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Nature-Based Solution to Man-Made Problems: Fostering the Uptake of Phytoremediation and Low-ILUC Biofuels in the EU

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Abstract

Soil contamination represents a major global environmental threat. Only in the European Union, around 340.000 contaminated sites are inventoried. At the same time, the need to foster the uptake of sustainable biofuels to curb greenhouse gas emissions from the transport sector is one of the pillars of the EU's climate action to achieve the overarching goals set under the European Climate Law and the Renewable Energy Directive. Against this backdrop, nature-based solutions for soil remediation are increasingly being advocated as sustainable options to enhance soil biodiversity while addressing soil contamination in line with the UN Sustainable Development Goals and, in the EU, the European Green Deal and the EU Biodiversity Strategy for 2030. Among several nature-based soil remediation techniques, phytoremediation consists of the use of plants and their associated microbes to stabilise, degrade, volatilise and extract soil pollutants. Furthermore, the non-food biomass generated as a result of phytoremediation could provide a meaningful low Indirect Land Use Change (ILUC) feedstock for the production of advanced biofuels to reduce climate change.
This paper addresses the policy and legal background surrounding the uptake of phytoremediation and recovery of output materials focusing on existing roadblocks currently hampering the full-scale adoption of such a complex yet inherently circular

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value chain. The paper concludes that meaningful steps must yet be taken to properly embed nature-based soil remediation techniques, such as phytoremediation, in the current legal framework and to ensure social ownership of the same to maximise its environmental benefits.

Keywords

European Green Deal – soil pollution – phytoremediation – advanced biofuels – soil strategy

1 Introduction

Soil contamination constitutes a major environmental and climate threat worldwide, as well as in the European Union. European soils are under the threat of sealing, erosion, compaction, pollution, salinisation, carbon loss and various effects of climate change (e.g. droughts, fires, storms, floods).[1] Against the long-standing dreadful accounts of the breadth of contamination across the European Union, unsuccessful attempts have been put in place to achieve a good quality status of soils ever since the notorious Soil Framework Directive was withdrawn in 2014.[2] Major pitfalls stand in the way to the adoption of a comprehensive EU governance framework dealing with soil protection to ensure that both its environmental and biodiversity potentials, as well as its positive climate change contribution as a carbon sink can be enhanced.[3] Effective soil governance is a key element to ensure that the EU lives up to

1 *European Environment Agency*, The European environment – state and outlook 2020, 2019 p. 115. The issue of widespread desertification was recently flagged by the European Court of Auditors, which pointed to the risk of 25% of land in Southern and Eastern Europe being at risk of desertification. See *European Court of Auditors*, Special Report n.33/2018: Combating Desertification in the EU: A growing threat in the need for more action, 2018.

2 See *M. Petersen*, European Soil Protection Law after the Setback of December 2007 – Existing Law and Outlook, EEELR 2008 (3) p. 146, 148 et seq.; more recently, see *S. Ronchi et al.*, Policy analysis for soil protection among the EU member states: A comparative analysis, 2019 82 Land Use Policy, pp. 763–780.

3 See recently, *I. Heuser*, Soil Governance in current European Union Law and in the European Green Deal, 2022 6 Soil Security, 100053. For an overview of the international framework related to soil protection from an ecosystem functions standpoint, see *M. Fermeglia*, Soil Functions and Soil Protection in the Era of Climate Change: A Multilevel Perspective, in L. Westra, K. Bosselmann and V. Zambrano (eds.), Ecological Integrity and Land Uses, 2019, p. 39–56.

its international commitments under the UNCBD and the UNCCD and other voluntary initiatives – such as the 4 per 1000 initiative adopted in the wake of UNFCCC COP21[4] – to achieve a land degradation-neutral world by 2050 thus protecting soil biodiversity while increasing carbon sinks.[5] Such commitments are in line with the achievement of several UN Sustainable Development Goals (foremost, SDGs no. 7, 13 and 15).[6] Moreover, soil protection has been embraced as one of the key challenges in the European Green Deal, the EU 8th Environmental Action Programme as well as the EU Research and Innovation Missions, thus channelling a great deal of financial resources to advanced techniques for remediation and enhanced soil quality.[7]

At the same time, the EU is stepping up its action to address greenhouse gas (GHG) emissions from all relevant sectors, notably the transport sector.[8] The transport sector currently accounts for approximately 27% of the total GHG emissions in the EU.[9] To this end, an increasingly ambitious policy addressing the use of sustainable biofuels in both the ground, maritime and aviation transport is expected under the Fit for 55 package implementing the commitments under the EU Climate Law and the European Green Deal.[10]

4 On the initiative, see *A. Chabbi et al.*, Aligning Agriculture and Climate Policy, 2017 7 Nature Climate Change, 307–309; *B. Minasny et al.*, Soil carbon 4 per mille, 2017 292 Geoderma, pp. 59–86.

5 See *I. Hannam*, Soil governance and land degradation neutrality, 2022 6 Soil Security, 100030 and, for a more critical outlook, *M. Raffelsiefen & T. Strassburger*, The Protection of Soil: Does the European Union Live up to Its Own Ambitions?, in: H. Ginzky et al. (eds.), International Yearbook of Soil Law and Policy, 2017, p. 389, 408.

6 See *R. Lal*, Soil degradation as a reason for inadequate human nutrition, 2009 1 Food Security, pp. 45–57; *J. Bouma et al.*, The challenge for the soil science community to contribute to the implementation of the UN sustainable development goals, 2019 35(4) Soil Use Management, pp. 538–546.

7 Commission Communication, The European Green Deal, COM(2019) 640 final, p. 14; Parliament and Council Decision 2022/591/EU on a General Union Environment Action Programme to 2030, Article 2(2); Commission Communication on European Missions, COM(2021) 609 final. See *L. Montanarella & P. Panagos*, The relevance of sustainable soil management within the European Green Deal, 2021 100 Land Use Policy, 104950.

8 See, among others, the Commission Communication, A Clean Planet for All, COM(2018) 773 final, at 10 ff.; Commission Communication, Stepping up Europe's 2030 climate ambition Investing in a climate-neutral future for the benefit of our people, COM(2020) 562 final.

9 See EEA, Greenhouse Gases emissions from transport in Europe, available at/www.eea.europa.eu/ims/greenhouse-gas-emissions-from-transport.

10 See Parliament and Council Regulation (EU) no. 2021/1119 European Climate Law and the Communication COM(2020) 562 final (supra n 8), at 8. See also the ReFuelEU Initiative under the Fit for 55 package with regard to sustainable aviation fuels, currently tabled by the Commission in its Proposal for a Regulation COM(2021) 561. With specific regard to the transport sector, see the Commission Communication, A European Strategy for Low-Emission Mobility, COM(2016) 501 final.

More specifically, the EU has set specific targets for the use of biofuels as part of the revision of the Recast Renewable Energy Directive (RED II).[11]

Both major objectives are, therefore, pivotal aspects of the broader framework of the EU environmental and climate action as it envisages at the same time the achievement of net-zero pollution in the EU by 2050 and massive transformational changes in all GHG-emitting sectors.[12] In addition, the adoption of a new European Soil Strategy in 2021, which pursues soil health restoration and protection while embracing soil as a key climate mitigation and adaptation solution, marked a new and ambitious phase in the EU's approach to soil governance.[13]

Where soil remediation is key to enhance soils' resilience against climate change, foster climate change mitigation and reduce overall pollution, at the same time the advancement of biofuels entail complex land-energy trade-offs as part of the broader water-food-energy nexus.[14] In particular, the issue of Indirect Land-Use Change (ILUC) stands out as a delicate one as the deployment of food-based crops for biofuels could result in land takes, soil degradation, monocultures both within and outside the EU.[15] The EU has already been exposed to severe criticism in relation to its outsourcing of GHG emissions through the importation of biofuels as well as to the increasing rate of internal land carbon footprint, namely the reduced carbon storage capability of soils and vegetation due to biomass feedstock production.[16]

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11 Parliament and Council Directive 2018/2001/EU on the promotion of the use of energy from renewable sources (RED II).

12 See Commission Communication, A Clean Planet for All (*supra* note 8); Commission Communication, Pathway to a Healthy Planet for All EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil, COM(2021) 400 final.

13 Commission Communication, A Soil Strategy for 2030, COM(2021) 699 final. See also *P. Panagos & L. Montanarella*, Soil thematic strategy: An important contribution to policy support, research, data development and raising the awareness, 2018 (5) Current Opinions in Environmental Sciences and Health, pp. 38–41.

14 See *IPCC*, Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems, 2019; *Sustainable Development Solutions Network* (*SDSN*) *and Fondazione Eni Enrico Mattei* (*FEEM*), Roadmap to 2050: The Land-Water-Energy Nexus of Biofuels, 2021.

15 See, for an empirical account of the transnational impacts of EU's biofuels policy, *T. Bicalho et al.*, Land use change within EU sustainability criteria for biofuels: The case of palm oil expansion in the Brazilian Amazon, 2016 89 Renewable Energy, pp. 588–597.

16 See the heavy criticism brought forward by *T. Searchinger et al.*, Europe's Land Future? Opportunities to use Europe's land to fight climate change and improve biodiversity – and why proposed policies could undermine both, 2022.

Against this background, far-reaching solutions that would ensure both the protection of the precious – and hardly restorable once lost – ecosystem functions of soils while ensuring low-ILUC feedstocks to reduce GHG emissions from the transport sector in a truly holistic manner are needed. In this respect, increasing attention is being paid to the adoption of *nature-based solutions* (NBS) over traditional, anthropocentric approaches to nature restoration.[17] NBS are defined as "actions to protect, sustainably manage and restore natural or modified ecosystems, that address societal challenges (e.g., climate change, food and water security or natural disasters) effectively and adaptively, simultaneously providing human well-being and biodiversity benefits".[18]

This paper advocates for the use of NBS for soil remediation, and more specifically *phytoremediation* of contaminated soils, also as combined with the generation of non-food, low-ILUC feedstock for conversion to advanced biofuels. More specifically, it will analyse the current policy and legislative framework in the EU addressing the adoption of unconventional soil remediation techniques throughout the production of sustainable biofuels to identify specific conducive elements and roadblocks to overcome regulatory silos, thus advancing both the European Green Deal's key objectives and the UN SDGs in the EU.

The article is structured as follows. Section 2 outlines phytoremediation as a NBS for soil remediation while underscoring both its environmental, social and economic benefits also as combined with its use for biofuels conversion. Section 3 charts the current policy and legislation framework under the European Green Deal as relevant for the adoption of phytoremediation and its feedstock conversion. Section 4 delves into specific legal issues entailed in the current EU framework to appraise the existing loopholes with regard to low-ILUC biomass for biofuels production. Section 5 concludes.

17 See *European Environment Agency*, Nature-based solutions in Europe policy, knowledge and practice for climate change adaptation and disaster risk reduction, 2021; *European Commission, Directorate-General for Research and Innovation*, Evaluating the impact of nature-based solutions: a summary for policy makers, 2021; *Id.*, The vital role of nature-based solutions in a nature positive economy, 2022. See also *K. Mrunalini et al.*, Nature Based Solutions in Soil Restoration for Improving Agricultural Activities, 2022 33(8) Land Degradation & Development, pp. 1269–1289.

18 This is the definition adopted by the Resolution 69, 2016 IUCN World Conservation Congress, Hawaii, USA. For an in-depth analysis of NBS' role for environmental and climate policy, see *N. Seddon et al.*, Nature-based Solutions in Nationally Determined Contributions: Synthesis and recommendations for enhancing climate ambition and action by 2020, 2019.

2 Phytoremediation as a Viable Nature-Based Solution for Soil Remediation and Biofuels Production

Against the need to achieve and maintain soils' good ecological status, the decision regarding the remediation strategies and techniques to be adopted is all but negligible. Soil is a complex system. According to FAO, "it may take hundreds to thousands of years to form one centimeter of soil from parent rock, but that centimeter of soil can be lost in a single year through erosion".[19] On the one hand, soil pollution negatively affects ecosystem services and human and environmental health and presents an emerging threat to food safety. On the other hand, soil remediation aims to remove contamination but does not necessarily ensure full ecological restoration of soil ecosystems. To restore degraded ecosystems includes a continuum of restorative activities:
– reduced societal impacts
– remediation
– rehabilitation
– ecological restoration.[20]

As opposed to conventional, anthropic means of dealing with soil remediation (e.g., by excavation), the European Commission has endorsed the definition of nature-based solutions as "[S]olutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring additional and more diverse natural features and processes into cities, landscapes and seascapes through locally adapted, resource-efficient and systemic interventions."[21] The use of NBS has finally been acknowledged internationally by the UN General Assembly and in the recent UNFCCC COP27 negotiations.[22]

Among the array of NBS for soil remediation, *phytoremediation* is defined as the "bioremediation of contaminated soils by using plants or crops, applicable for the removal or degradation of organic and inorganic pollution in soil, water

19 See FAO, Five reasons why soil is key to the world's sustainable future, available at:/www.fao.org/sustainable-development-goals/news/detail-news/en/c/277113/.

20 *G. D. Gann et al.*, International principles and standards for the practice of ecological restoration, Second edition. Restoration Ecology, 2019, p. 21.

21 See European Commission, *Directorate-General for Research and Innovation*, Nature-Based Solutions, available at/research-and-innovation.ec.europa.eu/research-area/environment/nature-based-solutions_en.

22 See the United Nation Environment Programme Resolution UNEP/EA.5/Res.5 and the COP27 Cover Decision (Decision -/CP27). See also the multi-stakeholder ENACT Initiative jointly launched by IUCN and the COP27 Egyptian Presidency to foster the uptake of NBS (see link:/cop27.eg/assets/files/initiatives/ENACT-BR-01-EGY-10-22-EN.pdf).

and air".[23] It thus constitutes a *in situ*,[24] environmentally sustainable[25] soil remediation technique.[26]

Phytoremediation comprises different applications: phytoextraction, phytostabilisation, phytovolatilisation, phytodegradation and rhizodegradation. The choice of phytoremediation application largely depends on the kind of contaminants to be addressed and the site-specific soil characteristics.[27] *Phytoextraction* leads to the accumulation of pollutants in harvestable biomass.[28] Phytoextraction is by far the most deployed technique, and is deemed reliable for addressing inorganic contamination, such as metals and metalloids (Cd, Ni, Cu, Zn, Pb, As) and organic contamination. Plants that accumulate metals often have to be harvested.[29] *Phytostabilisation* is not a clean-up technology of contaminated soils *per se*, but rather a mechanism that stabilises and limits potentially toxic contaminants.[30] *Phytovolatilization* refers to the process in which plants and their microorganisms take up, transport and volatize contaminants through transpiration.[31] Where both phytodegradation and rhizodegradation rely on contaminants' degradation, in phytodegradation it occurs in the plant, while in rhizodegradation it occurs in the rhizosphere, thus outside the plant.[32]

Adopting phytoremediation to cleanup contaminated soil entails advantages and disadvantages. Whilst conventional remediation normally operates on relatively short timeframes, phytoremediation requires a long-standing, natural process. Therefore, phytoremediation is advised only if soil contamination is moderate and spreads across a sizable plot of land;

23 See *B. Vanheusden*, Phytoremediation and the Legal Study of Soil, Animals and Plants, In: Steier, G., Patel, K. (eds) International Farm Animal, Wildlife and Food Safety Law, 2017, p. 576.

24 *M. Khan et al.*, In Situ Phytoremediation of Metals in B. R. Shlaefsky (eds.), Phytoremediation In-situ Applications, 2022, p.103.

25 *B. Nedjimi*, Phytoremediation: a sustainable environmental technology for heavy metals decontamination, SN Appl. Sci. 3, 2021, p.1.

26 *P.E. Gratão et al.*, Phytoremediation: green technology for the clean up of toxic metals in the environment, Brazilian Journal of Plant Physiology, 2005, p.54.

27 See *B. Vanheusden* (*supra* note 23).

28 *V.-Net. Edgar et al.*, Plant Biomass Derived from Phytoremediation of Potential Toxic-Metal-Polluted Soils to Bioenergy Production and High-Value by-Products – A Review. Appl. Sci. 2021, p. 2.; See also *J. Sumanet al.*, Phytoextraction of heavy metals: A promising tool for clean-up of polluted environment? Front. Plant Sci. 2018, 9, p. 1476.

29 *OVAM*, Phytoremediation Code of Good Practice, 2019, pp. 19–20.

30 See *J. Vangronsveld*, Phytoremediation of contaminated soils and groundwater: lessons from the field, Environ Sci Pollut Res, Springer-Verlag, 2009, p. 2.

31 *OVAM*, Phytoremediation Code of Good Practice, 2019, pp. 8–9.

32 *Id.*, p. 18.

whereas conventional soil remediation should be preferred for severe and large-scale contamination. Unlike conventional remediation techniques such as excavation, however, phytoremediation carries the benefit of avoiding the displacement of contamination from one site to another, thus preventing secondary contamination.[33] In addition, as compared to conventional techniques, phytoremediation is more cost-effective, less invasive on the soil ecosystem, more socially accepted and more conducive to the reconversion of the remediated soils as arable land for agricultural purposes.[34]

Relevant phytoremediation entails major advantages compared to conventional remediation techniques from an ecosystem services perspective. Physical remediation may cause irreversible damage to natural ecosystems by removing large amounts of soil and the replacement with soil which is not suitable for the native ecosystem.[35] Physical remediation could lead to further degradation.[36] Chemical remediation poses the risk of pollution of chemical reagents.[37] Differently, phytoremediation increases soils' ecosystem services while leading to soil remediation.[38] Bearing in mind the reciprocal feedback loops between biodiversity loss and climate change impacts; however, phytoremediation should foremost be deployed using native species in order not to endanger already affected biodiversity. Native species are strongly recommended due to their capability to adapt to the local climate condition, to survive, grow and not present a threat to biodiversity.[39]

The choice among the above available phytoremediation techniques crucially depends on the kind of soil contaminants to be addressed. Contamination can be of organic or inorganic origin (such as heavy metals).[40]

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33 *E.T. Alori et al.*, Bioremediation techniques as affected by limiting factors in soil environment, Front. Soil Sci., 2022, p. 2.

34 *H. Farraji et al.*, Advantages and disadvantages of phytoremediation: A concise review, Int J Env Tech Sci, 2016, p. 69.

35 *J. Burger*, The effect on ecological systems of remediation to protect human health, Am J Public Health. 2007, pp. 1572–1573.

36 *Id.*

37 *D. Teng et al.*, Describing the toxicity and sources and the remediation technologies for mercury-contaminated soil, RSC Adv., 2020, p. 23230.

38 *A. Burges et al.*, From phytoremediation of soil contaminants to phytomanagement of ecosystem services in metal contaminated sites, International Journal of Phytoremediation, 20:4, 2018, p. 391.

39 *B. Heredia et al.,* Phytoextraction of Cu, Cd, Zn and As in four shrubs and trees growing on soil contaminated with mining waste, Chemosphere, Volume 308, Part 2, 2022, p. 8. See also *G. Gajić at el.*, Ecological Potential of Plants for Phytoremediation and Ecorestoration of Fly Ash Deposits and Mine Wastes, Front. Environ. Sci., 2018, p. 124.

40 *R. Singh, et al.*, Heavy metals and living systems: An overview. Indian Journal of Pharmacology, 2011, pp. 246–253.

Only phytoextraction and phytostabilisation are considered reliable for the remediation of contaminated soils by heavy metals.[41] Yet, all phytoremediation applications follow a step-wise approach. First, the relevant plants/crops must be selected for phytoremediation. Second, the selected plants/crops must be sewed and harvested up to the desired contaminants extraction/stabilization/degradation capability. Third, and only in the case of phytoextraction the output materials must be duly managed and processed. Notably, the phytoextraction's output materials can be utilized for different purposes as biomass feedstock. In this respect, a promising use of phytoextraction's output materials consists in its conversion for advanced drop-in biofuels, such as biogasoline. Advanced biofuels are defined as biofuels produced out of specific feedstock listed in Annex IX of the RED II, including wastes, residues, co-products and some selected primary products, yet overall guaranteeing a meaningful GHG savings through their life-cycles.

Generating low-ILUC biofuels from phytoremediation's output materials, therefore, provides for both environmental and climate benefits as the remediated arable land is disposable for agricultural purposes, where contaminated feedstock unsuitable for food or feed production will be used to reduce the overall GHG impact of the transport sector, thus contributing to the EU's objectives under the RED II, as we shall explain further in the following Section.

3 The Policy and Legal Framework for Nature-Based Soil Remediation Solutions Under the EU Green Deal

Upscaling and deploying phytoremediation techniques faces manifold legal obstacles arising along all the above-mentioned steps from the crops' selection down to the output materials conversion as biofuels.[42] Overall, the European Green Deal aims to "transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use" while pursuing a net-zero pollution vision for mid-century.[43] The achievement of the EGD's objectives is therefore closely tied

41 *M. Laghlimi et al.*, Phytoremediation Mechanisms of Heavy Metal Contaminated Soils: A Review, Open Journal of Ecology, 2015, 375.

42 See *B. Vanheusden* (*supra* note 23).

43 Commission Communication, The European Green Deal, COM(2019) 640 final, p. 2.

to sustainable soil management.[44] The EGD underpins nature-based solutions as an environmentally sound tool to address climate change and provide a source of renewable energy and a pathway towards decarbonisation.[45] Phytoremediation as a plant-based remediation technology could become one of the building blocks of the EGD. In this Section, an array of policy and legislative regimes will be analysed as related to soil governance and biofuels generation, which encompass the deployment of low-ILUC feedstock from nature-based soil remediation.

3.1 *EU Biodiversity Strategy for 2030*

The EU's Biodiversity Strategy for 2030 is a comprehensive, ambitious and long-term plan to protect nature and reverse the degradation of ecosystems.[46] It encompasses soil biodiversity as a crucial element for the global food system.[47] Shifts in soil biodiversity influence the performance of broader ecosystem functions: plant diversity, recycling of nutrients, food web properties, carbon sequestration, and organic matter.[48] Yet, a major challenge is to improve food yields without exceeding the capacity of ecosystems.[49] As explained above, remediation of contaminated soils through phytoremediation will bring an impulse of life to biodiversity; namely, it will maintain and eventually increase soils biodiversity and ecosystem functions.[50]

The EU Biodiversity Strategy calls for the investigation and identification of contaminated sites, restoring degraded soils, defining the conditions for their good ecological status, introducing restoration objectives, and improving the monitoring of soil quality.[51] In this respect, it welcomes the adoption of phytoremediation strategies inasmuch as they can provide long-term net biodiversity gains.[52]

44 *L. Montanarella & P. Panagos*, The Relevance of Sustainable Soil Management Within the European Green Deal, Land Use Policy, 2021, p. 1 and *P. Panagos et al.*, Soil priorities in the European Union, 2022 29 Geoderma 00510.

45 See *European Commission, Directorate-General for Research and Innovation* (*supra* note 17).

46 Commission Communication, EU Biodiversity Strategy for 2030 – Bringing Nature Back into Our Lives, COM(2020) 380 final.

47 Id.

48 *C. Wagg et al.*, Soil biodiversity and soil community composition determine ecosystem multifunctionality, Proc Natl Acad Sci U S A, 2014, pp. 5266–5267.

49 *WWF*, Farming with Biodiversity Towards nature-positive production at scale, WWF International, Gland, Switzerland, 2021, p. 6.

50 *C.S. Rocha et al.*, Phytoremediation by ornamental plants: a beautiful and ecological alternative. Environ Sci Pollut Res 29, 2022, p.3340.

51 Commission Communication (*supra* note 46), p. 9.

52 *L. Montanarella & P. Panagos* (*supra* note 44).

3.2 *EU Soil Strategy for 2030*

The EU Soil Strategy for 2030 has replaced the 2006 Soil Thematic Strategy to reflect a higher degree of ambition and implement the medium and long-term EGD's objectives.[53] Unlike the 2006 Soil Strategy, the Soil Strategy for 2030 embraces soil health instead of soil quality, thus adopting a holistic approach to soil's biotic community and soil functions.[54] The Soil Strategy for 2030 defines soil health as "good chemical, biological and physical condition", as related to soils' capability to provide several ecosystem services, such as:

- Provide food and biomass production, including in agriculture and forestry;
- Absorbing, storing and filtering water and transform nutrients and substances, thus protecting groundwater bodies;
- Providing the basis for life and biodiversity, including habitats, species and genes;
- Acting as a carbon reservoir;
- Providing a physical platform and cultural services for humans and their activities;
- Acting as a source of raw materials.[55]

Warning data point out that 60–70% of soils in Europe would be deemed as unhealthy according to the above Soil Strategy definition.[56] To the above end, a proposal for a EU Soil Health Law is ongoing with the aim to adopt a comprehensive approach to soil management and protection, arguably including nature-based remediation activities.[57]

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53 Commission Communication, EU Soil Strategy for 2030, COM(2021) 699 final.

54 *D. E. Stott, B. N. Moebius-Clune*, Soil Health: Challenges and Opportunities in D.J. Field et al. (eds.), Springer International Publishing Switzerland, 2017, p.113, Global Soil Security, Progress in Soil Science.

55 Commission Communication (*supra* note 53), p. 4. For an analytical account of soil health indicators, see EEA, Soil Monitoring in Europe – Indicators and thresholds for soil health assessments, EEA Report no. 08/2022, 2023.

56 European Commission, Caring for soil is caring for life Ensure 75% of soils are healthy by 2030 for food, people, nature and climate, Report of the Mission Board for Soil health and food, 2020, p. 5.

57 The legislative proposal was submitted to public consultation between August 1 and October 24, 2022. See https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13350-Soil-health-protecting-sustainably-managing-and-restoring-EU-soils_it. A key role in the development of the EU Soil Health Law, as well as more broadly for the implementation of the EU Soil Strategy for 2030 is being played also by the EU Soil Observatory in terms of policy monitoring, providing a multi-stakeholder forum, integration of national and EU soil monitoring systems and support to Horizon Europe Research and Innovation programmes (see *P. Panagos et al.*, *supra* note 52).

3.3 *Farm-to-Fork Strategy*

The Farm to Fork (F2F) strategy is underscored as a core policy pillar of the EGD. The F2F aims to enhance more sustainable soil management, in order to secure a healthy food system.[58] In the F2F strategy, attention is paid to agriculture as one of the major contributors to pollution and GHG emissions in the EU.[59] The F2F strategy promotes sustainable agricultural practices to the overall objective of at least 25% of organic farming across the EU's agricultural land by 2030.[60] Carbon farming is recognized as an enabler of nature-based solutions also in light of the broader objectives of the EU Climate Adaptation Strategy and the vision for healthy soils embraced in the 2021 EU Soil Strategy.[61] Several initiatives are being put in place to support carbon farming, ranging from direct financial support for implementation (through the CAP, cohesion funds) and R&I (through Horizon Europe clusters), to capacity-building tools (through the European Climate Pact) and pilot demonstrators of carbon farming practices (through the Soil Living Labs under the mission "A soil deal for Europe").[62] Although the main concentration of F2F lies in food crops, attention is paid to producing renewable energy from agricultural waste and residues.[63] Legislation adopted under the F2F strategy shall take nature-based soil remediation techniques into account by encompassing them as agricultural activities, inasmuch as they consist of analogous techniques albeit serving a slightly different purpose.[64] This, as coupled with support for

58 Commission Communication A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system, COM(2020) 381 final, p. 1.

59 See FAO, CIRAD and European Commission, Food Systems at risk: new trends and challenges, 2019, p. 63.

60 Commission Communication (*supra* note 58), p. 11.

61 In December 2020, the European Commission released pointed recommendations on the Member States Common Agricultural Policy Strategic Plans to promote carbon farming, coupled in 2021 with a technical guidance handbook for the deployment of carbon farming mechanisms. See Commission Communication, Recommendations to the Member States as regards their strategic plan for the Common Agricultural Policy, COM(2020) 846 final; *European Commission, Directorate-General for Climate Action*, Setting up and implementing result-based carbon farming mechanisms in the EU: technical guidance handbook, 2021.

62 All the information about the Soil Living Labs is available at the following webpage of the Soil Mission Support:/www.soilmissionsupport.eu/ll-lh.

63 Commission Communication (*supra* note 58), p. 8.

64 See Article 2(c) of the Council Directive 86/278/EEC on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture, OJ L 181, 4.7.1986, pp. 6–12.

organic farming and overall low-carbon farming techniques, could provide an adequate framework to address the food vs fuels tradeoff.[65]

3.4 *Sustainable Carbon Cycles*

The need to foster the carbon cycle by enhancing carbon sinks is key to several objectives of the EGD and the UN SDGs.[66] In December 2021, the European Commission issued a Communication on Sustainable Carbon Cycle with a view to scale up carbon farming and other techniques aimed to store, recycle and capture carbon dioxide.[67] The Communication stresses the importance of circular approaches to carbon flows, for example, by recycling carbon from waste streams through sustainable biomass and the production of synthetic sustainable fuels.[68] Moreover, the role of carbon removals is underscored to offset GHG emissions stemming, among others, from land use and livestock.[69] One of the most relevant pillars of this policy is carbon farming. Carbon farming includes all farming activities that result in increased carbon sequestration from soils and biomass.[70] Two enlisted carbon farming techniques stand out as particularly relevant for the deployment of phytoremediation. First, those that aim at "protecting soils, reducing soil loss by erosion and enhancing soil organic carbon on degraded arable land".[71] Second, those aimed at restoration of peatlands and wetlands to increase the potential for carbon sequestration.[72]

The importance of remediated soils is moreover relevant in the Carbon Cycles Communication from the perspective of carbon removals certification.[73] In this respect, a proposal for a Regulation on certification of carbon removals has been put forward by the Commission, which includes both technology-based and nature-based solutions aimed to enhance soil organic carbon contents

65 *G. Monbiot*, 2004. Feeding Cars, Not People. The Guardian, 23 November 2004. Available from:/www.monbiot.com/2004/11/23/feeding-cars-not-people/ citing in *J. Tomei, R. Helliwell*, Food versus fuel? Going beyond biofuels, Land Use Policy, Volume 56, 2016, p. 321.

66 See *D. Reichle*, Carbon, climate change and public policy in *D. Reichle*, The Global Carbon Cycle and Climate Change, 2020, pp. 253–287.

67 Commission Communication, Sustainable Carbon Cycles, COM(2021) 800 final.

68 *Id.*

69 *Id.*

70 *Id.*, p. 3.

71 *Id.*, p. 5.

72 *Id.* The potential negative impact of certain carbon farming techniques on biodiversity is however controversial. See *Ecologic Institute and Institute for European Environmental Policy*, Carbon farming co-benefits: Approaches to enhance and safeguard biodiversity, 2023.

73 Commission Communication (*supra* note 67), p. 19.

and pursue agroforestry.[74] While certification is fraught with implementation challenges – e.g., on Monitoring, Reporting and Verification against the risk of non-permanence and reversibility of restored soils[75] – the proposal will certainly benefit the marketability of phytoremediation of contaminated soils inasmuch as it provides for increased carbon sequestration capacity for soils and sustainable biofuels production. This mechanism will moreover play out in the broader context of the global carbon market to be established under Article 6.4 of the UNFCCC Paris Agreement.[76]

3.5 *Biofuels Production*

The general backlash against biofuels in the EU is primarily due to controversies around the sustainability of food-crop-based biofuels.[77] A recent study commissioned by the European Commission highlights the risks posed by food-feedstock for conventional biofuels as the growing demand for biofuels in the transport sector could lead to detrimental yields and uncontrolled agricultural areas.[78] For example, land-use change-related GHG emissions from palm oil eliminate all GHG emission savings of fuels produced from this feedstock in comparison to the use of fossil fuels.[79] The resulting justified skepticism and indecisiveness by consumers in turn hampers the development of better performing biofuels upstream.

Considering the important role played by fuel consumers in steering the production patterns of fuels under mandate schemes, more dedicated regulation on the downstream chain is needed to streamline the supply chain. The RED II sets national targets and limits for the contribution of biofuels towards the EU-wide objectives on renewable energy share.[80] Specific (and increasing) targets are set, among others, for the deployment of advanced

74 Commission Proposal for a Regulation establishing a Union certification framework for carbon removals, COM(2022) 672 final.

75 See *European Environmental Bureau*, Certification of Carbon Removals – EEB Policy Recommendations, 2022.

76 See *UNFCCC*, Draft Recommendation: Requirements for the development and assessment of mechanisms methodologies pertaining to activities involving removals, A6.4-SB002-AA-A05. See also *B. Müller & A. Michaelowa*, How to operationalize accounting under Article 6 market mechanisms of the Paris Agreement, 2019 19(7) Climate Policy, pp. 812–819.

77 See *T. Searchinger et al.* (*supra* note 16).

78 Commission Report on the status of production expansion of relevant food and feed crops worldwide, COM(2019) 142 final.

79 *Id.*

80 Article 26(1) RED II.

biofuels in the transport sector.[81] A general objective of gradually phasing out biofuels and bioliquids with high ILUC-risk is planned by 2030.[82]

4 The Legal Framework for Phytoremediation Techniques and Biofuels Production in the EU

As noted in Section 3, several policy silos bear relevance for the full deployment of nature-based soil remediation as a source of non-food biofuels feedstock. When looking at the current EU legislative framework however, several pointed issues arise, which unfold a patchy and often conflicting regime, as outlined in this Section.

4.1 *EU Soil Legislation*

The EU legal framework on soil relies on a patchwork of legislation aimed to achieve soil quality as part of the general objective of ensuring a high level of protection of the environment pursuant to Article 191(2) TFEU, yet still not at a sufficient level.[83] The current EU legislative framework dealing directly or indirectly with soil protection comprises approximately 39 pieces of legislation, with over 50 different provisions.[84] The majority of such provisions, however, are neither binding nor explicitly referring to soil protection as its primary objective. Therefore, soil protection is rather seen as "a tool to achieve other environmental objectives or as a secondary issue which is to be integrated into the formulation of other environmental policies".[85] Against this backdrop, a EU comprehensive soil health legislation is advocated.[86] Such legislation shall set holistic objectives to achieve overall good soil quality status while addressing sustainable soil management and setting specific ecological requirements for soils, soil quality monitoring mechanisms and soil remediation/prevention measures.[87]

81 Article 25 RED II.

82 Article 26(2) RED II.

83 See *C. Olazábal*, Overview of the Development of EU Soil Policy: towards a EU Thematic Strategy for Soil Protection, Journal for European Environmental and Planning Law, 2006, p. 186; *I. Heuser* (*supra* note 3), p. 2.

84 *A. Frelih-Larsen et al.*, Updated Inventory and Assessment of Soil Protection Policy Instruments in EU Member States. Final Report to DG Environment, 2017.

85 *S. Paleari*, Is the European Union protecting soil? A critical analysis of Community environmental policy and law, Land Use Policy, Volume 64, 2017, p. 163.

86 See *H.H. Janzen et al.*, The "soil health" metaphor: illuminating or illusory? 2021 10 Soil Biology and Biochemistry, 10167.

87 See *German Environmental Agency*, The Need for Soil Protection Legislation at EU Level, Position Paper, October 2018 and *P. Panagos et al.* (*supra* note 44).

The EU Soil Strategy for 2030 envisages the adoption of a EU Soil Health Law.[88] The Soil Health Law shall aim to:

- Specify the conditions for a healthy soil;
- Determine options for monitoring soil conditions;
- Lay out rules conducive to sustainable soil use and restoration.[89]

Although there is still no piece of blueprint of the Soil Health Law, particular insights and directions are provided by the EU Soil Strategy. For instance, the issue of ensuring full separation between clean and contaminated excavated contaminated will be addressed, as well as net land-take.[90] Phytoremediation clearly presents a valuable option to mitigate and reduce pressure on land-take and soil sealing by converting contaminated land into productive land. Oppositely to "spoiling greenfields", phytoremediation leads to soil redevelopment in an ecological and environmentally sustainable perspective.[91] Moreover, part of the Soil Health Law will be dedicated to sustainable soil management.[92] Thanks to its characteristic as a regenerative practice, phytoremediation may strongly contribute to enhance and maintain soil health if adopted as an integral process within the soil management framework under the Soil Health Law.

Yet, as recent literature explains, one of the major obstacles to the full upscaling of sustainable soil management practices resides in the legislative regulations concerning private land use to achieve soil protection.[93] A major argument against a common soil legislation is that it would also affect property issues, which fall within the competence of the Member States.[94] It is thus clear that a EU-wide approach to soil health and soil protection would help creating a system of values leading to conceptual change concerning the relationship between the free movement of capital, land ownership and soil protection.[95]

88 See Commission Communication (*supra* note 53).

89 See Id. all the information about the proposal at the following link:/ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13350-Soil-health-protecting-sustainably-managing-and-restoring-EU-soils_en.

90 Commission Communication, (*supra* note 53), p. 8.

91 *J. B. Eisen*, Brownfields Policies for Sustainable Cities, Duke Environmental Law and Policy Forum, 1999, p. 189.

92 Commission Communication (*supra* note 53), p. 14. See also *L. Montanarella and P. Panagos* (*supra* note 44), p. 1, in turn referring to *FAO*, Voluntary Guidelines for Sustainable Soil Management, 2017.

93 See *P. Stankovics et al.*, The interrelations of land ownership, soil protection and privileges of capital in the aspect of land take, 2020 99 Land Use Policy, p. 105071.

94 Id.

95 See *I. Heuser* (*supra* note 3).

4.2 *Waste Legislation*

Since the ultimate purpose of phytoextraction strategies is to absorb or stabilise contaminants into what could become harvestable biomass, in many cases its output materials could include a non-negligible degree of contamination. The status of phytoremediation's feedstock as waste under the Waste Framework Directive comes thus into play as a key to understand the potential future role of phytoremediation uptake through a value chain leading to biofuels production downstream. The definition of waste under Article 3 WFD includes both subjective and objective elements.[96] Of particular importance is the notion of "discard", which as interpreted by the CJEU broadly in light of the precautionary principle and the principle of preventive action pursuant to Article 191(2) TFEU encompasses both recovery and disposal of a substance or object.[97] Hence the definition of by-product is laid down in Article 5(1) WFD is relevant here as including "a substance or object resulting from a production process the primary aim of which is not the production of that substance or object is considered not to be waste, but to be a by-product".[98] Such definition if further operationalized under four conditions, which must be met cumulatively: (a) further use of the substance or object is certain; (b) the substance or object can be used directly without any further processing other than normal industrial practice; (c) the substance or object is produced as an integral part of a production process; and (d) further use is lawful, i.e. the substance or object fulfils all relevant product, environmental and health protection requirements for the specific use and will not lead to overall adverse environmental or human health impacts.[99]

The process entailed in the recovery of phytoremediation's feedstock to produce biofuels is inherently circular and aims to avoid disposal in line with the WFD's waste hierarchy. In the case of phytoremediation, the creation of a value chain for re-use of output materials clearly speaks for both the certainty of further use and for its integration in another production process, which will lead to clear financial gains.[100] The requirement related to the compliance

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96 See Article 3 of the Parliament and Council Directive 2008/98/EC on waste and repealing certain Directives, OJ L 312, 22.11.2008, p. 3–30 (WFD).

97 See Case C-624/17, Criminal proceedings against Tronex BV [2019], para. 18.

98 Article 5(1) WFD.

99 Id.

100 Case C-113/12, Reference for a preliminary ruling from Supreme Court (Ireland), Donal Brady v Environmental Protection Agency [2012], para. 44. See also the eloquent opinion of AG Medina in the Porr Bau case: "I consider it important that the Court also adopts a dynamic understanding of how regular a certain by-product is supplied as such by an undertaking, which is not, by the way, a condition expressly established by Article 5(1) of Directive 2008/98. Even if a material were not provided on a regular basis as a

with normal industrial practice is probably the most problematic aspect since recovery operations are in principle excluded. As clarified by the European Commission, however, the product may well be dried, washed, filtered, and modified in shape and size; and, it is allowed as well to add materials necessary for further use or to carry out quality control.[101] Importantly, all the above considerations seem in line with the consolidated interpretation given by the CJEU, which increasingly looks at the overall minimisation of the impacts on the environment and human health, as well as the achievement of EU's circular economy objectives pursuant to Article 4 and Article 11(2)(b) WFD.[102]

4.3 *Renewable Energy Legislation*

Adopting complex and low-emissions and nature-based value chains such as phytoremediation of contaminated sites for low-ILUC biomass feedstock meets high demanding requirements imposed by the RED II. The RED II defines low ILUC-risk biofuels, bioliquids and biomass fuels as "biofuels, bioliquids and biomass fuels, the feedstock of which was produced within schemes which avoid displacement effects of food and feed-crop based biofuels, bioliquids and biomass fuels through improved agricultural practices as well as through the cultivation of crops on areas which were previously not used for cultivation of crops".[103] Feedstock derived from land remediated through nature-based techniques falls under this definition. Importantly, the RED II indirectly values biofuels produced from degraded land by establishing a specific correction

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by-product […] that should not lead to the conclusion that the supply of that material cannot evolve and be transformed into an activity capable of being performed on a more regular basis if that results into an economic benefit for an undertaking". See Opinion of Advocate General Medina in Case C-238/21, Porr Bau GmbH v Bezirkshauptmannschaft Graz-Umgebung [2022], para. 48.

101 *European Commission*, Guidelines on the interpretation of key provisions of Directive 2008/98/EC on waste, 2012, p. 18.

102 See also Recitals 8 and 29 of the WFD. More generally, with regard to the by-product and end-of-waste definition, see Case C-629/19, Sappi Austria Produktion and Wasserverband "Region Gratkorn-Gratwein", [2020], paras. 49 ff.; Case C-60/18, Tallinna Vesi, [2018], para. 22. With specific reference to materials to be reused for agricultural purposes, see Case C-113/12, Donald Brady v Environmental Protection Agency [2012], paras. 53 ff. and more recently with regard to uncontaminated excavated soils, Case C-238/21, Porr Bau GmbH v Bezirkshauptmannschaft Graz-Umgebung [2022], para. 58. See *T. Tuurunen & J. Alaranta*, The Role of the CJEU in Shaping the Future of the Circular Economy, 2021 (2) EEELR, pp. 51–61.

103 Article 2(37) of the Directive 2018/2001/EU of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources, PE/48/2018/REV/1, OJ L 328, 21.12.2018.

factor in the methodology for calculation of life cycle GHG emissions from biofuels production and use.[104]

To appraise the kind of feedstock falling into a such definition, however, sustainability criteria for biofuels, bioliquids and biomass fuels are laid down under Article 29 RED II.[105] Importantly, alongside the sustainability criteria, advanced biofuels feedstock should be selected based on the following elements:

– the principles of the circular economy and of the waste hierarchy established in the WFD;
– the need to avoid significant distortive effects on markets for (by-)products, wastes or residues;
– the potential for delivering substantial GHG emissions savings compared to fossil fuels based on a lifecycle assessment of emissions;
– the need to avoid negative impacts on the environment and biodiversity;
– the need to avoid creating an additional demand for land.[106]

The scope of biofuels sustainability criteria is further defined the ILUC Regulation.[107] The ILUC Regulation allows for the certification as low-ILUC risk fuels only for biofuels, bioliquids or biomass fulfilling certain additionality requirements.[108] The general approach to additionality in the ILUC Regulation draws from the framework of the Clean Development Mechanism under the UNFCCC Kyoto protocol. Accordingly, the certification of low-ILUC biofuels should focus on processes that are either not financially attractive or face barriers to their implementation.[109] Moreover, the ILUC Regulation recognises

104 Annex V, Section C, point 8 RED II. However, the correction factor, which amounts to 29 g CO2eq/MJ for a period up to 20 years from the date of land conversion, only refers to biofuels obtained from means land that "for a significant period of time, has either been significantly salinated or presented significantly low organic matter content and has been severely eroded" and provided that "steady increases" in carbon stocks and "sizeable reduction in erosion" are demonstrated.

105 See Recital 94 RED II, which emphasizes how the fulfillment of the sustainability criteria for biofuels "is essential for the achievement of the energy policy objectives of the Union as set out in Article 194(1) TFEU".

106 Article 28(6) RED II.

107 Commission Delegated Regulation (EU) 2019/807 of 13 March 2019 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council as regards the determination of high indirect land-use change-risk feedstock and the certification of low indirect land-use change-risk biofuels, bioliquids and biomass fuels, OJ L 133, 21.5.2019, pp. 1–7 (ILUC Regulation).

108 Id.

109 See, among others, *A. Michaelowa*, Interpreting the Additionality of CDM Projects: Changes in Additionality Definitions and Regulatory Practices over Time, in D. Freestone & C. Streck (eds.), Legal Aspects of Carbon Trading: Kyoto, Copenhagen and Beyond,

additionality for biomass feedstocks that "allow for cultivation of food and feed crops on abandoned land or severely degraded land".[110] These requirements arguably favour biofuels produced through measures that increase productivity or prompt cultivation of feedstock on previously unused land.

Yet two main pitfalls are in the way to the uptake of nature-based solutions under the additionality framework. First, the eligibility of measures must be limited to a reasonable period that allows economic operators to recuperate investment costs and ensures the continued effectiveness of the framework. The ILUC Regulation sets such temporal limitation at ten years before the obtainment of the certification.[111] This approach could be at odds with long-lasting processes such as phytoremediation, which can operate over a time span of fifteen to twenty years. Second, the definition of "severely degraded land" under the ILUC Regulation does not specifically comprise contaminated land as it more generally refers to land that "for a significant period of time, has either been significantly salinated or presented significantly low organic matter content and has been severely eroded".[112]

Requirements for the adoption of sustainable, advanced biofuels have also been adopted under the revised Fuels Directive.[113] Yet the amended Fuels Directive looks at sustainable biofuels from a life-cycle GHG emissions perspective, thus aiming at preventing biofuels produced from raw materials drawn from specific, high-ILUC risk and GHG intensive emissions crops (e.g., oils, cereals or starch) or produced on agricultural land that would count for the RED II renewable energy targets.[114]

Hence overall, the sustainability criteria pose a challenge to achieve a fully enabling legislative framework for phytoremediation of contaminated sites as combined with biomass production. In this respect, a more prominent role should be provided for non-food feedstock that comes from truly sustainable processes such as phytoremediation. Where, instead, the legal regime under the RED II, the Fuels Directive and the ILUC Regulation currently does not

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2009; *L. Schneider*, Assessing the additionality of CDM projects: practical experiences and lessons learned, 2009 9(3) Climate Policy, pp. 242–254.

110 Article 5(1)(a)(i) ILUC Regulation.

111 Article 5(1)(b) ILUC Regulation.

112 This definition operates, by reference of Article 5 ILUC Regulation, pursuant to point 9, Annex V, Part C of RED II.

113 Directive (EU) 2015/1513 of the European Parliament and of the Council of 9 September 2015 amending Directive 98/70/EC relating to the quality of petrol and diesel fuels and amending Directive 2009/28/EC on the promotion of the use of energy from renewable sources (Text with EEA relevance), OJ L 239, 15.9.2015, p. 1–29.

114 *Id.*, Article 7b(2).

comprise a specific focus on the originating processes of feedstock that goes beyond its overall GHG impact. The proposal for a revision of the RED II should therefore take all the above aspects into due consideration, given its expressed objective to address "[F]eedstock for advanced biofuels and biogas for transport, for which technology is more innovative and less mature and therefore needs a higher level of support" also in light of the overarching EGD objectives related to circular economy and the fight against pollution in soil, water and air.[115]

The EC proposal for a further revision of the RED II puts forward an amendment to Article 29 RED II on sustainability criteria to mandate – albeit only for forest biomass – that the feedstock is harvested "considering maintenance of soil quality and biodiversity" including avoiding those harvested on vulnerable soils".[116] Notably, the RED II revision proposal recognises the need to implement the cascading principle for biomass use, which aims to achieve resource efficiency of biomass use by prioritising biomass material use to energy use wherever possible, in line with the WFD waste hierarchy and the principles of the circular economy.[117]

In this respect, the *ad hoc* voluntary biofuels certification schemes envisaged under the RED II and the ILUC Regulation could be instrumental to enhance the market's confidence in advanced biofuels if they were to take into due account the overall ecosystem benefits provided by phytoremediation feedstocks.[118] However, voluntary schemes are still not harmonised and fragmented, thus increasing consumers' uncertainty towards advanced biofuels. There are currently 13 certification schemes for biofuels recognised by the European Commission.[119] Among these, for example, the International Sustainability & Carbon Certification System is mandatory in Hungary, but no national

115 See Recital 91 RED II. For a comprehensive account of the interplay across the manifold EGD's objectives, see *L. Krämer*, Planning for Climate and the Environment: The European Green Deal, 2020 17(3) JEEPL, pp. 267–306.

116 See Commission Proposal for a Directive of the Parliament and Council amending Directive (EU) 2018/2001, COM(2021) 957 as to the amendments to Article 29 RED II.

117 *Id.*, p. 10.

118 See *D. Maes et al.*, Assessment of the sustainability guidelines of EU Renewable Energy Directive: the case of biorefineries, 2015 88 Journal of Cleaner Production, pp. 61–70; *T. Mai Moulin et al.*, Effective sustainability criteria for bioenergy: Towards the implementation of the European renewable directive II, 2021 138 Renewable and Sustainable Energy Reviews, p. 110645.

119 The full list of the voluntary certification schemes approved by the Commission through Implementing Decisions on April 12, 2022 is available online at the following link:/energy.ec.europa.eu/topics/renewable-energy/bioenergy/voluntary-schemes_en#voluntary-schemes-under-the-revised-renewable-energy-directive.

sustainability certification for biofuels and bioliquids exists in Spain.[120] Since the road vehicle and oil industry work inherently at a multinational scale, the adoption of EU-wide or at least mandatory national certification schemes may be seen as a major barrier to the uptake of advanced biofuels by end-users.

5 Conclusion

The achievement of the European Green Deal's objectives involves addressing several complex tradeoffs. One example of such *conundrum* regards the energy vs land vs food nexus, which showcases in the context of biofuels production. Phytoremediation of contaminated sites as a truly ecological technique to address soil contamination provides a win-win solution to both the major issue of soil remediation and as a potential sustainable, low-ILUC source of feedstock for biofuels production for the transport sector.

While the upscaling of phytoremediation still faces economic and technical challenges, this paper has identified pitfalls in the current EU legislative framework. The current legal regime directly or indirectly dealing with the technique at hand unveils silos-thinking and a lack of enabling framework conditions for deploying phytoremediation as a source of low-ILUC non-food feedstock for biofuels. The development of a dedicated and harmonised European legal regime addressing sustainable soil management and setting the tone for a coordinated approach to soil remediation including non-conventional techniques is essential. These issues will hopefully be addressed in the upcoming Soil Health Law, which, however, will deploy a certain degree of flexibility and leeway for implementation by Member States. Notwithstanding, the approach adopted by the CJEU in interpreting the WFD provisions on waste and by-products definitions could be conducive to the valorisation of phytoremediation feedstocks in line with the EGD objectives thus contributing to the uprooting of a value chain as related to the production of biofuels and other recovery activities. Yet major issues still regard the key enabler of the phytoremediation output material conversion process, namely the sustainable criteria under the RED II framework. The sustainability criteria shall embody soil remediation and the overall preservation of its ecosystem services as a main objective under the EU's biofuels policy alongside the reduction of biofuels GHG intensity and the protection of high biodiversity land and

120 Thus far the Commission has only recognized one National Certification Scheme, the Austrian Agricultural Certification Scheme (AACS). See *id.*

carbon sinks. This approach would be in line with several key objectives of the EGD. In other words, the case of phytoremediation analysed in this article further underscores that complex environmental challenges cannot but call for complex solutions that go beyond policy silos as the climate change and pollution crisis must be fought with all the tools available at an unprecedented pace.

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