D0.23 – Web Platform

DATASET

“GrounDwater sAlinizaTion and pollution AsseSsmEnt Tool”

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-	-	-	-

EXECUTIVE SUMMARY:

The D0.3 accompanies the GIS platform developed within the DATASET project. It describes the research framework in which the initiative is situated, the design choices that guided the construction of the application and illustrates, chapter by chapter, the tools made available to users.

DOD is intended for use by DATASET project researchers only.

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1 General information

DATASET, an acronym for GrounDwater sAlinizaTion and pollution AsseSsmEnt Tool, is an international research project funded by the European Union under the Water4All partnership of Horizon Europe. It stems from the awareness that groundwater protection today requires a change of approach: no longer isolated studies on individual basins, but shared research frameworks and platforms able to operate simultaneously across different climatic and geological contexts with underlying layers of data already built in and available to users.

The fragility of coastal and semi-arid aquifers is documented by a now well-established body of scientific literature. Seawater intrusion, over-exploitation of aquifers, and pollution from agricultural and industrial origin happen with consistent dynamics yet call for solutions tailored to each territory.

Among the pressures weighing on aquifers, salinization holds a position of particular importance, especially in coastal settings. The mechanism is well characterized by hydrogeological literature: excessive extraction lowers the hydraulic head of the freshwater aquifer, altering the balance with the saline wedge and favouring its advance inland; prolonged irrigation with highly mineralized water accumulates salts in the soil profile, seawater upconing can move ancient trapped saline water in brine. Climate change amplifies all processes, through sea-level rise, the intensification of drought periods and the reduction of natural recharge. The consequences, which include the loss of agricultural productivity, the impairment of sources intended for human consumption and the degradation of coastal and transitional ecosystems, manifest themselves at the environmental, economic and social levels, with costs that are often difficult to reverse in the medium term. Groundwater pollution represents the second major challenge. Nitrates of agricultural origin, persistent organic compounds, plant-protection product residues, heavy metals of industrial origin: once they reach the saturated zone, these substances can persist for decades and in some cases for centuries, depending on flow velocity, residence times and the lithological characteristics of the aquifer. The slowness of aquifer recharge and self-purification processes turn every pollution episode into a long-lasting problem, with effects that fall on the generations following those that produced it and with remediation costs generally orders of magnitude higher than those of prevention.

The project takes this tension as the very subject of its research, proposing comparable protocols without giving up the specificity of the case studies. The main goal of **DATASET** is the realization of a methodology for groundwater vulnerability assessment applicable to any coastal area around the world and that relies on the five main pillars: “Easy”, “Open”, “Reliable”, “Flexible”, and “Dynamic” (Figure 1).

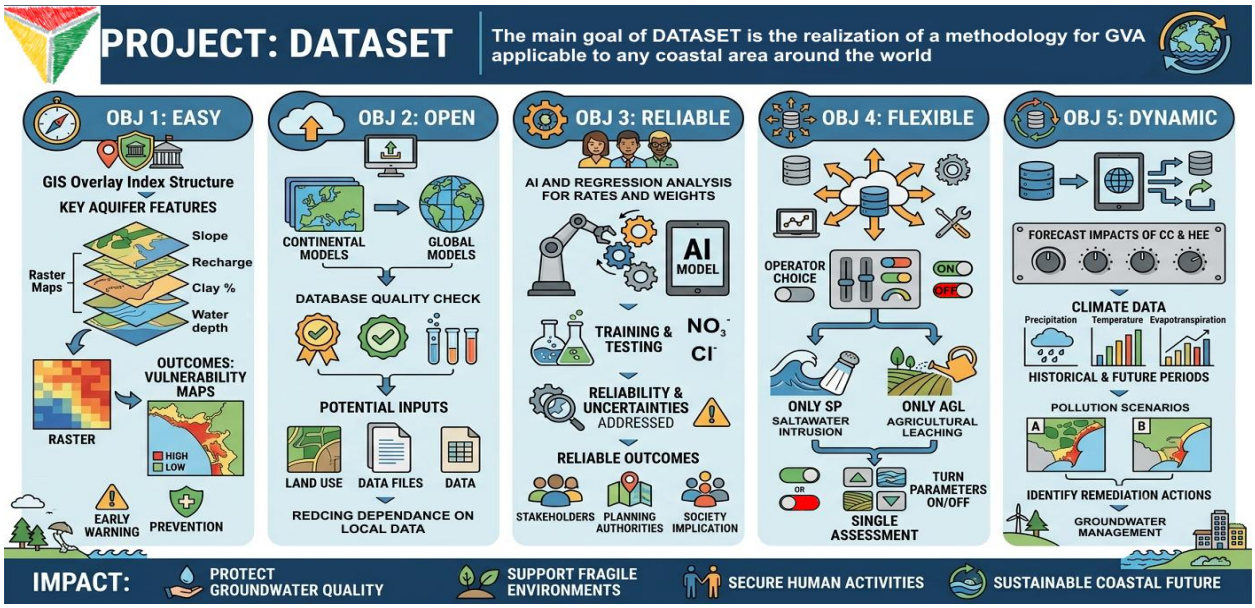

Figure 1: Key pillars of the DATASET project: Easy – Friendly user methodology affordable for anybody; Open – All data necessary to apply the index are freely provided and with worldwide spatial coverage; Reliable – The method has been validated and calibrated in 15 study areas with different hydrogeological conditions; Flexible – Users can choose to apply AGL or SP assessment; Dynamic – Offering the possibility to simulate scenarios.

2 From orientation to analysis

Those approaching the platform for the first time find a rich but not dispersive interface. For those who prefer a guided itinerary, the consortium proposes the operational sequence described below, designed to lead from general orientation to detailed analysis, without omitting the intermediate steps.

The first useful step is opening the legend. Understanding the meaning of the colours, shapes and classes is the prerequisite for any subsequent reading, and it avoids building interpretations resting on conventions that are not mastered. Immediately afterwards comes the choice of the analytical perspective: AGL mode if agricultural leaching vulnerability is of interest, SP mode if attention is directed at salinization.

Once the framework is defined, one moves on to isolating the geographic context. The Layer widget serves precisely to keep active only the countries and sub-layers useful to the analysis, leaving out what is not needed. The territory is then explored with the usual zoom and pan commands; the reading of the Coordinates widget accompanies this phase whenever positional precision is required.

The next step leads naturally to the consultation of numerical data. The Attribute Table returns the complete body of information of the selected layer (identifiers, attributes, relationships) and makes it possible to work on the records as one would with a spreadsheet. When the analysis requires specific tools, the rest of the bar comes into play: Elevation Profile for elevation readings, Viewer for dedicated in-depth studies, Window SP for salinization assessments, Wayback for the comparison between different periods of the territory.

It closes, as far as possible, with the comparison between the two perspectives. AGL and SP are not mutually exclusive alternatives: it is in their dialogue that the richest readings of the territory emerge, because the same areas respond differently to the two sources of pressure. This overlapping of viewpoints is, ultimately, the very reason for which the platform was built.

3 The WEB Platform

The application was developed with ArcGIS Experience Builder and is configured as a data consultation platform built on criteria of graphic restraint and readability, suited both to quick consultation and to prolonged use in research contexts.

The platform is currently freely accessible without registration trough the project website at this link: https://www.datasetw4all.info/webplaatfoorm

The interface is organized into three functional components (Figure 2). An upper header hosts the selector for the AGL and SP reading modes, which governs the interpretive key with which data are rendered on the map. The cartographic space, placed at the center, occupies most of the windows and is the primary site for analysis. A vertical bar arranged on the left margin gathers the eight operational widgets, accessible at any time during consultation.

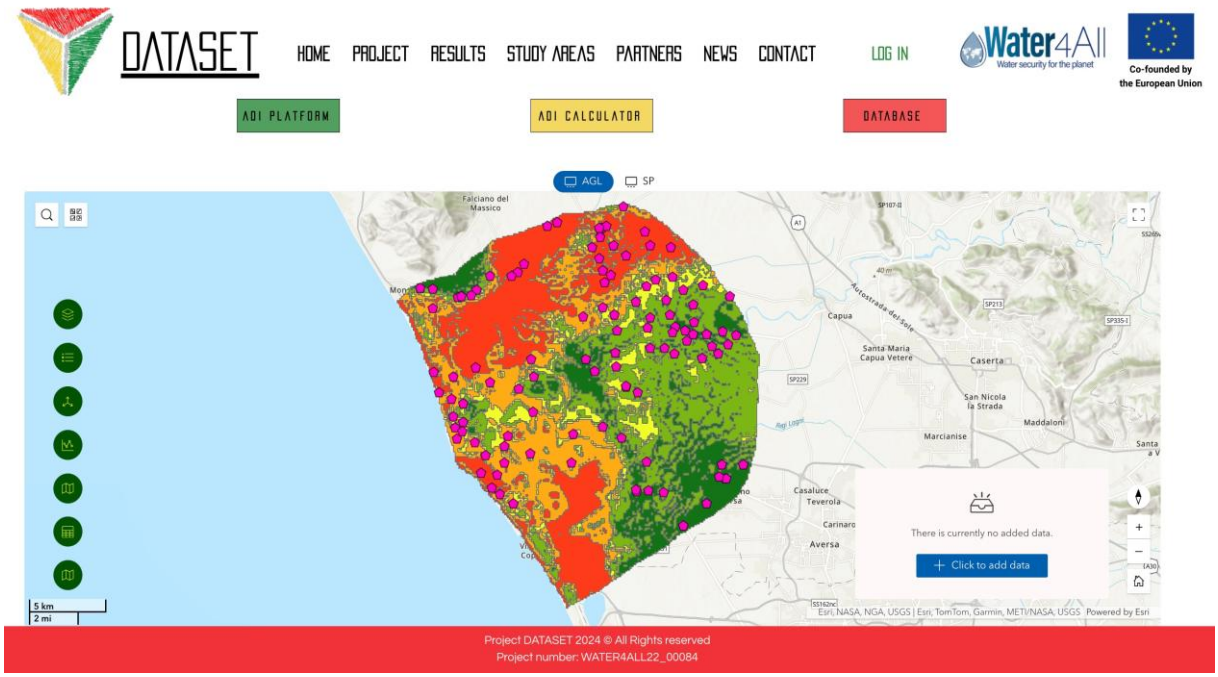

Figure 2: General view of the application in AGL mode, with the monitoring sites of the Volturno Plain.

The portal is structured with a dual function, that is with a dual map window.

The first, called AGL (Agricultural Leaching), shows maps relating to the vulnerability of aquifers to agricultural pollutants (mainly nitrate). The second, called SP, displays instead maps relating to the same project sites concerning coastal vulnerability, associated both with saline intrusion and with the upconing of seawater (focusing on chloride).

To switch from one mode to the other, simply select the corresponding button (AGL or SP) in the selection bar above the main map. Each mode keeps its own layer configuration, symbology and legend, updating automatically when the perspective changes.

The choice to keep the two analytical dimensions of vulnerability separate, rather than overlapping, responds to a precise interpretive need. The AGL mode (Agricultural/Leaching Vulnerability) represents the territory's susceptibility to the leaching of substances of agricultural origin towards the aquifer. The SP mode (Salinization) renders instead the vulnerability to salinization, linked mainly to seawater intrusion and saline concentration processes. The two readings share the same territorial base but answer distinct scientific questions.

	AGL	SP
FULL NAME	Agricultural Leaching	Salinization Processes
OBJECT OF STUDY	Susceptibility to leaching from agricultural practices	Susceptibility to aquifer salinization
MAIN FACTORS	Depth to water, recharge, slope, soil permeability, aquifer hydraulic conductivity	Piezometry, recharge, distance from salt/freshwater sources, elevation, soil and aquifer hydraulic conductivity.
REPRESENTATION OF WELLS	Magenta pink pentagons	Purple pentagons
TYPICAL USE	Agricultural/land use planning and nutrient management	Management of drinking water resources in coastal areas

3.1 Management of map Layers

The first tool on the bar allows the user to manage the map layers loaded onto the platform. The list shown returns, purely by way of example, some of the territories already assessed for both AGL and SP vulnerability using the novel DATASET indices (Figure 3a): Morocco, South Africa, Thailand, Poland, Italy, Nigeria, Mexico, Iran, India, Colombia, China, Algeria, Australia.

This is an illustrative sample, not a closed perimeter: the platform is structurally designed to accommodate further countries and study sites, depending on the extension of scientific collaborations.

Each country is organized as an expandable container, within which one or more sub-layers correspond to the various objects represented: the monitoring wells, the vulnerability surfaces, and any auxiliary layers such as administrative boundaries or hydrographic networks (Figure 3b).

The user can selectively turn each element on and off, building the view best suited to each analysis: focusing on a single country for a local in-depth study, or comparing two geographically distant areas by switching on the corresponding layers.

By clicking the side arrow next to a country's name, the widget expands the tree structure, showing the available sub-layers (Figure 3c). These include, depending on the area, the monitoring wells and the vulnerability surfaces. The wells can be turned on or off independently of the vulnerability layer, allowing customized views to be built for each analysis.

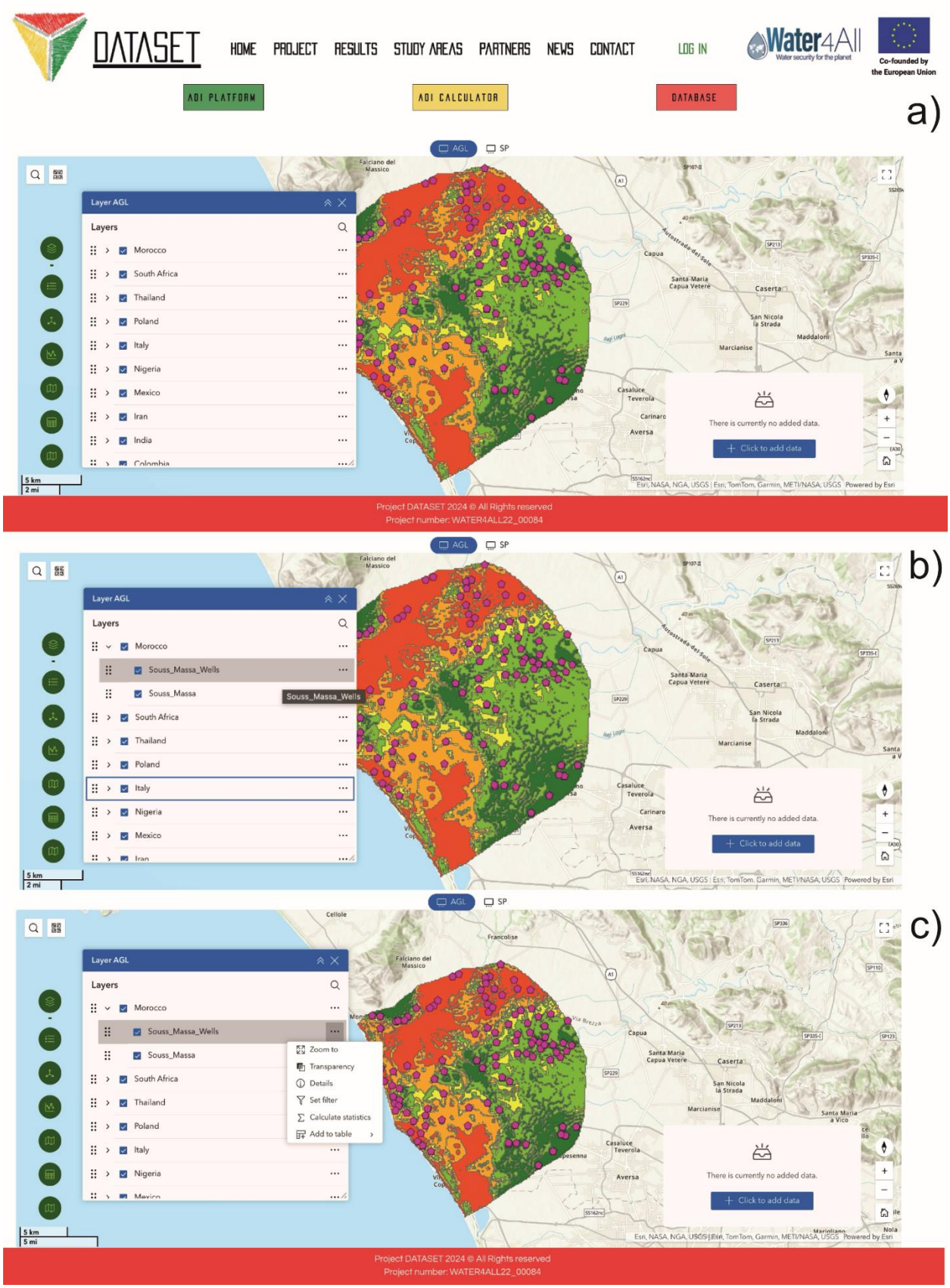

Figure 3: Layer widget: illustrative sample of the territories configurable on the platform; the list is open and subject to extension.

3.2 Symbology and classes

Every thematic map lives on its own symbolic apparatus. The Legend widget makes explicit the graphic convention adopted (Figure 4): the shape of the well markers, the colour scale of the vulnerability classes and their correspondence with the actual values. For the Volturno Plain, for example, vulnerability is rendered on a five-level scale (Very low, Low, Medium, High, Very High) with a gradation that runs from dark green to red, passing through the intermediate shades of light green, yellow and orange.

Reading the legend before exploring the map is not a formality. Knowing the colour scale and the symbols prevents misreadings and makes the areas requiring priority attention evident .

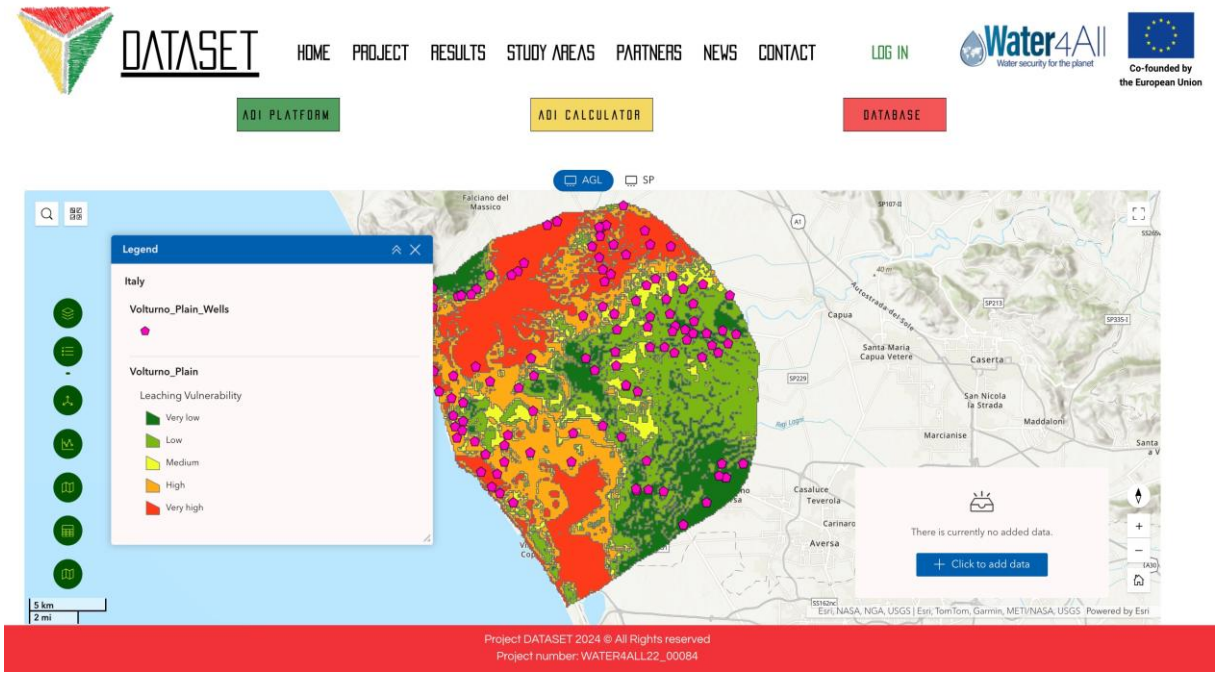

Figure 4: Legend with the five-class vulnerability classification.

3.3 Elevation analysis

Among the tools for reading the territory, the elevation profile holds a prominent position in hydrogeological studies. By tracing a transect on the map, even one made up of several segments, the widget returns the elevation profile along the route, making it possible to correlate the terrain's morphology with the distribution of vulnerability classes (Figure 5).

The tool proves particularly useful for investigating the relationship between elevation, aquifer gradient and saline-intrusion dynamics in coastal areas, where even modest changes in elevation can have significant repercussions.

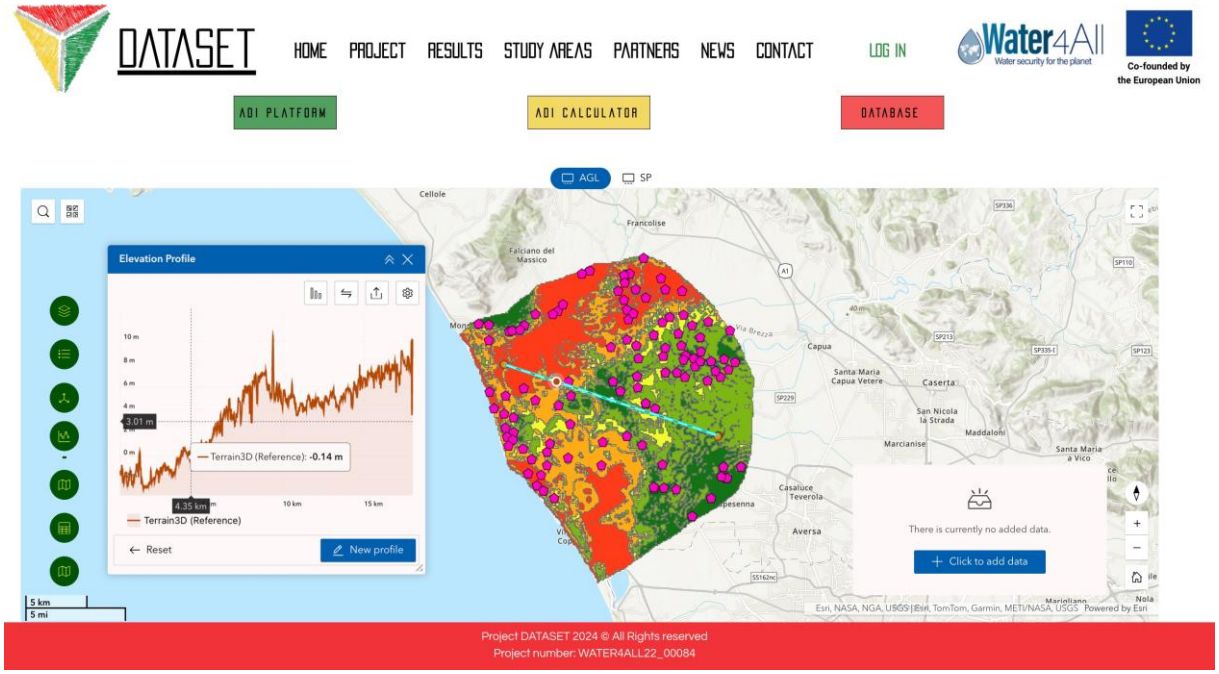

Figure 5: Elevation Profile widget on opening: the window awaits the indication of the first point of the transect.

3.4 Comparison between areas

When analysis requires concentrated attention on a specific portion of the territory, the Viewer widget opens a dedicated window that reproduces the main map in an independent view.

All active layers are retained, from the vulnerability polygons with their fills to the wells with their markers, but freed from the context of the other open tools. The Comparison Map allows a second map window to be opened, called Comparison window AGL, set to the same AGL mode as the main view. This function makes it possible to compare two distinct geographic areas simultaneously using the same parameter and the same classification system, facilitating the assessment of vulnerability differences between one site and another (Figure 6). The two maps can be navigated independently and support zoom, pan and search by address or place.

3.5 Tabular data

Behind every cartographic object lives an attribute table. The Attribute Table widget makes it directly consultable, returning in spreadsheet form the entire body of information associated with the selected layer. In the example shown, the twelve wells of the Souss_Massa_Wells layer in Morocco are visible, each described by an internal identifier (FID), the label code (MAR0043, MAR0052, MAR0617 and so on) and the supplementary information available such as chemical species or hydrogeological information (Figure 7).

The table is sortable, selectable and, through the context menu, exportable in the main exchange formats to continue the analysis in other environments.

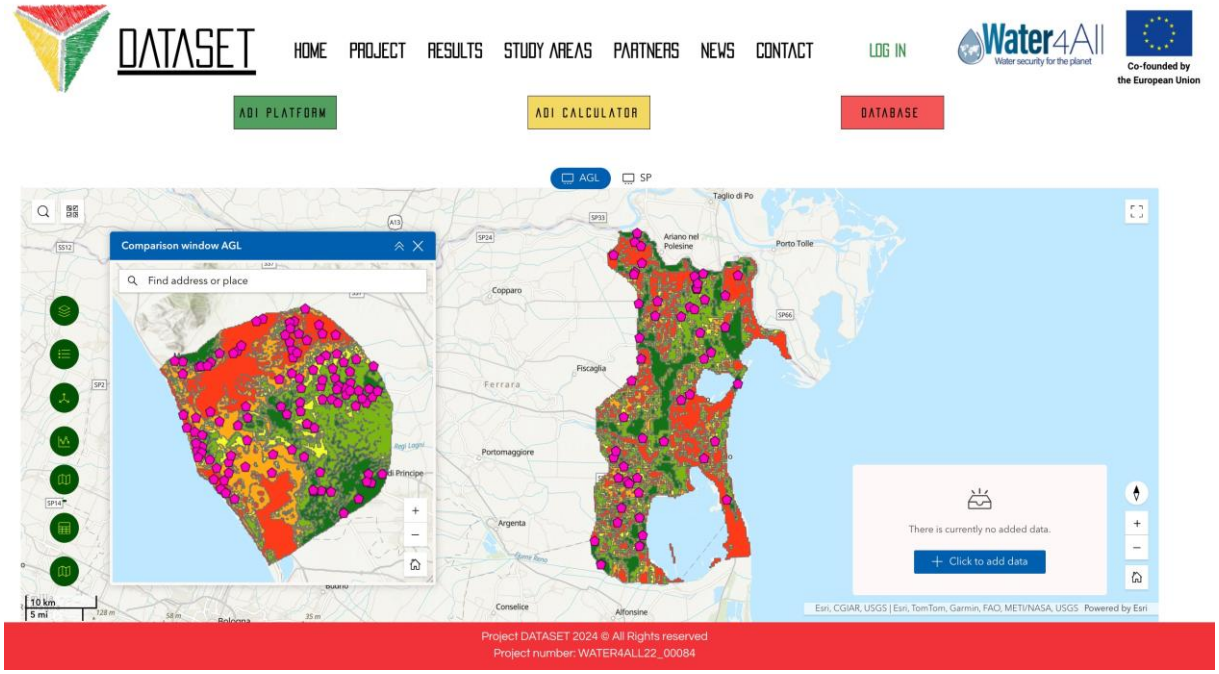

Figure 6: Comparison window AGL: two Italian areas (Volturno Plain on the left, Po delta on the right) compared with the same AGL parameter for a comparative assessment of vulnerability.

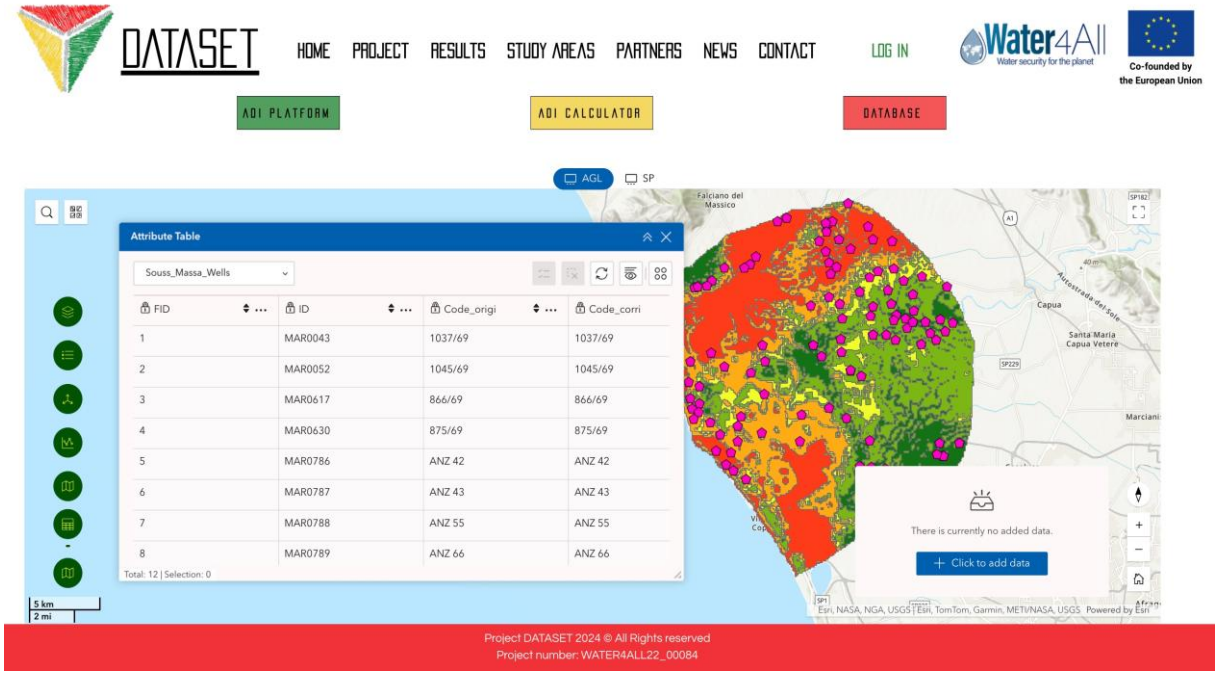

Figure 7: Attribute table of the Souss_Massa_Wells layer: internal identifier (FID), DATASET code and origin code (Code_origi) for each monitoring well.

3.6 Salinization view

The last tool on the bar opens a view dedicated to SP mode, sitting alongside, without replacing, the main AGL reading (Figure 8). The change of perspective is immediately noticeable: the wells shift from pink to purple; the vulnerability surfaces change classification and colour, and the reading of the territory reorients itself towards the salinization dimension.

The example below shows the same portion of the Volturno Plain rendered in the two modes: on the left, in the dedicated window, the SP reading with the salinization vulnerability classification; on the right, in the main AGL view, the same area according to agricultural leaching vulnerability. Placing the two perspectives side by side is the analytical gesture most characteristic of the tool: on one side seawater intrusion and its coastal dynamics, on the other agricultural pressure and its effects on the aquifer. The same area, read from two different angles, returns complementary information that neither perspective alone could express.

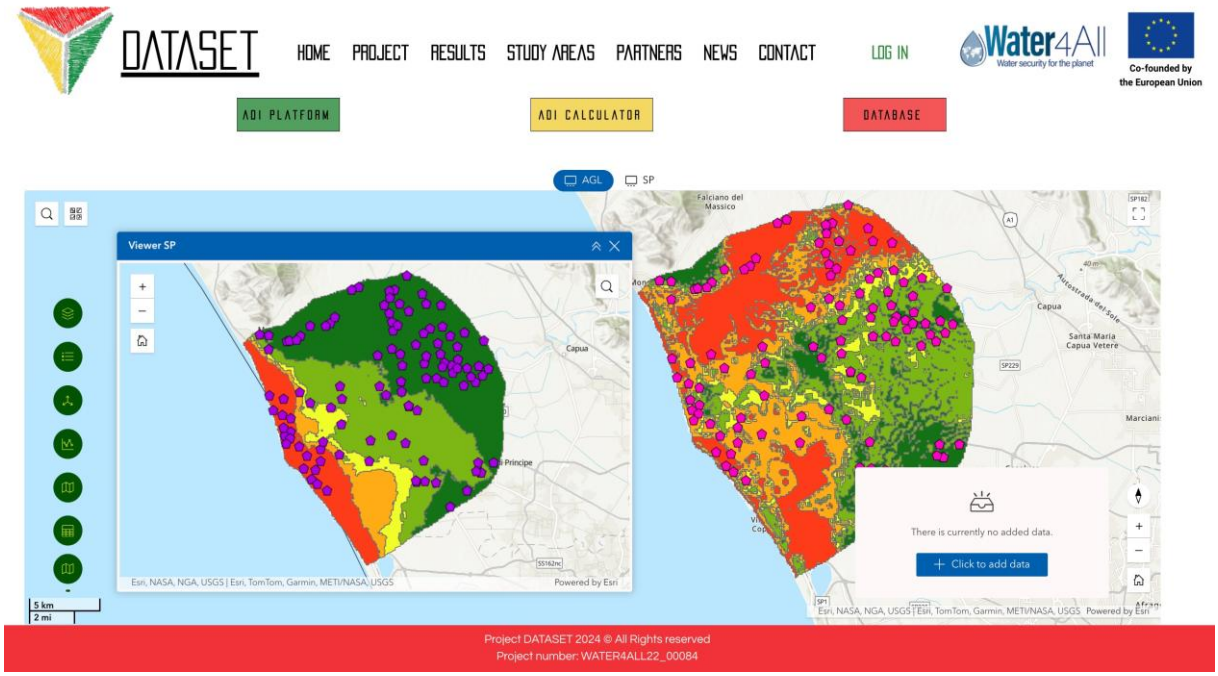

Figure 8: Viewer window opened on a sector of the Volturno Plain, with the monitoring wells and the areas classified by vulnerability.

3.7 Imagery Atlas

The eighth and last tool on the bar allows access to the Wayback archive, which preserves all the versions of World Imagery published over time. Each layer available in the archive corresponds to a state of the global satellite coverage updated to a specific date.

World Imagery provides high-resolution satellite and aerial imagery for most of the planet. When the coverage is updated, previous versions are no longer visible in the standard view but remain accessible through Wayback. This tool makes it possible to retrieve historical acquisitions that can document vegetation cover, agricultural layouts, coastal configurations or urban expansions prior

to a given event, enabling the comparison of different states of the territory over time, starting from 20 February 2014.

In the field of groundwater vulnerability studies, the tool makes it possible to reconstruct the evolution of land use, the variations of surface water bodies and coastal dynamics, all factors that directly affect the pressure exerted on the aquifer.

The two screens that follow illustrate the operational workflow: the main view of the platform with the add-data button active and the search panel opened on ArcGIS Online with the Wayback layers available for loading.

A comprehensive video explaining in detail the web platform is available in our YouTube channel trough the link

https://www.youtube.com/watch?v=BU-JIBKNqDU

4 Target Users and Impact

An applied research project exists to the extent that its results reach those who must decide, design, implement, study, or simply understand. DATASET addresses a deliberately broad audience, recognizing that groundwater governance cuts across different skills and interests. For each target user it is worth distinguishing three moments: the situation one starts with, what the platform makes available and the way this concretely changes everyday practices (Figure 9).

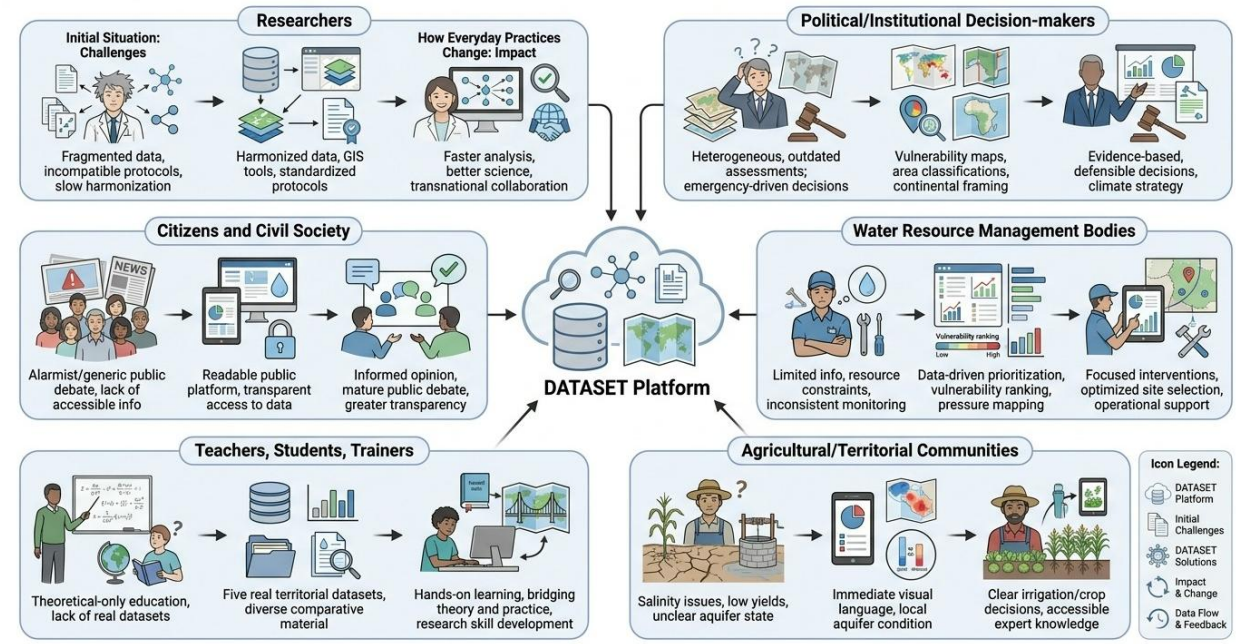

Figure 9: Impact and target users of the DATASET platform.

Researchers

Those who study groundwater salinization or pollution work today in a fragmented landscape. Data are scattered among different bodies, collected with protocols that are not always compatible, often accessible only after lengthy institutional negotiations. Much of the initial time of a research project is consumed in preliminary harmonization, sometimes with unsatisfactory results all the same.

DATASET tackles the problem upstream. It makes available data that are already harmonized, collected according to common protocols at the five pilot sites, and a GIS platform on which one can work directly. What was previously the endpoint of months of work becomes the starting point: time shifts from data organization to actual analysis, to the benefit of the scientific quality of the results and of the possibility of launching comparative collaborations on a transnational scale.

Political and institutional decision-makers

Choices concerning groundwater, from protection plans to territorial planning, from concessions to mitigation measures, are often based on assessments built quickly, with heterogeneous and not always up-to-date data. The difficulty of having a comparable framework translates into decisions that favour the emergency over the long-term perspective.

The platform provides a stable reference. The vulnerability maps, the classifications by area, the framing of local data within continental patterns offer a technical basis on which to build administrative acts and climate-adaptation strategies. It does not replace political decision-making, but makes it more defensible: every choice can be anchored to validated scientific evidence shared with the other European and non-European partners.

Water resource management bodies

Land-reclamation consortia, river basin authorities and water service operators work with limited resources and growing demands. The choice of areas on which to concentrate monitoring, recharge interventions and quality controls falls daily on technicians who have partial information, often inconsistent across different sources.

DATASET provides a data-based prioritization criterion. The zones classified as having high or very high vulnerability emerge immediately from consulting the platform, as do the areas where anthropogenic pressure converges with the fragility of the aquifer. The planning of interventions, the choice of sites for new wells, and the evaluation of alternative extraction scenarios find operational support that previously required case-by-case dedicated consultancy.

Agricultural and territorial communities

For those who farm in coastal or plain areas, groundwater quality is already a budgetary matter. Even modest increases in salinity translate into lower yields, into forced choices on crops, and into rising costs for treatment and filtration. These decisions are often made without a clear picture of how the aquifer is evolving over time.

The platform returns, in an immediate visual language, the condition of the aquifer on which a farm depends. Choices concerning irrigation, the drilling of new wells, and crop rotation can thus rely on territorial information that was previously the exclusive preserve of specialists. It is an important step: scientific knowledge of the aquifer leaves the circuits of research and becomes a tool for economic decision-making for those who operate on the territory.

Teachers, students, trainers

The teaching of hydrogeology and environmental sciences has long grappled with a recurring difficulty: the gap between the theoretical cases proposed in textbooks and the complexity of real contexts. Working on real datasets, in university classrooms or technical training courses, requires access that is not always available.

With the opening of the platform, five distinct territorial contexts become immediately usable teaching material. Students can compare an Italian alluvial plain with a South African coastal area, build spatial-analysis exercises on real data, and understand how the same phenomenon takes on different forms in different contexts. It is a rare opportunity to bring teaching closer to the practice of active research.

Citizens and civil society

Public debate on groundwater, when it opens, often takes on alarmist tones or generic reassurances. Citizens lack a tool through which to form an independent opinion on the condition of the aquifer that concerns their own territory.

The public section of the platform, designed to be readable without specific technical skills, offers precisely this possibility. It does not replace the mediation of specialists, but opens a channel of direct access to the data: an act of transparency that helps make the collective debate on water-related choices more mature.