commons," where individual overconsumption leads to resource depletion. Current water allocation methods in France are done through free-access under a volume of 10 000 m3/year, and by means of governmental approval above [4 5]. However, this is proving inefficient: in periods of droughts, some actors are simply prohibited from using any water [6]. Because these periods of droughts are bound to increase, there will be increasing discontentment amongst stakeholders, especially those who simply happen to require water later in the drought season.

Existing water trading schemes—such as the Murray-Darling Basin Plan in Australia [7] or Chile's water rights market [8] —demonstrate the potential of markets to allocate water efficiently. We want to implement similar Trading Schemes around french basins, but accounting for changing groundwater levels using our data-driven solution.

b) Presentation of our project

We propose a novel water credit system that leverages advanced machine-learning models to predict water availability from water sources accurately. Based on these predictions, we determine the volume of water that can be consumed, and the volume needed to maintain sustainable reserves for the ecosystem in the water basins. We then distribute water "free" credits amounting to the consumable volume, proportionally to various stakeholders—private individuals, agricultural enterprises, and industrial users. The allocation will reflect the total water availability, the sustainable reserves and an assessment of the needs of each party, grounded in a comprehensive and evidence-based function encompassing socio-economic conditions, firm KPIs and individual characteristics. This allocation algorithm would be publicly available for secondary market participants. Once a year, based on cases presented to us (Basin Authorities) by invested parties, we can modify our allocation algorithm.

Stakeholders can then trade credits within a regulated market if their needs exceed their allocation, or they use less than allocated. This ensures flexibility while maintaining an overarching cap on water use to prevent over extraction.

⚠ While the ETS's goal is to monetise carbon and incentivise reduction by reducing the amount of "free" allocations over time, our goal is not to reduce water consumption or put pressure on all water prices but rather to monetise only the water credits above the granted allocation to maintain a sustainable balance based on natural availability.

c) Presentation of our team

Three ENSAE students to ensure a full-proof modelling and data analysis of our information… Three HEC students (including two with extensive training in Micro-economics) to envision the global management and economic aspects of our initiative… What more could you ask? We offer cutting edge expertise on data-science and financial related matters.

II. Business approach

a) What is the value of our solution

Our state-of-the-art machine-learning model allows us to obtain precise and accurate predictions of water availability several months ahead. This means that alongside the allocation algorithm, there is near perfect information on allocations from all parties, up to 1 year ahead (after algorithm allocation revision post Basin Authorities meeting). All market participants can therefore evaluate the price of water credits in advance, which allows them to optimise their water consumption strategy. Through this optimisation, water-saving technologies and conservation strategies could appear as users respond to price signals.

b) How does it integrate in real-world operations

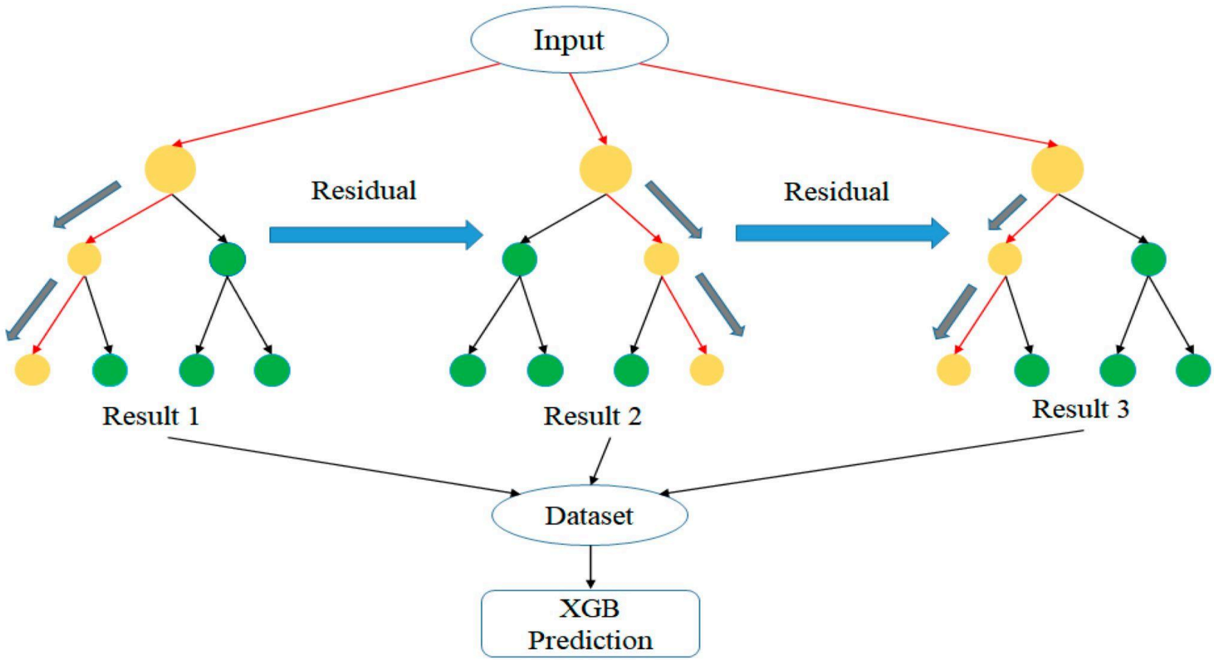
To implement our water credit system effectively, several institutions will need to be established or adapted, drawing inspiration from the governance structure of the European Trading Scheme (ETS).

Name	Role	Functions		
Water Allocation Authority (WAA)	Mirroring the role of the European Commission in the ETS, acting as the central regulatory body overseeing the system's implementation and governance.	Determining the Cap: Establishing the total water credits available for allocation per basin based on **machine-learning predictions** of water availability	Allocating Credits: Distributing water credits to stakeholders (individuals, companies, municipalities) in proportion to their assessed needs.	Flexibility: These allocated water credits would be flexible and subject to change if enough of a case is presented by the Basin authorities (see below).
Water Trading Platform (WTP)	Akin to the trading infrastructure used in the ETS, such as exchanges where carbon credits are bought and sold	Facilitating the trading of water credits among stakeholders, ensuring a transparent and efficient market		
Basin Authorities (BAs)	Complement the central WAA, regional entities would focus on localized implementation	Supporting local stakeholders by providing support within their jurisdiction regarding credit allocation	Bearing the role of monitoring and enforcing compliance with water credit usage	Mediating conflicts between stakeholders

c) How is it different from other solutions? What makes it novel?

Our initiative is a pioneering one, never implemented in France. Its added value resides in our predicting model. We predict groundwater levels across various dates in the future. However, our project also sought to create departmental and communal maps establish the average groundwater levels per department and per commune. We have an example of maps based on a sampled dataset from X_train (see annex). This allows for a precise granularity.

III. Scientific approach



For our predictions, we use the Extreme Gradient Boosting model (XGBoost). It leverages the interpretability and simplicity of decision trees while making accurate and complex predictions.

In practice, the model builds an ensemble of decision trees sequentially, where each tree attempts to correct the errors (residuals) of the previous tree by minimizing a loss function. XGBoost also uses regularization techniques to improve the model performance by reducing overfitting and selecting the most relevant features for our predictions. The individual tree predictions are then combined to make the best possible final prediction. In practice, we maximized the performance of our model by training one hundred trees.

In our approach we also leveraged our predictions and previous values of the target variable to improve the future ones. This “lag” variable helps our model better understand the changes in the water level.

XGBoost is also highly scalable, making it well-suited for handling large datasets and complex tasks. First, its structure allows the algorithm to be optimized for parallel processing. The algorithm also automatically stops to avoid overfitting thanks to the regularization techniques it uses. Finally, XGBoost supports batch-wise training, allowing it to process data in chunks and avoid memory issues. All these factors make XGBoost a great model for very large datasets.

IV. Results

a) Relevant variables

After training, our model returns the key variables for making accurate predictions. This showed us that knowing the previous water levels and using these for our new predictions are key to predict water shortages. As we could expect, the closest water level values (from the previous day or the previous week) are the most relevant for making accurate predictions.

In addition, we discovered that knowing the precise location of the water point (through the BSS code of the station) is key to understanding the changes in the water level.

b) Future potential of our solution

Our system benefits from scalability. As our water trading scheme becomes more mainstream and recognised, we can hope that more private sector individuals may participate in the trading of credits on the secondary market. This will increase liquidity on our trading platform and help gather a price that will be more representative of fundamental values.

Bibliographie

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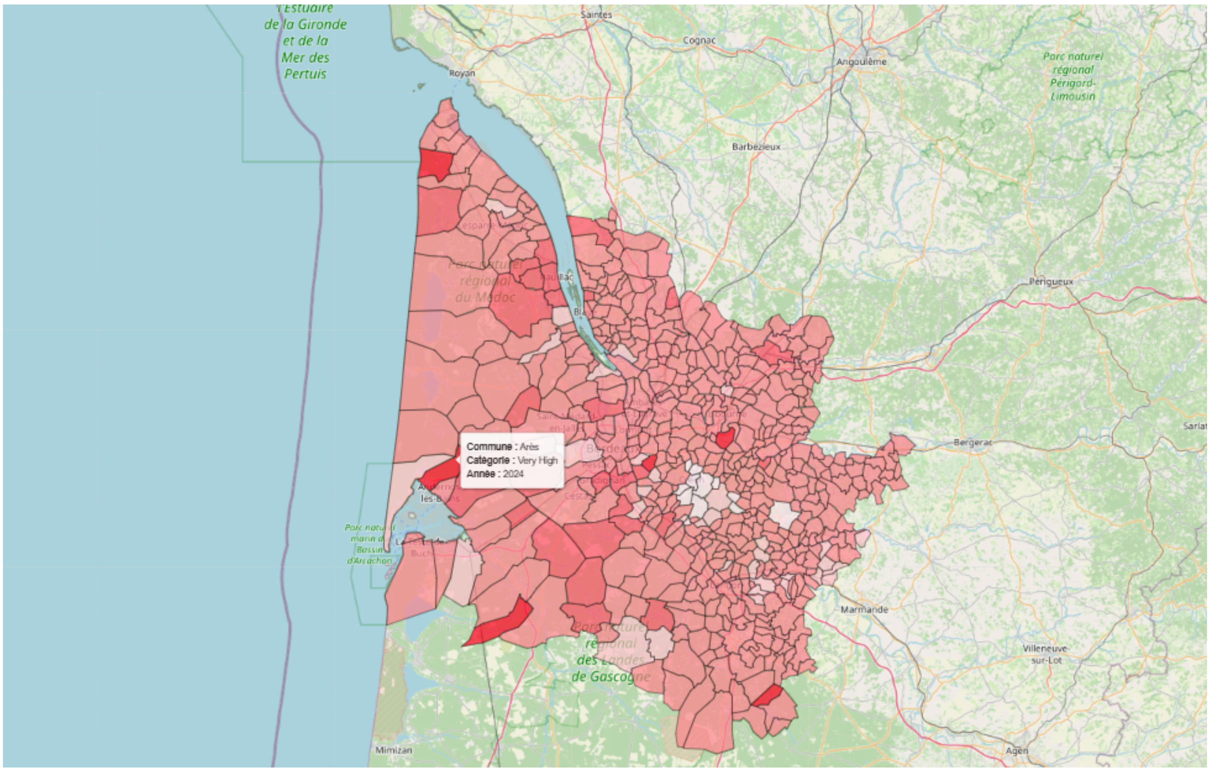
Annex

Maps based on a dataset sampled from X_train.
Code findable on following google collabs: [Link]



Map 1. Departmental map generated for Gironde in 2024

Map 2. France map generated in 2024