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The monetization of soil: An emerging imperative?

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ABSTRACT

This Viewpoint proposes assigning explicit economic value to soil—not merely as a platform for infrastructure but as a finite, three-dimensional resource crucial to food production and ecosystem services provision. Unlike water or air, soil is rarely accounted for its fundamental environmental importance. To fill this gap, we advocate a Total Economic Value framework spanning use, option and non-use benefits, which, contrary to conventional land appraisal, considers soil thickness, density and quality. Embedding these metrics in policy instruments, markets and land transactions could reward conservation and drive sustainable management. While challenges such as spatial heterogeneity, market design and equity persist, pricing soil can shift social perceptions, curb degradation and foster practices that rebuild soil health. Recognising our shared economic stake in soil is not just theory, but an essential step toward safeguarding a routinely neglected natural asset.

1. Introduction and rationale

1.1. Why price matters for natural resources

Nowadays, there is often the perception that everything that does not have a price has no real economic value. This is especially true for those natural resources that have long been erroneously perceived as unlimited. Among these is water, which is increasingly less accessible in many parts of the world and creates tensions and even conflicts here and there (Dolgin, 2023). While water has gradually been assigned an economic value, helping to raise awareness of its scarcity, the same has not occurred for soil, another finite and fundamental resource for humanity, which is increasingly threatened by degradation and is therefore becoming ever less available (Montanarella et al., 2016). We mean soil as a three-dimensional body, not as the cadastral surface, which has a value mostly independent from the intrinsic properties of the matter. In fact, soil as land for building or farming has a market value, whereas soil as the material that supports life and stores carbon and water does not. Yet, it is precisely these characteristics that give soil its true value. Is not soil, in addition to providing more than 95 % of our food (FAO, 2022) and supporting infrastructure in that scant 1 % of global land that is built-up (Liu et al., 2014), also the source of a range of fundamental ecosystem services, such as rainwater regulation, climate change mitigation, and biodiversity conservation (Brevik et al., 2018; Certini and Scalenghe, 2023)?

1.2. Soil as a three-dimensional asset

Each soil is a body with its own distinct thickness and density, which remain relatively stable over time unless substantial changes are induced (e.g., through erosion or compaction). As such, if we want to attribute an economic value to a soil, it should be based on the quantity of this soil per unit area (possibly excluding stones, which generally diminish the ability of soil to provide ecosystem services) and its physicochemical characteristics, which vary with both distance and depth. Soil is a slow-to-accumulate capital that must be preserved—and possibly improved—to yield and be functional for ecosystem's functioning. However, investments in soil conservation and enhancement are often not reflected in land values and, therefore, are not implemented except to support particularly valuable crops (Gardner and Barrows, 1985). Indeed, on a global scale, the cost of erosion-induced soil loss is eventually expressed in terms of reduced productivity, without accounting for the decline in other ecosystem services provided by the soil (Sartori et al., 2019).

The question is: does it make sense to assign soil an intrinsic economic value, calculated by volume or weight and based on its most important characteristics, for the primary purpose of safeguarding it? In our view, it does. What might seem, at best a curious provocation,

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carries its own legitimacy. Generally, we are less inclined to waste what has a cost, and the higher the cost, the stronger this tendency. In principle, there is no obstacle to assessing the value of soil like any other ecosystem service. The literature on environmental valuation is large, particularly following Robert Costanza's estimation of world's natural capital (1997), which provided a global assessment of the value of natural resources across different ecosystem types. There is, however, no existing estimate of soil value based on volume or weight; only hectares of soil have been assessed in monetary terms. Nonetheless, the distinction between soil surface and soil quantity is fundamental, as the third dimension—its thickness—is the true indicator of the ecosystem services it can provide. Hence, evaluating soil quantity per unit area rather than considering only surface extent is essential to inform sound policy decisions.

Dominati et al. (2010) developed a framework to quantify soil natural capital by linking soil properties to ecosystem services through inherent and manageable traits. Integrating soil process knowledge, it captures soil variability in ecosystem service models and tracks value changes under different land uses. Combined with economic valuation, it provides a powerful tool for sustainable land management and policy. Another useful framework for soil valuation is the Total Economic Value (TEV), commonly used to assess the economic worth of natural resources, ecosystems, and ecosystem services (Howarth and Farber, 2002). TEV acknowledges that the value of natural resources extends beyond direct use and includes: (i) "Use values", i.e., their actual, consumptive use, as well as benefits from non-consumptive functions such as water filtration or carbon sequestration; (ii) "Option values", i.e., the benefits of their conservation today to secure future use; (iii) "Non-use values", i.e., bequest values tied to preserving those resources for future generations or recognizing their intrinsic worth (Peterson and Sorg, 1987). Applied to soil, these categories highlight its value goes beyond the mere surface extent. Soil provides direct use values (e.g., fertility for crops, physical support for infrastructure), indirect use values (e.g., filtration capacity, carbon storage, archaeological record), and non-use values (e.g., preservation for future generations or for its intrinsic importance). A comprehensive soil valuation should capture all these dimensions.

2. Economic valuation of soil

What could be a plausible value to attribute to a given amount of unspecified soil? We posed this question to students in our Pedology courses—thirty-six at the University of Florence and twenty-seven at the University of Palermo, Italy. They provided highly variable figures, ranging from zero to several hundred euros per kilogram. Interestingly, the most frequent responses differed substantially between the two groups: 10 and 0.5 EUR, respectively. Part of this discrepancy was most probably due to the timing of the survey: at the end of the course in Florence – when the students were confidently aware of the critical functions the soil plays for human welfare and environmental quality – whereas in Palermo the students were questioned before beginning the course. This contrast highlights the role of knowledge and familiarity in shaping one's ability to assess environmental values (Needham et al., 2018). Our feeling is that a larger and more representative sample of the general population would have assigned the soil an extremely low value—or none. But things will inevitably have to change. Despite the steadily increasing demand for food driven by the exponential growth of human population, productive land is being progressively reduced by urban expansion (van Vliet et al., 2017) and other threats (Montanarella et al., 2016; Certini and Scalenghe, 2024). How can we stop this self-destructive trend? Perhaps by starting to assign soil a proper value—not merely symbolic, but concrete and quantifiable—so that transactions would involve buying or selling a specific amount of soil, measured by weight or volume, rather than just a piece of land. How much, then?

2.1. Methods for estimating soil value

To estimate the TEV, a tempting idea is to start from the crude elemental composition of soil, that is, by summing the market price of its individual elements (http://www.leonland.de/elements_by_price/en/). Which would, for example, assign an average value of less than 3 euros per kilogram to agricultural soils in Japan, based on the median elemental composition reported by Yanai et al. (2012). Alternatively, certain soil fractions hold economic interest, such as clay for the ceramic and brick industries, or gravel or sand for manufacturing and construction (Torres et al., 2017). However, this approach has several limitations. First—and perhaps most obvious—the intrinsic extraction costs of individual elements or fractions often exceeds their market value, rendering the method unviable. Second, the aggregate value of elemental components or fractions provides little insight into other critical dimensions of soil, such as its ecological or cultural significance. Third, any TEV assessment should focus on marginal changes rather than absolute values. Since soil is a finite and essentially non-renewable resource, the key question is how much we are willing to invest in improving its health or preventing its degradation (Dasgupta, 2019). In this context, soil's value increases as its availability declines due to urbanization or other threats, rather than when it is treated as an endlessly abundant substrate.

Assigning an economic value to soil as a three-dimensional body—proportional to its quality—is a complex yet intriguing concept that may become feasible. Land valuation methods generally overlook soil quality in a consistent, quantitative way. For example, the Land Capability Classification (LCC), developed by the U.S. Department of Agriculture during the Dust Bowl era, categorizes land based on its agricultural, pasture, and forestry limitations—such as slope, low fertility, excess water, and adverse climate. While widely applied, the LCC does not directly assess critical soil attributes like organic matter content, structure, or biological activity, which underpin long-term productivity and ecosystem functioning. Its capacity for site-specific evaluation is limited unless combined with modern technologies and complementary frameworks (Dar et al., 2024). Existing soil maps and classifications provide an initial basis for assessing soil quality, which can be partially translated into economic value (Brevik et al., 2016; Minasny and McBratney, 2016; Certini and Scalenghe, 2019). Yet many soil characteristics that define quality and health are rarely considered in taxonomic or productivity-oriented frameworks. Comprehensive large-scale assessments remain time-consuming and costly, especially for difficult-to-measure features (Vogel et al., 2019). Advances in soil testing and remote sensing are increasingly enabling rapid, accurate evaluations (Wadoux and McBratney, 2021; Peng et al., 2025), making large-scale economic valuation more feasible. Alongside technology, standardized methods, policies, and regulations will be essential to support this process.

2.2. Linking soil quality to land markets and policy instruments

Soil quality could play a more explicit role in land transactions, particularly as sustainable and regenerative agricultural practices gain popularity and attract government support. Carbon markets, for instance, could assign higher value to soils richer in organic matter or with greater carbon sequestration potential. Strengthening the connection between soil quality and economic value would offer policymakers with crucial information to design more effective soil conservation initiatives. Existing agricultural policies, such as the EU's Common Agricultural Policy (CAP), already incentives practices that improve land environmental quality (Tyllianakis and Martín-Ortega, 2021). A more accurate assessment of soil value could help design efficient schemes that fairly reward farmers for soil conservation efforts.

While designing and administering these programs may be complex and costly, private investors could help support farmers. Private agreements for environmental conservation, such as Payment for Ecosystem

Services (PES) schemes, already exist. In a PES, private parties agree on a specified level of environmental service or quality to be delivered, with corresponding compensation for the provider. Incorporating soil value into these frameworks could extend PES schemes to soil conservation, thereby promoting improved soil health (Lehmann et al., 2020). Healthier soils support higher productivity, better water retention, and greater climate resilience, all of which strengthen farmers' economic stability. Crops from high-quality soils could also command premium prices, particularly in markets that prioritize sustainability and organic practices. If soil health were quantified and certified, products could carry premium labels, further incentivizing investment in soil quality (Bagnall et al., 2021). Improved soil quality would also raise land value, enhancing farmers' opportunities for sales, leasing, or loan collateral.

Knowing that land value can rise with improved soil management, farmers may be more inclined to adopt regenerative practices—such as crop rotation, cover cropping, and reduced tillage—that enhance soil organic matter, structure, and biodiversity (Levin, 2022; Petersson et al., 2025). This shift could also expand the average area managed by landowners or under long-term leases, better aligning incentives and improving soil health (Stevens, 2022). Market mechanisms that reward high soil quality are far more effective than penalties for its decline and ideally markets should increasingly reflect soil quality in economic terms. Encouragingly, Meissner and Musshoff (2022) showed that soil quality consistently influences farmland price differences in Germany, though without a time-varying effect (see also (Heckenhahn and Drupp, 2024)). This suggests that soil quality provides a stable indicator of land value, although specific management practices can still enhance or degrade it over time (similar effects are observed for green and blue space values, (McCord et al., 2024)).

3. Implementation challenges and policy implications

Implementing a system that links soil quality to economic value presents clear challenges. Soil heterogeneity is chief among them, as characteristics can vary significantly even within a small areas, making consistent valuation by weight or volume difficult. Moreover, soils are dynamic systems whose quality shifts over time due to management, climate, and natural processes. Any valuation framework would therefore require continuous monitoring and periodic reassessment.

3.1. Economic and market risks

Another concern is land speculation, where investors might purchase land primarily for its soil value rather than for sustainable use. This could inflate prices and further restrict access for small-scale or new farmers. Ethical considerations are also critical: who benefits from soil valuation, and who risks exclusion? For such a system to be equitable, all farmers—regardless of initial soil quality or financial capacity—must have access to the resources and support needed to improve their soils. Otherwise, the system risks widening inequalities, favoring well-resourced farmers while leaving those with fewer means at a disadvantage.

3.2. Integrating soil value into broader environmental governance

For soil to be economically valued in practice, broad market acceptance is essential. Buyers, sellers, and financial institutions would need to adopt this approach, which departs significantly from traditional land assessment methods. Linking land value to soil quality could also make it more vulnerable to fluctuations caused by degradation, extreme weather, or policy shifts, thereby introducing financial risks that may discourage investment. Educational and cultural barriers present further challenges. Many farmers and landowners may not fully grasp the importance of soil health or the available methods to improve it, while deeply rooted traditional practices could foster resistance to new valuation models. Widespread information campaigns and awareness-raising efforts will therefore be critical to ensure stakeholders understand the value of healthy soils and the benefits of sustainable management. Finally, soil health is closely interconnected with water availability, climate regulation, and biodiversity (Lladó et al., 2025). These interdependencies must be considered valuation frameworks to avoid unintended consequences, such as prioritising soil health at the expense of other essential ecosystem functions.

4. Soil is more than a commodity

Soils sold by weight or volume currently fetch modest prices—0.2 EUR per kilogram or litre for fill dirt, 0.3 EUR for gardening topsoil, and 0.4 EUR for potting soil (average prices from ebay.co.uk). Yet these figures reflect only soil's market value as a commodity.

The key challenge of our proposal is to assess soil based on factors beyond fertility and independently of its physical removal from its original location—thereby also accounting for its non-use values. Natural soils, in equilibrium with their environment, delivers ecosystem services most effectively when left undisturbed, especially when not displaced. While cadastral systems already assign soil-related values, aligning them with this broader approach would require correction factors that reflect both soil quality and quantity.

4.1. Quality variation with depth and horizon analysis

Quantifying soil requires information on both bulk density and thickness, ideally for each horizon. Bulk density is relatively easy to measure and, in some cases, already available. For instance, the SoilGrids platform provides global soil density maps derived from over 230,000 soil profiles, using machine learning to generate high-resolution estimates of various soil properties. By contrast, soil thickness is a critical yet largely unknown variable, as its measurement is hindered by technical challenges and high natural variability. Anyway, integrating remote sensing, digital mapping, global databases, and modelling approaches can yield sufficiently reliable estimates of this trait (Pelletier et al., 2016; van der Westhuizen et al., 2024).

However, soil is not a uniform mass from base to surface; it typically consists of multiple horizons with distinct compositions and characteristics. As a result, both quality and value can vary significantly with depth. Identifying a soil by name and referring to a theoretical "typical" profile may serve as a starting point for preliminary assessment, but it is insufficient for a comprehensive evaluation. A thorough appraisal of soil quality requires detailed analysis of each horizon. In particular, topsoil is generally more fertile and provides more ecosystem services than subsoil, owing to its higher organic matter content, greater porosity, and more active biological processes.

When assigning economic value to soil, its services—food and biomass production, life support, water regulation, and carbon sequestration—are clear priorities. Less obvious is whether geotechnical functions, such as bearing capacity for infrastructure, should be included. While crucial for engineers, these properties may be less relevant to environmental valuation, especially since soils can often be engineered for construction, and such conversion usually diminishes ecological and productive functions. Another overlooked dimension is soil's role as a cultural archive, preserving archaeological records that reveal past civilizations and major natural events. This capacity depends on factors like age, pH, oxygen levels, and biological activity (Kibblewhite et al., 2015). Although vital for heritage and identity, this cultural service is often viewed as intangible or secondary in monetary valuation.

Ideally, soil would fulfil all its ecological, economic, and cultural functions equally well. In reality, trade-offs are inevitable, and assigning value requires prioritisation tailored to specific contexts.

Fig. 1. An illustrative image was generated using the AI tool DALL·E 4o (OpenAI) on 15 August 2025 to visually represent the conceptual balance between soil value and economic considerations discussed in this Viewpoint. The prompt used was: "Prepare an extremely realistic photograph, with one arm in the coin container (the currency must not be visible) and a small pile of soil in the other. The photograph must be as realistic as possible." No post-processing was applied other than [cropping/resizing, if applicable]. Its inclusion is intended to support the communication of the article's central message within the broader framework of soil valuation in policy discourse.

4.2. Trade-offs and double counting risks

Soil valuation should consider opportunity costs, as enhancing one function may compromise others. These decisions are context-specific and rest with policymakers, supported by sound technical and scientific frameworks. TEV assessments must also avoid pitfalls: trade-offs arise when competing uses—such as maximizing food production versus conserving soil biodiversity—conflict, while double counting occurs if both intermediate services (e.g., nutrient cycling) and the final services they enable (e.g., crop yield) are valued separately, inflating totals.

5. Conclusions

The goal of resource valuation is to ensure that prices reflect the true costs of extraction, use, and depletion. Assigning an economic value to soil—potentially even on a weight basis, adjusted for quality and function—may seem unconventional, but it could effectively highlight the importance of this finite and diminishing resource. Despite its essential role in sustaining life and ecosystems, soil is often neglected, degraded, or irreversibly lost. Giving soil a tangible value could raise public awareness, improve management, and strengthen conservation. Financial incentives would further motivate land managers to adopt practices that enhance soil health, advancing sustainable approaches, such as regenerative agriculture. Furthermore, land consumption through sealing would be strongly discouraged except where necessary.

Establishing a global price for soil based on both amount and quality is ambitious but feasible, particularly as awareness of soil health grows. Achieving this will require careful consideration of ecological, economic, and ethical dimensions to ensure that valuation benefits both the environment and society. Major challenges remain, e.g., measurement, standardisation, market acceptance, policy support, equity, environmental impacts, and overcoming them will demand coordinated, multidisciplinary efforts backed by strong public engagement.

Ethics and consent

not applicable

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Giacomo Certini: Writing – review & editing, Writing – original draft, Conceptualization. **Gianluca Grilli:** Writing – review & editing, Writing – original draft. **Riccardo Scalenghe:** Writing – review & editing, Writing – original draft, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

No data was used for the research described in the article.

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