Integrating Satellite, Ground Sensors, and AI for Surface Water Protection: The EcoNet Project

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Abstract:

Human activities introduce contaminant mixtures, disrupting freshwater ecosystem balance. Monitoring surface freshwater is therefore crucial for safeguarding ecosystems and promoting sustainable development of (peri)urban areas. Current monitoring systems are discontinuous and do not meet timeliness requirements, making difficult to detect ecosystem changes before their impact on habitat and biodiversity.

The EcoNet project (www.econet.cnr.it), funded by the Italian Space Agency under the "Innovation for Downstream Preparation for Science" program, aims to develop and demonstrate a sensoristic system with ground-based sensors and satellites data integrated using Artificial Intelligence (AI) for rapid diagnostic monitoring of variations in the natural state of surface waters (Figure 1). This multiparametric and flexible system combines a microalgae-based toxicity biosensor and satellite sensors for monitoring water parameters, alongside with multi/hyperspectral images from PRISMA, Sentinel-2, and Landsat 8/9 missions. Leveraging the synergy between these multisensory technologies, an Artificial Neural Network (based on a Multi-Layer Perceptron model) is implemented to effectively handle and analyze subtle data relationships. Overall, the proposed integrated sensor-driven system aims to overcome limitations of single ground or remote acquisition techniques. The results from ground bio/chemosensor measurements highlight significant variations in selected physico-chemical parameters among different water sampling points, attributed to agricultural and peri-urban anthropogenic pressures. Retrieval relevant parameters (e.g., concentration of Chlorophyll-a, Total Suspended Matter, Colored Dissolved Organic Matter, Total Phosphorus and Total Nitrogen) from satellite data is underway. Additionally, synthetic satellite images are being generated to expand the hyperspectral dataset used for the neural network algorithm training process. The Artificial Neural Network models development proved to be interesting for estimating these parameters and assessing the natural state over entire surfaces of the tested water basins. Overall, EcoNet aims to establish a comprehensive downstream service to support user communities in managing protected areas, such as the Natura 2000 sites, and promotes environmental awareness through dissemination actions.

Keywords: Integrated Analytical Systems, PRISMA, Sentinel-2, Hyperspectral remote sensing, Bio/chemosensoristic devices, Artificial Intelligence, Freshwater ecosystems, Natura 2000

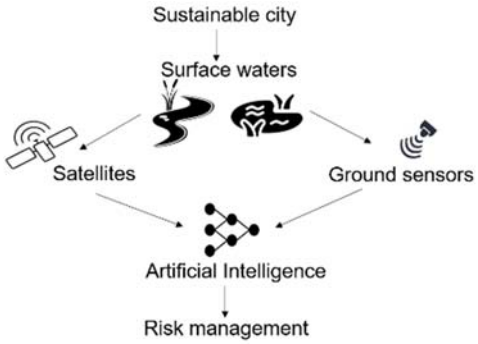

Figure 1: Schematic representation of EcoNet concept

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