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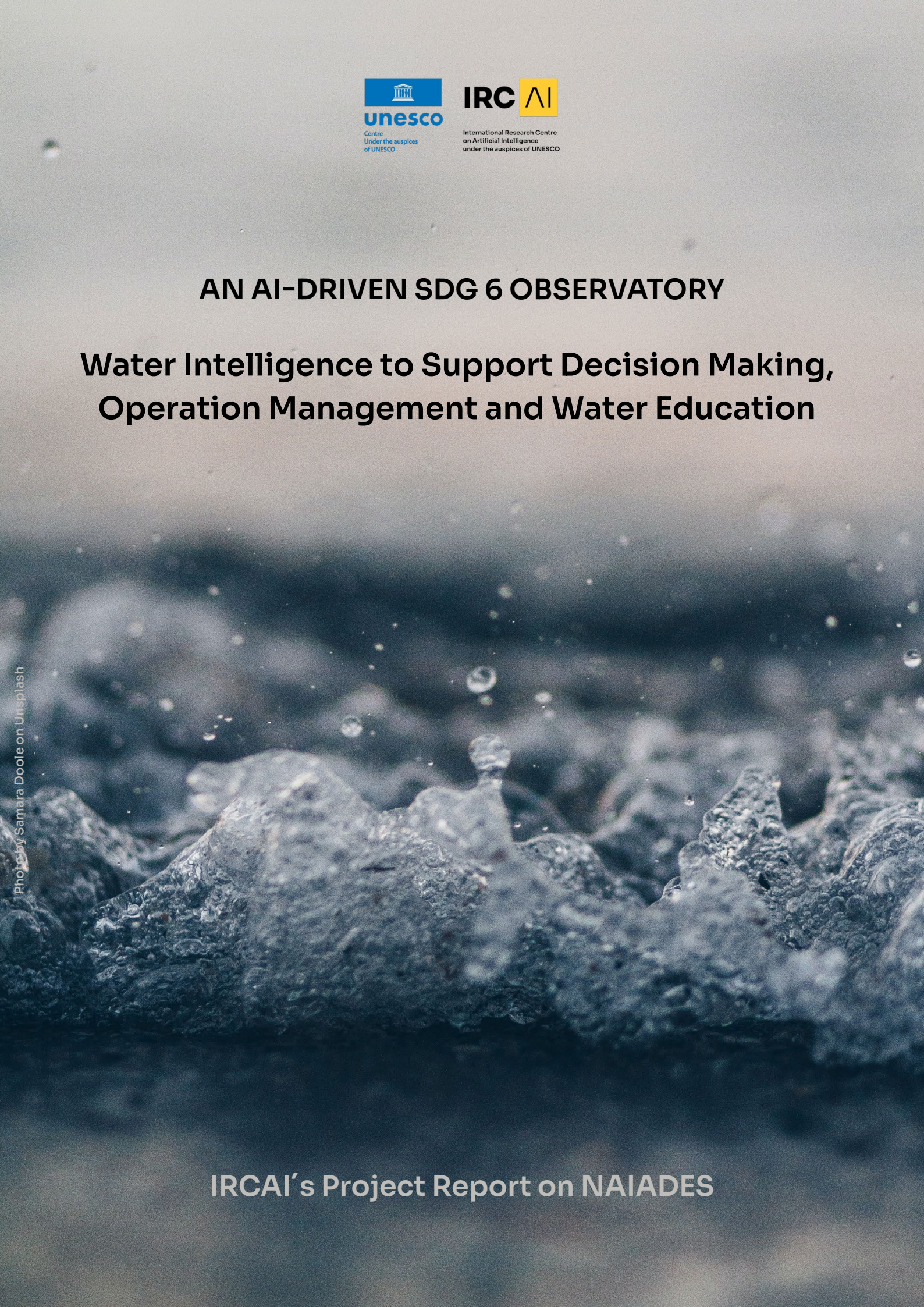
AN AI-DRIVEN SDG 6 OBSERVATORY

Water Intelligence to Support Decision Making, Operation Management and Water Education



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IRCAI's Project Report on NAIADES

Foreword

The importance of managing water resources cannot be overstated in the modern world. Challenges faced globally in terms of water quality and scarcity driven by both a lack of infrastructure and extreme weather events due to climate changes lead to; widespread loss of life both human and animal, desertification, migration crises and even war. This report presents the outcome of the Naiades project and collaboration with IRCAI that uses digital technology and AI to support better management of water resources. The project has built an online open access tool that makes open data from the UNEP and media resources accessible and available. This allows users to track real time information on water topics as well as explore historical data on SDGs related to water quality and historical weather data. These efforts directly feed in to progress towards meeting SDG 6 and also tackling SDG 13. The work is pioneering in showing what can be done with the latest big data and AI technology to empower utilities and water management companies to make better decisions that lead to improvements in water management and thereby protect our environment and natural resources. It opens the door for further development in the future making valuable data resources more widely available and accessible to the AI community and researchers while also drawing attention to the huge opportunity to use data and AI to help make better use of resources. It is a landmark project and report that will drive further progress in this space through greater collaboration and knowledge sharing between resources managers and AI researchers who can work together to solve problems that have global impact.

Prof Aidan O'Sullivan, Chair AI and Climate IRCAI

Executive Summary

Aligned with the UN Congress on Water we discuss how the management of water resources has become a critical concern, and AI and business intelligence have emerged as powerful tools for improving water management. In this report, we give a particular focus to the innovative Water Observatory built in the context of the European Commission's NAIADES project that we built to explore existing global information and business intelligence that can contribute to the global and local climate change resilience through AI. The NAIADES Water Observatory (available online at naiades.ircai.org) has proven useful for understanding water-related topics such as extreme events, reclaimed water, and water contamination.

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Introduction

Entering the ageof Big Data, Artificial Intelligence is feeding the data-driven digital transformation across industries and evidence-based decision-making by the leadership across companies and local authorities. It is essential to highlight the meaningfulness of those approaches, transferring them to opportunities that are coming to the water sector as well. The amount and heterogeneity of data generated allied to the rapid progress of scientific research and consequent technological development allow for a new reality in regards to water management and sustainability. While the frequency of the data ingested and the dynamic of what is being observed can dictate the different pace that real-time observation can take, the usefulness of the insightful information digested from that data in the context of priorities within the workflow of professionals will dictate its meaningfulness.

Leveraging the European Commission's collaboration through the NAIADES project[1], building a holistic water ecosystem for digitisation of urban water sector, IRCAI developed a Water Observatory designed to serve the different stakeholders in the Water Sector, and built with some of them to better address different workflows and priorities leveraging open data, better align to the Sustainable Development Goal 6 and to other European and national guidelines, and evaluate commitments in time. The water resource managers are using the information generated by the observatory in the resolution of problems related to water events, to understand how their actions are perceived by the consumers, and to explore successful scenarios in similar cases.

The NAIADES Water Observatory is built together with water resource management utilities and local governments to properly address the challenges in industry, society and research, from the perspective of machine learning extracting insights and best practices. It provides benefits to the following target stakeholders:

- Water Management Utilities – access to a variety of perspectives on water for decision-making
- Regional Authorities – access to data-driven dashboards supporting policy-making
- Educational Institutions – access to resources for the education on water topics
- Research Institutions – access to data over interactive visualization and research
- General Population – access to local progress and global certified information

As an outcome, the NAIADES project came up with SDG 6-specific recommendations, to which the Water Observatory contributed as follows:

1. **Strengthen the alignment between the SDGs and the Water Framework Directive and daughter directives.** Technological solutions and digital innovations provide enormous potential to support the achievement of the SDGs and their targets. To address the disconnect between the SDGs and the EU water directives, further SDGs should be considered in the EU water directives. This includes SDG 14 to support biodiversity and SDGs 7, 11 and 12 to stimulate resource efficiency, responsible consumption, and production, as well as renewable energy production.

2. **Empower the water utilities and regional governments in data-driven decision-making making use of open data through the NAIADES Water Observatory.** Different data exploration workflows, relating indicators, news, and published science, allow for a deeper understanding of the general and local context of water events (e.g. floods or water contamination), and to extract best practices for a rapid and efficient response. This novel technology can also ease the planning on the environmental transition offering data (on, e.g., wastewater management and reclaimed water) exposing patented technologies, worldwide news and SDG progress.

3. **The usage of the NAIADES Water Observatory allows for students and the general public to access and explore historical data on major water topics that are perspectives of water education for a more water efficient society.** The observatory is localized in the 3 languages of the use cases as well as in English, to ease the access of all types of public and students of all ages. Additionally, a version of it was made available to be used in touchscreen technologies, designed to be implemented at the Water Museum in Alicante. It provides a global as well as a local perspective on several aspects of water usage and water stress, complemented by a large body of scientific knowledge with the progression of trends in identified water topics of interest.

[1] https://cordis.europa.eu/project/id/820985

Functionality

The NAIADES Water Observatory was built by the AI research center under the auspices of UNESCO (IRCAI) through the Institute Jožef Stefan, in collaboration with the NAIADES consortium partners, and is now released at the NAIADES platform, integrating the bigger picture of the NAIADES platform of services serving the Water Sector. In this Water Observatory we are putting together: (i) real-time information from multilingual world news on water topics; (ii) data visualisation of water-related indicators through time, sourced directly from the Sustainable Development Goal 6 portal dedicated to water, and other publicly available open data; (iii) scientific knowledge from published research on water-related topics (e.g., water contamination) over more than 126 million articles; and (iv) geolocated historical data on water resources and weather conditions to analyse and forecast the impact of climate change in the sector with specification to the region where the water resources are located.

INDICATORS PERSPECTIVE

The Indicators view relies on interactive data visualisation allowing the user to compare progress on specific indicators (e.g. water stress or usage to citizens, industry and agriculture) between countries and regions. This ensures data-driven insights from the data ingested in the system to support evidence-based policy-making for water optimization evaluating in real-time the Sustainable Development Goal 6 items.

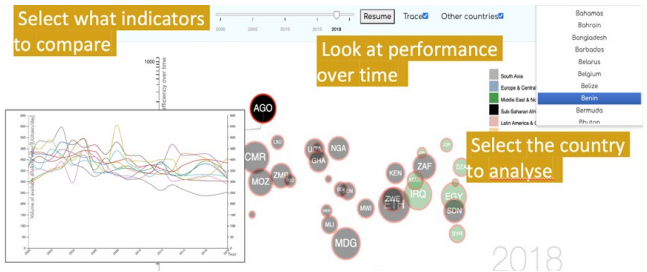

Figure 1 - Local and global indicators view, allowing for an animated visualisation of the progress in different perspectives of the SDG6

MEDIA PERSPECTIVE

On the other hand, the media view extracts insight from world and local news, as well as from social media (Twitter) to monitor and better understand water events. Moreover, it allows to extract best practices on water reuse or extreme water events (e.g. floods and landslide) from millions of worldwide multilingual news to learn from similar cases how to solve your water-related problems. It also provides access to causal relations and alerts from social media through our Twitter dashboard configured to the priorities and scenarios that are most relevant for your national strategy.

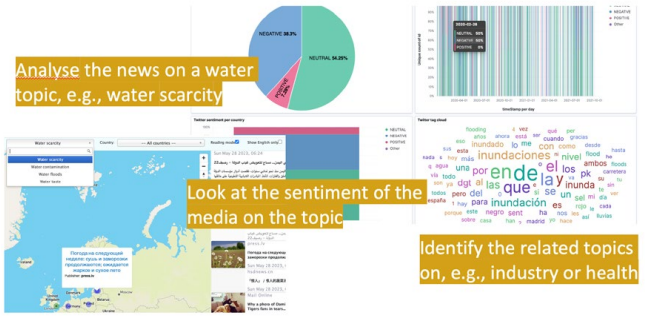

Figure 2 - Interactive data visualisation of the insights extracted from news and social media

SCIENCE PERSPECTIVE

The NAIADES Water Observatory is also providing the user with the access to text-mining tools to improve effectiveness in reviewing a topic over a large dataset of published science and patented technology. It helps the NAIADES user to identify the most prominent water trends from insights on the patented technology (e.g. on wastewater management) exploring the Microsoft Academic Graph (with over 126M patents and articles). Moreover, it provides access to the MEDLINE dataset of the well-known biomedical search engine PubMed to explore problems in water contamination of extreme water events, and how to find a better fit solution.

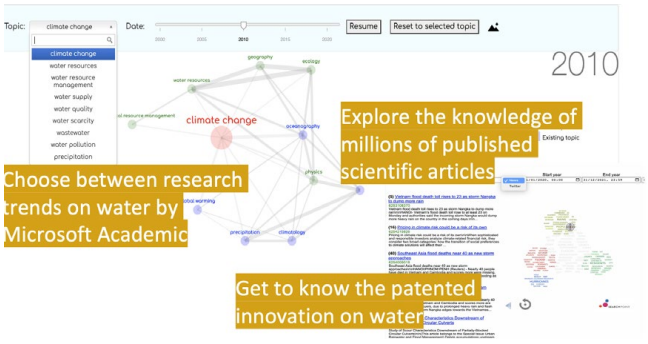

Figure 3 - Exploration of scientific publications to extract best practices using text similarity

Application

ADDRESSING CLIMATE ACTION

Observing the world on a global scale can also help us understand better the role of water in a climate change context, engaging us all as the target SDG 13. The usage of powerful machine learning algorithms on open data measurements and statistical indicators is helping the water sector to better understand the behavioral changes in seasons and better prepare.

The NAIADES Water Observatory is being used in the context of extreme weather events to collect, analyze, and explore the insights and best practices from worldwide experiences of researchers and practitioners in water topics like, e.g., floods, landslide, and contamination, building business intelligence from available open data in combination with local sources. In the present decade, Climate Change has become positioned as one of the world priorities, a global problem with great socio-economic impact. It has been in the focus of European and Worldwide strategies, rapidly changing priorities towards sustainability and environmental efficiency, transversely to most domains of action. The European Commission's Green Deal is a good example of this, aiming for a climate neutral Europe in 2050, and boosting the economy through green technology over a new framework to understand and position water resource management in the context of the challenges of tomorrow.

In the context of the NAIADES project we repurpose and customize the NAIADES Water Observatory, adding a measurements dimension to its text mining capabilities to allow for forecasts on, e.g., water level and temperature to complete the perspective on the impact of climate change for the preparedness both of water management utilities and users as in, e.g., smart agriculture. This will improve the climate change preparedness of water resource management facilities and local authorities in a global context, in particular in European regions where water scarcity or extreme weather events are predicted. The water-related climate change topics that we are already addressing include, e.g., water reuse, wastewater management, saline intrusion and groundwater contamination.

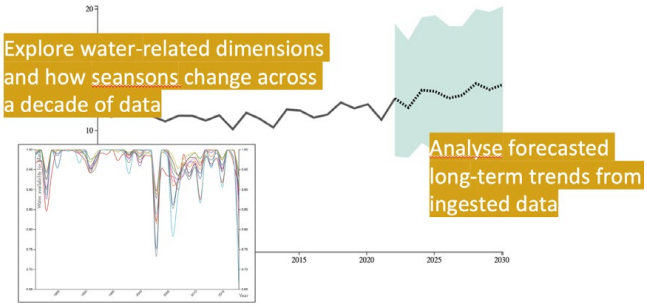

Figure 4 - Complex data visualisation of over 20 years of data on water levels and temperature based on Markov chains

The scientific research on climate change topics can bring an important complement in this context, providing success stories and best practices that can be extracted from the textual data, and explored with complex data visualization technology allowing the user to powerful Lucene-based queries over the article's metadata and to relate that research across time suggesting related topics. These data analytics technologies are able to analyze simultaneously multiple time-series providing interactive exploration tools to understand trends in climate change research and water topics related to it.

Adapting to climate change is an important topic for water management services, since their work is quintessential for the well-being of people. Understanding the seasonality changes and forecasting the availability of resources at the local levels is therefore crucial to enable relevant adaptation at the correct granularity. Although the predictions are in accordance with IPCC's and Meteoswiss forecasting, this preliminary work needs to be extended with ingesting several other data variables and compared to the existing widely used models to bring more accurate insight specially for the weather data, but also the water-relevant resources.

We use complex data visualization algorithms to, e.g., understand the behavior of water temperature and water levels over 20 years, identifying seasonality within the usual seasons. We have developed a neural network using Chaos Theory to obtain optimal time steps and produce a long-term forecast aiming to observe, e.g., the trends in the behaviour of water levels and water temperature.

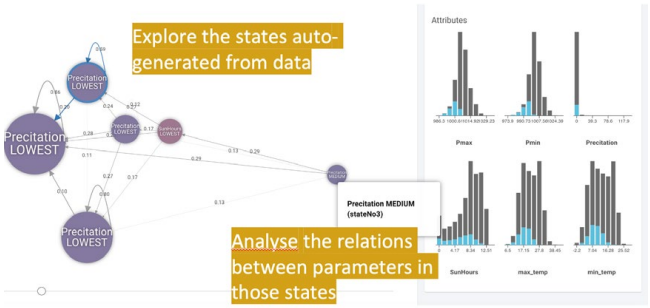

Figure 5 - Long-term forecast of water-related parameters to understand the evolution of behaviors in a climate change context

The NAIADES Water Observatory will continue contributing to NAIADES' Sustainability Strategy maintaining and further developing technologies. We are also establishing an extension of the Water Observatory as IRCAI's SDG 6 Observatory, expanding beyond the European use cases to have a wider worldwide reach to SDG 6 and SDG 13 objectives. We will be soon publishing a full IRCAI report on the research achievements and usefulness of the Observatory.

LESSONS LEARNT FROM WATER REUSE

The rapid advance of climate change felt in Europe in recent years is alerting governments and populations to the responsible usage of water resources, having led to imposed limitations in some EU member states. The appropriate reuse of water could be a key to the sustainability of, e.g., the quality of life of the civil society or the agriculture infrastructure that is much affected by these changes. The progress of wastewater management can also be a highly relevant contribution to a healthier ecosystem of services, resources and actors, leading to a more robust climate change preparedeness. With this motivation and exposing IRCAI's potential in the participation of its Water Observatory in the Smart Water Conference, we have prepared with Aguas de Alicante a special scenario focusing on wastewater management to show the potential of the usage of open data in addressing this shared priority. It shows the flexibility of the system to address a new priority defined by the user, focusing on a relevant topic in the water sector, while reusing the data ingested and reconfiguring the system.

The demonstration starts with the analysis of some of the wastewater-related indicators, both at global and local levels (e.g., Reused Water, Treated Water), to understand the progress made with a focus on the Spanish region of Alicante. We then investigate the worldwide news and Twitter feed using the Wikipedia term "Wastewater", and filtering the news feed by adding terms like, e.g., "Reused Water", "Wastewater Treatment", etc. In the Twitter dashboard, we can analyse the sentiment about wastewater, or the other concepts in that wastewater context that can be used in further searches.

We then move to the Research view to explore the MAG dataset on what is published about wastewater and in which different contexts. We can then define a time window for the search and distinguish between scientific articles and patents, which will also help us identify forthcoming solutions to solving wastewater-related problems. The final plan for the pilot is available since early 2022 with functionalities available and tested at the overall system.
This effort is also aligned with the European Commission's regulation on minimum requirements for water reuse establishing the new regulation to be applied in 2023 to stimulate and facilitate water reuse. IRCAI's Water Observatory will continue to help promoting transparency, monitoring critical information about any water reuse indicators, news and research, synchronised with the main targets of the NAIADES user. Moreover, this transversal pilot was not planned, and extends the tool's value for the NAIADES adopters, highlighting its capability to address new water-related topics. Furthermore, it will also show the potential and flexibility of the tool to provide knowledge not yet foreseen.

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