

Modeling the effect of land cover change on sediment accumulation in small agricultural reservoirs in Tuscany region

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Abstract

Among the problems that hilly agriculture must face, water management has always been of primary importance. In hilly regions, the water regime is an important constraint on entrepreneurial choices as it reduces the crops' applicability and technical alternatives [1]. The use of small reservoirs for irrigation purposes and for the mitigation of drought effects in agriculture is historically widespread within the Italian territory. However, the presence of an artificial barrier, necessary for water resource storage in the reservoir, modifies the natural equilibrium of water streams, creating an area characterized by low water speeds and, consequently, by a high capacity of sedimentation of the solid material transported by the streamflow, resulting in an increasingly careful phenomenon which is the sediment accumulation in the reservoirs.

Sediment accumulation is one of the most critical problems in reservoir management and affects the functionality and lifetime of the storage: over time, in fact, the reservoirs may lose partially or totally their storage capacity, due to soil erosion within the watershed. In non-anthropized contexts, the rate of sediment removal is sufficiently slow, so the processes of soil formation, by rock disintegration and alteration, compensate for the losses, and the thickness of the soil remains almost unchanged [2]. With some types of crops, the erosive processes can be particularly accelerated, causing, in addition to the loss of fertility of the soil itself, a faster sediment accumulation in the reservoirs that are downstream and a significant reduction of their useful capacity in a short time. One of these is certainly the vineyard, which, due to its surface morphology and the mechanical operations of soil leveling necessary for crop implementation, is responsible for the high production of sediments within the watershed of which it is part [3].

The present work aims at estimating the effects of the application of this crop on sediment accumulation in hilly reservoirs, with the use of HEC-HMS. We have estimated the production of sediments at a basin scale and the consequent accumulation of sediments in a reservoir that is located within the Suvignano farm, which is currently free of significant sediment accumulation issues. The Suvignano estate is in the hilly area of Crete Senesi, is about 15 km from Siena, and is property of Ente Terre Regionali Toscane, after the seizure of this property confiscated from organized crime on 16/11/2018. In this area of Tuscany, wine production is particularly developed, but not within the farm of Suvignano, where the cultivation of cereals, renewal crops, and forage is practiced and there is a large grazing area.

The analysis aimed at estimating how much the rate of sediment accumulation in the reservoir would vary with the replacement of currently arable land with vineyards. We evaluated 3 scenarios: in the first scenario, we estimated the amount of sediment accumulated in the reservoir with crops currently practiced within the basin, without variations of land cover; in the second scenario we estimated the sedimentation with the replacement of currently arable land with vineyard within the perimeter of the estate of Suvignano; in the third, we evaluated the change in sedimentation with the replacement of arable land with vineyards in the entire catchment area upstream of the reservoir.

The results, represented in Figure 1, show that this change would lead to a high increase in annual sediment accumulation in the reservoir, which should be considered at least at the agronomic design stage, as well as in the estimation phase of the costs of water supply, which must include the cost of the reservoir volume restoring, lost by sediment accumulation.

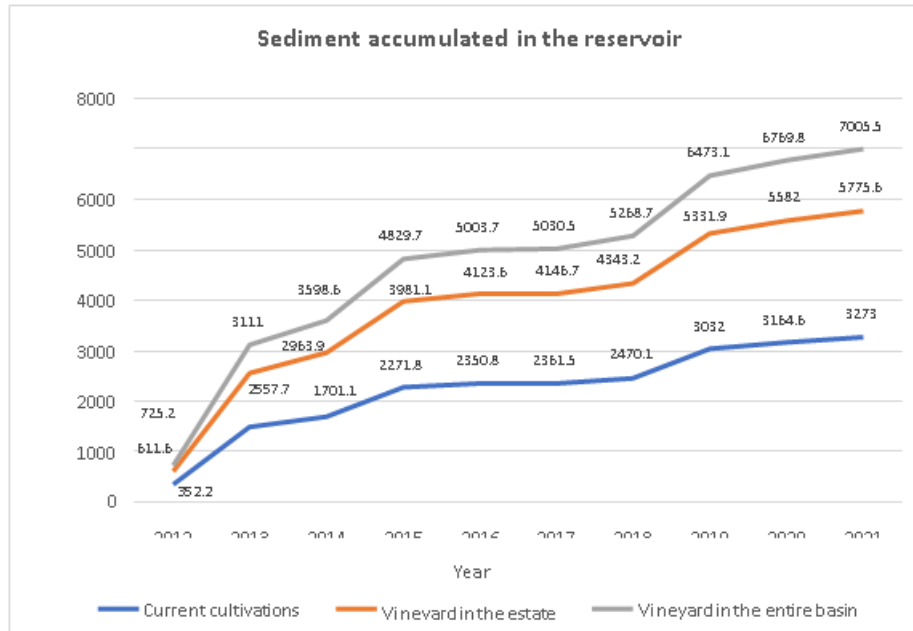


Figure 1. Comparison of the tons of sediment accumulated in the reservoir in the various soil cover scenarios analysed

Keywords: Reservoirs, Sedimentation, Erosion, Vineyards, HEC-HMS, Watershed

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