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A Bayesian Belief Network framework to predict SOC stock change: the Veneto region (Italy) case study

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A key challenge for soil scientists is predicting agricultural management scenarios that combine crop productions with high standards of environmental quality. In this context, reversing the soil organic carbon (SOC) decline in croplands is required for maintaining soil fertility and contributing to mitigate GHGs emissions. Bayesian belief networks (BBN) are probabilistic models able to accommodate uncertainty and variability in the predictions of the impacts of management and environmental changes. By linking multiple qualitative and quantitative variables in a cause-and-effect relationships, BBNs can be used as a decision support system at different spatial scales to find best management strategies in the agroecosystems.

In this work we built a BBN to model SOC dynamics (0-30 cm layer) in the low-lying plain of Veneto region, north-eastern Italy, and define best practices leading to SOC accumulation and GHGs (CO_2-equivalent) emissions reduction.

Regional pedo-climatic, land use and management information were combined with experimental and modelled data on soil C dynamics as natural and anthropic key drivers affecting SOC stock change. Moreover, utility nodes were introduced to determine optimal decisions for mitigating GHGs emissions from croplands considering also three different IPCC climate scenarios. The network was finally validated with real field data in terms of SOC stock change.

Results showed that the BBN was able to model real SOC stock changes, since validation slightly overestimated SOC reduction (+5%) at the expenses of its accumulation. At regional level, probability distributions showed 50% of SOC loss, while only 17% of accumulation. However, the greatest losses (34%) were associated with low reduction rates (100-500 kg C ha^{-1} y^{-1}), followed by 33% of stabilized conditions (-100 $<$ SOC $<$ 100 kg ha^{-1} y^{-1}). Land use management (especially tillage operations and soil cover) played a primary role to affect SOC stock change, while climate conditions were only slightly involved in C regulation within the 0-30 cm layer.

The proposed BBN framework was flexible to perform both field-scale validation and regional-scale predictions. Moreover, BBN provided guidelines for improved land management strategies in a perspective of climate change scenarios, although further validation, including a broader set of experimental data, is needed to strengthen the outcomes across Veneto region.