NATURE BASED SOLUTIONS TO CONTRAST CLIMATE CHANGE EFFECTS, INCREASE RESILENCE AND BIODIVERSITY: ACTION STRATEGIES OF PHUSICOS PROJECT IN THE MASSACIUCCOLI LAKE BASIN (TUSCANY, ITALY)

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Abstract

The catchment of Massaciuccoli Lake is characterized by large-scale and intensive agricultural use and the presence of a valuable and vulnerable receiving water body (SIC and Ramsar convention). Erosion, subsidence and lake eutrophication and siltation are the main problems facing the area. In this context, the Phusicos Project aims to identify, apply and monitor the Nature-Based Solutions (NBSs) able to restore the pristine conditions according to the EU Water Framework and Floods Directives. NBSs are intended to limit soil and nutrient loss from cultivated fields and to treat superficial waters from the ditches network before they arrive to the lake. NBS consist of large-scale buffer-strips combined with conservation agriculture techniques (minimum-tillage and cover-crops), gently management of channels and sediment traps. The effectiveness of NBSs are analysed through multidisciplinary activities including stratigraphic and grain size analyses, soil sampling, key horizons dating, analysis of precipitation and temperature trend, hydrogeological and geochemical characterization of soil and water, qualitative-quantitative and solid transport monitoring of superficial waters and groundwater, and crop productivity. A further objective is to replicate NBS as "best practice" in other areas by providing farms with new opportunities for growth, development and revitalization in the post-Covid-19 phase.

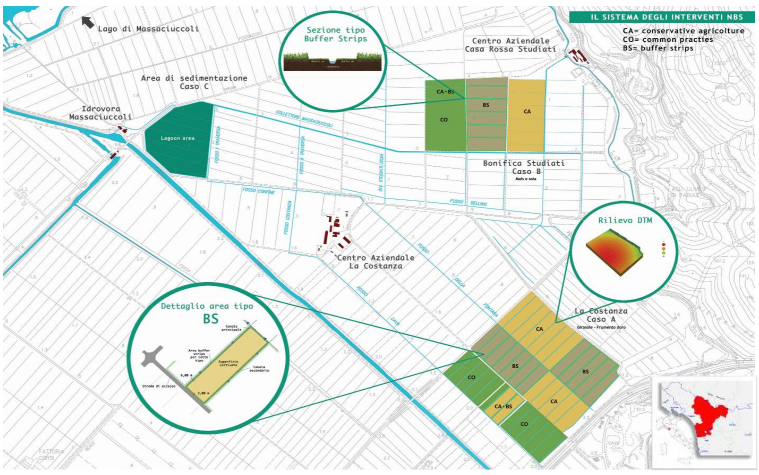
Massaciuccoli Lake basin

Massaciuccoli Lake (7 km^2 wide and about 2 m deep) is a coastal lake surrounded by marshy areas. Large part of the basin has been reclaimed for agricultural purposes since 1930 by means of a complex network of artificial ditches and pumping stations forcing water from the drained areas into the lake. As final water receptor, the Massaciuccoli Lake has become a sensitive and vulnerable area, especially to nutrients, such as nitrates and phosphates, and silting phenomena. Considering the ecological value of this wetland, actions are needed to restore and preserve this area.

Landscape framework of the area

Action strategies

Action strategies carried out in Massaciuccoli Lake area come out from "*Phusicos - According to nature*", funded by the EU Horizon 2020 program and aimed at demonstrating how Nature-Based Solutions (NBSs) are adequate, low environmental impact and economically sustainable measures to reduce the risk of extreme weather events (floods, drought, etc.) in rural landscapes. NBSs were identified through a participatory path to mitigate the hydrogeological risk and improving the delicate environmental systems of the Massaciuccoli Lake area. The focus is to experiment the function and effectiveness of alternative land managements, which represent a natural approach with a low environmental and landscape impact to achieve 360° environmental improvements by increasing the resilience of the territory, favoring biodiversity and usability of natural areas. The buffer strips are part of a broader general intervention plan for the area. They have the advantage of being reversible, sustainable over time, synergistic with other measures.



The NBSs integrated system

Shared participation

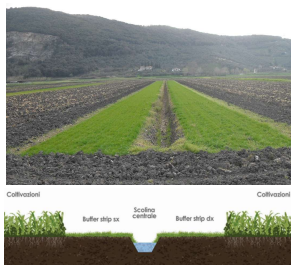
The local farmers are the main actors in the implementation of these NBSs works. In fact, by providing extensive agricultural areas, their specific knowledge and actively participating to the implementation of the NBSs works, they allowed the project to take shape. The implementation of dedicated Living Labs then enabled the building of a path of shared participation with the main stakeholders aimed at planning the works to be carried out within this project.

Living Labs sessions

The research activity

The project aims to evaluate the effectiveness of agronomic and hydraulic techniques in containing the risks of erosion and nutrient losses from cultivated fields, which are one of the main causes of the degradation of Lake Massaciuccoli. In particular, two farms representative of the different soil conditions of the area have been involved to compare the farming practices usually adopted with two alternative cropping systems.

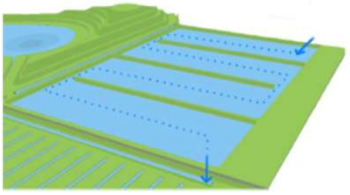
The first is based on the use of ***buffer strips*** that are vegetated areas consisting of multi-annual herbaceous bands and/or tree and shrub species placed at the margins of cultivated fields. They limit soil erosion, solid transport in canals, the flow of potential contaminants or pollutants from the land to water bodies, favoring a process that improves the water quality and the ecological status of lake ecosystems and surrounding areas, with a consequent increase in the resilience of the territory. The buffer strips also contribute to implement the Framework Directive on Water (2000/60/EC) and the Floods Directive (2007/60/EC).



The buffer strip system

The second one is referred to the principles of **conservation agriculture** and is characterized by a substantial reduction in the intensity of tillage and using cover-crops, that is, plants like for examples "Lolium multiflorum Lam", inserted between one cash crop and the next, only for ecological and agronomic purposes or sod-seeding.

Conservation agriculture system: cover-crop (*Lolium multiflorum* Lam.), sod-seeding



In addition, another work is planned to complete the mitigation actions on the transport of soil and nutrients. It is a water retention basin that will be built at the outflow of the sub-catchment, just before the pumping station that raises the drainage waters to deliver them to the Lake. The ***sedimentation basin***, about 5.0 ha wide, can significantly abate the particulate materials by means of the sedimentation processes. Moreover, the plants growing into the basin can uptake N and P by reducing the nutrient loads destined to reach the Lake.

The monitoring systems

Two monitoring systems were at present arranged: i) a monthly monitoring of the main ditches of the area, aimed at evaluating the general hydrological and chemical-physical conditions of superficial water (hydrometric level, electrical conductivity, pH, turbidity), and ii) a continuous monitoring of the ditches water selected for the buffer strips experiment, through multiparametric probe (HydroLab HL7) that measure pH, dissolved solids, temperature, water flow, redox potential, dissolved oxygen, salinity, conductivity, turbidity, total dissolved gases (TDS) Nitrates (NO3-) e Ammnoium (NH4+). In addition, a seasonal chemical characterization of both superficial and groundwater is also carried out, analyzing the main cations, anions and trace elements. One station is equipped with a Doppler radar rain gauge to provide information on the intensity of rain, the size of the water droplets and the rate of fall.

A microcontroller unit interrogates the probes using the protocol for communications between intelligent SDI-12 environmental monitoring sensors with low energy consumption. Communication takes place through an encrypted connection, using a web portal realized by NEXMAN s.r.l. for the project, in order to guarantee the privacy and integrity of the information exchanged. Drilling operations are realized with the dual purpose of characterizing the sediments of the study area and implementing a groundwater monitoring system.

A: study area and sampling points of superficial and groundwater;
B-C-D: sampling and chemical-physical analysis;
E-F: drilling operations and construction of the PH1 piezometer;
G: drill core derived from PH1;
H-I: multiparametric probe and alimentation system.

Expected results

The performance of the crop systems compared will be evaluated from the agronomic point of view (yield levels obtained), economic (profitability of the solutions adopted) and environmental (loss of soil and nutrients), in order to provide useful information to demonstrate how the solutions nature-based (NBS) measures are adequate, low environmental impact and economically sustainable measures to counter the effects of climate change and reduce the risk of extreme weather events (floods, droughts, etc.) in rural landscapes

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The IT Phusicos Team with the farmers

The EU Phusicos Team

PARTNERS

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