A Critical Analysis of the Effectiveness of the United Kingdom Soil Protection Legislation From an Ecosystem Services Perspective

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Abstract

This research seeks to critically analyse the effectiveness of the United Kingdom (UK) legal framework for protecting soil and soil ecosystem services (ES). Soil is an incredibly complex, variable and – as its formation occurs over long periods of time compared to the lifespan of humans – non-renewable natural resource. It is the natural capital that provides the flow of most terrestrial ES, which are the benefits that humans obtain from ecosystems for survival and well-being. Soil ES are also a valuable aspect of the economy as most economic activities are impossible without functional soils.

Soil degradation is one of the most serious global threats to ecosystem sustainability. Extensive soil degradation can lead to a decline in the capability of soil to provide ES along with several other negative consequences. Therefore, sustainable management of soil to increase its productivity and resistance to adverse natural and human impacts is crucial. To achieve this, the importance and value of soil and soil ES should be understood, recognised and integrated into environmental law and policy.

To understand how the concept of ES and its value can be used for more sustainable policies and decisions, several researches have been undertaken. However, soil and soil ES – especially other than the provisioning services – are mostly overlooked in ES studies. Besides, soil could not draw enough attention in the UK environmental law and policy. Indeed, soil is not regulated through a comprehensive and coherent set of rules, which is an inherent defect of the European originated soil protection laws. Even though policies coming from the European Union (EU) in areas, such as agriculture, water, waste, chemicals, and prevention of industrial pollution indirectly contribute to soil protection, the focus of these policies is not soil. Therefore, these policies cannot guarantee a satisfactory level of soil protection. Moreover, while most threats to soils are due to economic activities many of which are steered by EU sector-related policies, soil protection is subject to national law, which typically deals with one specific threat, such as contamination.

The need for a strong soil protection in the UK has been ignored by law makers for many years. Due to lack of information and incoherent administration of soil, this area of law has not seen progress as fast as air or water protection. Furthermore, the government has falsely claimed that there is a functioning soil protection framework and has argued that the subsidiarity principle requires regulation in addition to the European legislation only when needed. Additionally, that soil is subject to private ownership causes additional difficulties and implications in legislation. As seen in the EU policy,

even though air and water regulations have aspects of soil protection, their focus is preventing deterioration of air and water quality, not protecting soil resources. Finally, whether soil issues emerging from land use, such as agriculture, industry, waste management and development are tackled properly is questionable.

This research aims to develop a novel understanding of soil protection through the multidisciplinary approach of ES and provide policy recommendations in light of this perception. This research focuses on a number of gaps in the literature, namely the lack of legal analysis on soil protection laws and insufficient reflection on the importance of soils and their ES.

The first chapter of this research will present a background on the topic, which will be followed by a literature review on the issues that are found in soil protection legislation, the concept of ES, the need for a new approach, how to operationalise the concept of ES, the ES approach, the classification and valuation of ES, criticism towards ES, the concept of ecosystem disservices, how these concepts are interrelated to soil and soil research. Following this, the second chapter will discuss the need for multidisciplinary research and introduce the Environmental Law Methodology. This research will use a modified version of this methodology. The third chapter of this study will demonstrate the importance of protecting soils and soil ES through studying their interactions with each other, soil functions and processes, and major soil threats. The fourth chapter will offer a brief introduction to the UK soil policy and ascertain the reasons why soils have been disregarded in the UK law and policy. In the fifth chapter, this research will critically analyse the effectiveness of soil protection legislation in the UK, including those that originated from the EU to identify their weaknesses. Using these results as a departing point, this research will make recommendations for a more robust policy, which offers soils stronger protection. To achieve this, the sixth chapter will introduce the Ecosystem Services Framework, which has been generated through an analysis of different methods of integrating the importance and value of soil and soil ES while considering legal, scientific, economic and societal pressures. The seventh chapter will conclude this study by showing how this framework can integrate the critical considerations introduced in the third chapter and respond to the challenges introduced in the fourth and fifth chapters.

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List of Abbreviations

AEM	Agri-Environmental Measures
AES	Agri-Environmental Schemes
ARIES	Artificial Intelligence for Ecosystem Services
BBN	Bayesian Belief Network
BPS	Basic Payment Scheme
CAP	Common Agricultural Policy
CBA	Cost-Benefit Analysis
CBD	Convention of Biological Diversity
CC	Cross Compliance
CICES	Common International Classification of Ecosystem Services
CSS	Countryside Stewardship Scheme
DEFRA	Department for Environment, Food and Rural Affairs
EA	Ecosystem Approach
EAP	7^{th} Environment Action Programme
EBM	Evidence Based Medicine
EDS	Ecosystem Disservices
EEC	European Economic Community
EFA	Ecological Focus Areas
ELD	Environmental Liability Directive
ELM	Environmental Law Methodology
EPA	Environmental Protection Act
ES	Ecosystem Services
ESA	Ecosystem Services Approach
ESD	Ecosystem Services Districts
ESS	Environmental Stewardship Scheme
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GAEC	Good Agricultural and Environmental Conditions
GHG	Greenhouse Gases
GIS	Geographic Information Systems
GMO	Genetically Modified Organisms
IPM	Integrated Pest Management
LANDIS	Land Information System

LATS	Landfill Allowance Trading Scheme
MCDA	Multi-Criteria Decision Analysis
MEA	Millennium Ecosystem Assessment
NAP	National Action Plans
NC	Natural Capital
NIMBY	Not In My Backyard
NVZ	Nitrate Vulnerable Zones
OM	Organic Matter
PES	Payment for Ecosystem Services
PTE	Potentially Toxic Elements
SDG	Sustainable Development Goals
SMR	Statutory Management Requirements
SOM	Soil Organic Matter
SWAT	Soil and Water Assessment Tool
TEEB	The Economics of Ecosystems and Biodiversity
UK	United Kingdom
UKFS	UK Forestry Standard
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
WFD	Water Framework Directive

CHAPTER ONE

Introduction

1.1. Introduction

Soil is crucial for humans[1] as it delivers vital functions that maintain and support life as we know.[2] It sustains the growth of plants by providing a medium for plant roots and nutrients.[3] The continuous flow of clean water is dependent on functioning soils[4] as soil stores and moves water.[5] It operates as nature's recycling system for dead bodies of plants, animals and humans.[6] It is a habitat for countless biotic organisms and vast biodiversity ranging from small mammals to microscopic cells.[7] It is an essential medium for production as it provides not only building material but also the foundation for any construction.[8]

Several studies have confirmed that soil is also a critical component of global sustainability issues, such as the decline in biodiversity, water security, food security, energy security, climate change, and hunger eradication.[9] These issues require international attention and policies at the global level.[10] Soil is also seen as an essential aspect of the United Nations Sustainable Development Goals (SDG)[11] on which states are expected to establish their national legislation.[12] Integrating soil in environmental policy and decision making is crucial for an enhanced natural resource management, societal benefits and sustainable development.[13]

Today, sustainable development has become a paramount matter as humans have become more alienated from nature due to urbanisation and the digital age.[14] Evidently,

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[1] Nyle C. Brady and Raymond R. Weil, *The Nature and Properties of Soils* (11th edn, Prentice-Hall 1996) 2
[2] ibid 2
[3] ibid 3
[4] ibid 3
[5] Thomas F. Scherer, Bruce Seelig and David Franzen, 'Soil, Water and Plant Characteristics Important to Irrigation' (*North Dakota State University*, 1996) <https://www.ag.ndsu.edu/publications/crops/soil-water-and-plant-characteristics-important-to-irrigation#section-12> accessed 5 June 2018
[6] Brady and Weil (n 1) 3
[7] ibid 3
[8] ibid 3
[9] Kabindra Adhikari and Alfred E. Hartemink, 'Linking Soils to Ecosystem Services — A Global Review' (2016) 262 Geoderma 101; Johan Bouma and Alex McBratney, 'Framing Soils as an Actor When Dealing with Wicked Environmental Problems' (2013) 200-201 Geoderma 130
[10] Adhikari and Hartemink (n 9)
[11] United Nations, 'About Sustainable Development Goals' (*Sustainable Development Goals*) <https://www.un.org/sustainabledevelopment/sustainable-development-goals/> accessed 15 January 2019
[12] UNDP, 'Aligning Nationally Determined Contributions and Sustainable Development Goals' (November 2017) <https://www.undp.org/content/undp/en/home/librarypage/climate-and-disaster-resilience-/ndcs-and-sdgs.html> accessed 15 January 2019
[13] Johan Bouma, 'Soil Science Contributions Towards Sustainable Development Goals and Their Implementation: Linking Soil Functions with Ecosystem Services' (2014) 177 J. Plant Nutr. Soil Sci. 111; Gretchen Daily and others, 'Ecosystem Services Supplied by Soil' in Gretchen Daily (ed) *Nature Services: Societal Dependence on Natural Ecosystems* (Island Press 1997); Estelle Dominati and others, 'A Soil Change-Based Methodology for the Quantification and Valuation of Ecosystem Services from Agro-Ecosystems: A Case Study of Pastoral Agriculture in New Zealand' (2014) 100 Ecol. Econ. 119; David Robinson, Inma Lebron and Harry Vereecken, 'On the Definition of the Natural Capital of Soils: A Framework for Description, Evaluation, and Monitoring' (2009) 73 Soil Sci. Soc. Am. J. 1904
[14] Richard Louv, *Last Child in the Woods: Saving our Children from Nature-Deficit Disorder* (revised edn, Atlantic Books 2013)

humans are less aware of nature's functions. Accordingly, as we become more developed, we lose our intimate contact with soils, and cannot realise how our prosperity and survival depend on healthy and functioning soils.[15] Thus, soil does not draw the attention it deserves.

This omission intensifies the effects of the global challenge of soil degradation. It is estimated that a third of all soils are already degraded.[16] Degradation occurs mainly due to wind and water erosion, pollution, sealing, compaction, soil organic matter (SOM) loss, salinisation and desertification.[17] Growing industrial development and urbanisation at the global level, which causes unsustainable and improper land use and management, exacerbates these threats leading to irreversible soil loss.[18]

Soil degradation is one of the most serious global threats to ecosystem sustainability.[19] Extensive soil degradation can lead to a decline in the capability of soil to provide ecosystem services (ES).[20] This is an imperative issue as human life depends on ES, which are the benefits humans obtain from ecosystems.[21] Indeed, some ES provided by soils are vital for humans, such as food production and clean water.[22] Therefore, soil must be one of the primary facets of any environmental policy. However, the ongoing soil degradation proves that laws at multiple policy levels are not adequate for robust conservation of soils and ES obtained from them.

Several legal and policy challenges emerge in the context of soil protection. Firstly, the functions of soils other than the ones related to food production are not entirely appreciated due to the immense gap in education, awareness and research in this field.[23] This lack of awareness can be associated with the neglect of the significance of soils in policy.[24] The concept of ES can be useful for drawing attention of the public and policy makers to soils through its common and anthropocentric spotlight.[25]

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[15] Brady and Weil (n 1) 2
[16] Food and Agriculture Organization of the United Nations, 'Nothing Dirty Here: FAO Kicks off International Year of Soils 2015' <http://www.fao.org/news/story/en/item/270812/icode/> accessed 17 July 2018
[17] ibid
[18] Winfried E. H. Blum, 'Functions of Soil for Society and the Environment' (2005) 4 Reviews in Environmental Science and Bio/Technology 75; Hikmet Gunal and others, 'Threats to Sustainability of Soil Functions in Central and Southeast Europe' (2015) 7 Sustainability 2161
[19] L. R. Oldeman, 'Soil Degradation: A Threat to Food Security' (1998) <http://www.isric.org/sites/default/files/isric_report_1998_01.pdf> accessed 1 December 2017; Adhikari and Hartemink (n 9)
[20] Jannes Stolte and others, 'Soil Threats in Europe: Status, Methods, Drivers and Effects on Ecosystem Services' European Commission Joint Research Centre Technical Reports (European Union 2016)
[21] Millennium Ecosystem Assessment, *Ecosystems and Human Well-being: Synthesis* (Island Press 2005)
[22] ibid
[23] Dominati and ohers (n 13)
[24] Alfred E. Hartemink and Alex McBratney, 'A Soil Science Renaissance' (2008) 148 Geoderma 123
[25] Food and Agriculture Organization of the United Nations, *Status of the World's Soil Resources – Main Report* (FAO 2015)

There are other complications in regulating soils as good practice for different types of soil changes from one place to another.[26] Soil policy also faces monetary obstacles, such as the fact that land has a price but soil paradoxically does not.[27] Besides, an additional difficulty arises due to private ownership of land.[28] Incorporating the concept of ES into soil policy can offer a different focal point through practices, such as valuation and monetisation of the services focusing on the distribution of benefits and responsibilities rather than merely private property rights.[29]

This research aims to develop a novel understanding of soil protection through the multidisciplinary approach of ES and provide a set of framework recommendations in light of this perception. The rest of this chapter will provide a literature review focused on soil protection legislation, the concept of ES and the objective of operationalising and incorporating this concept into soil policies. Chapter two will present the methodological approach of this research. Chapter three will provide a thorough explanation of the importance of soils by studying soil processes, functions and ES. This will be followed by a description of the most significant global threats to functioning soils and the provision of soil ES. Chapter four will offer a brief introduction to the UK soil policy and ascertain the reasons why soils have been disregarded in the UK law and policy. Chapter five will present a comprehensive analysis of the effectiveness of the existing United Kingdom (UK) soil protection legislation. This legal analysis will answer whether these instruments provide robust protection for soils and effectively factor in the protection of soil ES. Chapter six will present the Ecosystem Services Framework, which was developed following the critical appraisal of a number of methods used in different frameworks for integrating the importance and value ES into policy and decision making. Chapter seven will conclude by discussing how this framework can improve soil protection.

1.2. Literature Review

This research aims to fill several important gaps in the literature. First, there is a clear lack of critical literature that analyses the effectiveness of soil protection legislation in the UK. Also, there is a scarce number of studies, which present framework recommendations for integrating ES into legislation with a specific focus of soil

[26] Matthias Schroter and others, ‘Ecosystem Services as a Contested Concept: A Synthesis of Critique and Counter-Arguments’ (2014) 7 Conservation Letters 514
[27] Stuart Bell, ‘A Slow Train Coming? Soil Protection Law and Policy in the UK’ (2006) 3 JEEPL 227
[28] ibid
[29] Tim Daw and others, ‘Applying the Ecosystem Services Concept to Poverty Alleviation: The Need to Disaggregate Human Well-Being’ (2011) 38 Environ. Conserv. 370

protection. Therefore, it is essential to study the existing literature mainly focused on soil protection legislation, soil ES and soil research in order to identify the research gaps to date.

1.2.1. Soil Protection Legislation

The alarming levels of the ongoing soil degradation are clear evidence of the fact that the existing soil protection laws are not effective.[30] The existence of soil in international environmental law has been poor due to an obvious lack of appreciation.[31] The recognition of the ecological features and requirements for soils in the existing international law is minor.[32] It has been argued that the existing binding instruments for ensuring sustainable use of soils at the global level are inadequate.[33] Although these instruments have the potential of safeguarding soils, they are not properly implemented.[34] Non-binding instruments do provide a level of conceptual legal elements; however, these do not operationalise environmental law concepts to achieve the sustainable use of soils.[35] Overall, legal and institutional systems of the countries around the globe are commonly inadequate in tackling soil degradation issues effectively.[36] This is especially the situation in low and middle income countries where soil legislation instruments mostly do not contain operational provisions.[37]

High income countries are also ineffectual in dealing with soil degradation as the existing legal instruments fail to halt soil degradation trends.[38] This situation is apparent in the European Union (EU) where there is a level of recognition of the problems related to soil; nevertheless, there is no effective and comprehensive legislation to address these other than provisions spread across various policy areas.[39] Indeed, the existing soil protection is indirect and derives from the protection of other environmental media, i.e., water and air.[40] However, unless the soil is protected adequately, other environmental

[30] Ian Hannam and Ben Boer, *Legal and Institutional Frameworks for Sustainable Soils: A Preliminary Report* (IUCN 2002) xiv
[31] Alexandra M. Wyatt, 'The Dirt on International Environmental Law Regarding Soils: Is the Existing Regime Adequate?' (2008) 19 Duke Environmental Law & Policy Forum 165
[32] Hannam and Boer (n 30) xiv
[33] ibid xiv
[34] Wyatt (n 31)
[35] Hannam and Boer (n 30) xiv
[36] Ben Boer and Ian Hannam, 'Legal Aspects of Sustainable Soils: International and National' (2003) 12 RECIEL 149
[37] ibid
[38] Mark G. Kibblewhite, Ladislav Miko and Luca Montanarella, 'Legal Frameworks for soil protection: Current Development and Technical Information Requirements' (2012) 4 Environmental Sustainability 573
[39] 'EU Soil policy' (*Environment*) <https://ec.europa.eu/environment/soil/soil_policy_en.htm> accessed 15 July 2021
[40] Ana Frelih-Larsen and others, 'Updated Inventory and Assessment of Soil Protection Policy Instruments in EU Member States' Final Report to DG Environment <http://ec.europa.eu/environment/soil/pdf/Soil_inventory_report.pdf> accessed 31 July 2018

aspects will be under an inevitable risk as all environmental media are interlinked.[41] Another issue is that some of the existing legal instruments are not legally binding. Thus, these cannot be used as a basis for reinforcing soil conservation within the current European policy.[42] Furthermore, it is argued that EU policies do not consider some soil threats, namely compaction, salinisation and soil sealing.[43] Similarly, some critical threats, such as erosion, decline in SOM, loss of biodiversity and pollution were covered in the existing legislation only through a few directives, which provided targets for eliminating soil threats.[44] Also, there are no set of rules for detecting or defining historically contaminated sites.[45] Moreover, most EU policies focus on land protection from pollution.[46] However, it is argued that a comprehensive soil protection cannot be achieved through merely focusing on land protection as the land can still be protected whilst soil functions are being lost.[47] Soil functions and ES are not taken into consideration as it is not clear in the law what their protection implies, and their representation in legal texts is limited.[48] Overall, the EU recognises the importance of soil protection, but there is still no agreement on how to reduce soil threats and improve soil functions and the delivery of ES.[49]

A few states have formed primary soil protection legislation. For example, Germany[50] drafted a federal act that recognises soil functions and considers precautionary measures to avoid negative impacts on soils.[51] Some countries have developed legislation focused on particular threats, such as the Netherlands on pollution.[52] Other nations have merely published non-binding strategies to inform soil protection policy, e.g., England.[53] Overall, many countries do not have a formal legal framework for soil protection.[54] This

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[41] European Commission, 'Questions and Answers on the Thematic Strategy on Soil Protection' (22 September 2006) <http://europa.eu/rapid/press-release_MEMO-06-341_en.htm> accessed 1 December 2017
[42] Frelih-Larsen and others (n 40)
[43] Nadia Glæsner, Katharina Helming and Wim de Vries, 'Do Current European Policies Prevent Soil Threats and Support Soil Functions?' (2014) 6 Sustainability 9538
[44] ibid
[45] Frelih-Larsen and others (n 40)
[46] ibid
[47] ibid
[48] ibid
[49] Susanna Paleari, 'Is the European Union Protecting Soil? A Critical Analysis of Community Environmental Policy and Law' (2017) 64 Land Use Policy 163
[50] European Commission (n 41); Ines Vogel, Claus Gerhard Bannick and Holger Böken, 'The German Soil Protection Law and Regulations for the Utilisation of Biowaste' I International Conference Soil and Compost Eco-Biology 2004 Session 1 – Paper 4 <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.522.5451&rep=rep1&type=pdf> accessed 21 February 2019
[51] Federal Soil Protection Act of 17 March 1998 (BBodSchG) Federal Law Gazette I 1998 p. 502, art 1
[52] European Commission (n 41)
[53] ibid; Department for Environment, Food and Rural Affairs, 'Safeguarding Our Soils – A Strategy for England' (2009) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69261/pb13297-soil-strategy-090910.pdf> accessed 8 November 2017
[54] Kibblewhite, Miko and Montanarella (n 38)

finding is alarming as the current state of soil proves that these fragmented and incoherent policies are incapable of providing sufficient soil protection in Europe.[55]

Similarly, in the UK, legislative instruments that are focused on protecting other environmental media do provide a basic level of protection for soils; however, these are not focused on soil protection.[56] There is limited but ongoing discussion on whether the existing UK legal instruments provide adequate soil protection. The findings of this literature review suggest that soil threats, other than pollution, are generally overlooked.[57] The need for robust soil legislation has been ignored, and this has stalled any legislative progress in this field.[58] Additionally, the progress has been hindered by information shortcomings, confusion and incoherent administration about how soil should be regulated.[59] There are additional difficulties, such as lack of research, available data and monitoring.[60] Furthermore, complications emerging from land use, such as agriculture, industry, waste management and development are not fully addressed in the current legislation.[61] Overall, it has been argued that soil does not receive the same amount of attention as air and water,[62] and is mostly absent in the UK policy.[63]

The present study's findings suggest that there is a significant gap in the literature as to the effectiveness of soil protection laws, which are not often analysed. This is noticeable in the literature on the UK soil legislation. This is even more striking when a comparison is made between the number of works on soil and other environmental media, i.e., air and water, or other environmental issues, e.g., climate change. Besides, most works on soil legislation only analyse the instruments at one policy level, ignoring the fact that soil degradation is a wide-ranging issue that requires a broader assessment. Moreover, research on soil commonly focuses on one particular aspect of soils or one specific threat. Finally, researchers mostly avoid considering soil functions and ES, which are fundamental aspects of a soil protection framework. This research will address these gaps in chapter five by scrutinising the effectiveness of the UK soil protection laws and policies and, analysing whether soil and soil ES are protected adequately by these laws and policies.

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[55] European Commission (n 41)
[56] Bell (n 27)
[57] ibid
[58] ibid
[59] ibid
[60] 'Securing UK Soil Health' (*POSTNOTE 502*, August 2015) <http://researchbriefings.files.parliament.uk/documents/POST-PN-0502/POST-PN-0502.pdf> accessed 12 December 2017
[61] Bell (n 27)
[62] ibid
[63] 'Securing UK Soil Health' (n 60)

1.2.2. Ecosystem Services

The awareness of the fact that humans benefit from the environment, directly or indirectly,[64] and the appreciation of ecosystems as valuable capital assets can be traced back to Plato.[65] However, the concept had not emerged until the 1970s as 'environmental services'.[66] It was re-named as 'ecosystem services' after a decade.[67] The commonly accepted definition was developed by Millennium Ecosystem Assessment (MEA) in 2005 as "the functions and products of ecosystems that benefit humans, or yield welfare to society".[68]

The momentum was gained from 1997 onwards as the decline in ES over the past century has highlighted the need for ES quantification, monitoring and valuation.[69] Following the arguments of increasing demands of human kind upon the Earth's limited resources and growing burdens upon nature's balance, ES became a substantial part of the international environmental law discussion.[70] The interest in ES in the literature has sparked after two key publications in 1997: 'Nature's Services', which focused on providing an overview of nature's benefits,[71] and Costanza and others' article estimating the value of the world's ES.[72] The estimation in the latter work was made in order to demonstrate that the importance of ES to human well-being is much higher than a monetary approach had given them credit for.[73] This publication received the attention that its authors hoped for and stimulated a discussion leading the way for further research on this topic.[74]

The continuous flow of ES depends on the availability of natural capital (NC), i.e., the world's stocks of natural assets, which includes geology, soil, air, water and all

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[64] Sharachchandra Lele and others, 'Ecosystem Services: Origins, Contributions, Pitfalls, and Alternatives' (2013) 11 Conservation & Society 343
[65] Daily and others (n 13)
[66] C. M. Wilson and W. H. Matthews, *Man's Impact on the Global Environment: Report of the Study of Critical Environmental Problems* (MIT Press 1970)
[67] Paul R. Ehrlich and Harold A. Mooney, 'Extinction, Substitution, and Ecosystem Services' (1983) 33 BioScience 248
[68] Millennium Ecosystem Assessment (n 21)
[69] Robert Costanza and others, 'The Values of the World's Ecosystem Services and Natural Capital' (1997) 387 Nature 253; Gretchen Daily (ed), Nature's Services – Societal Dependence on Natural Ecosystems (4th edn, Island Press 1997); Brendan Fisher, R. Kerry Turner and Paul Morling, 'Defining and Classifying Ecosystem Services for Decision Making' (2009) 68 Ecological Economics 643; Erik Gomez-Baggethun and others, 'The History of Ecosystem Services in Economic Theory and Practice: From Early Notions to Markets and Payment Schemes' (2010) 69 Ecological Economics 1209; Bhim Bahadur Ghaley, Lars Vesterdal and John Roy Porter, 'Quantification and Valuation of Ecosystem Services in Diverse Production Systems for Informed Decision making' (2014) 39 Environmental Science & Policy 139
[70] Karsten Grunewald and Olaf Bastian, *Ecosystem Services – Concept, Methods and Case Studies* (Springer 2015)
[71] Daily (n 69)
[72] Costanza and others (n 69)
[73] Robert Costanza and others, 'Twenty Years of Ecosystem Services: How Far Have We Come and How Far Do We Still Need To Go?' (2017) 28 Ecosystem Services 1
[74] ibid

living things.[75] Due to the unique contribution to human well-being, the concept of sustainability supports that certain elements of NC are critical.[76] These elements can be conceptualised as ES.[77] If NC reduces, substitutes (manufactured or human capital) can be used.[78] Adding fertilisers into the equation to offset the decrease in soil fertility is a common example.[79] However, such substitution is not possible in cases, such as the loss of culturally important species or in which substitutions are economically impractical for the loss of services, such as erosion control.[80] As the original public good is free, difficulties arise when using substitutes is too costly, or an available substitute for that particular service is absent.[81] Also, it is important to note that many ES do not have feasible substitutes.[82]

1.2.3. The Need for a New Approach

When economic activities were limited and NC was sufficient, the interaction between the economy and ecology was much narrower.[83] As the demand for economic development is now so great[84] that society's competing desires lead to trade-offs that result in many vital ES becoming degraded.[85] These competing interests constitute a serious problem, especially for future generations, as when the demand for a service reaches the limit of the available supply or the supply decreases to the minimum level for survival, the price of that service could increase towards infinity.[86] The impossibility to access these vital services would eventually weaken human well-being.[87]

The irresponsible manner in which humanity has used natural reserves for a long time must be switched in order to avoid the abovementioned scenario in the near future.[88] A more intelligent model must be adopted to maintain natural resources for future

[75] World Forum on Natural Capital, 'What is Natural Capital?' <https://naturalcapitalforum.com/about/> accessed 17 January 2018
[76] Fridolin Brand, 'Critical Natural Capital Revisited: Ecological Resilience and Sustainable Development' (2009) 68 Ecological Economics 605
[77] ibid
[78] Costanza and others (n 69)
[79] Millennium Ecosystem Assessment, *Ecosystems and Human Well-being: A Framework for Assessment* (Island Press 2003) 14
[80] ibid 14
[81] Gretchen C. Daily, 'Management Objectives for the Protection of Ecosystem Services' (2000) 3 Environmental Science & Policy 333
[82] Costanza and others (n 69)
[83] Daily (n 81)
[84] Millennium Ecosystem Assessment (n 79) 4
[85] 'Biodiversity & Human Well-being' (*Green Facts*) <https://www.greenfacts.org/en/biodiversity/index.htm#2> accessed 17 November 2017
[86] M. A. Finvers, 'Application of e^{2}DPSIR for Analysis of Soil Protection Issues and an Assessment of British Columbia's Soil Protection Legislation' (2008) <https://www.for.gov.bc.ca/hfd/library/documents/bib108847.pdf> accessed 01 November 2017; Costanza and others (n 69)
[87] Daily (n 81)
[88] ibid

generations as a requirement of sustainable development[89] and intergenerational equity, i.e., the notion of fairness or justice between generations.[90]

Protecting ES and NC is challenging but crucial. However, these concepts have been undervalued by governments, businesses and the public, and eventually have been overlooked in decision and policy making.[91] Ill-informed marketplace decisions and policy choices lead to under-protection of the natural environment.[92] Indeed, there is a lack of information in this area.[93] The flows of ES are characterised inadequately in the necessary biophysical and ecological terms at the local and regional scales, hindering their protection.[94] Also, the science of ES is complex,[95] and practical problems, (e.g., ES value calculations) are unsolved.[96] Governments only invest in the protection of specific services if there is obvious information on their benefits, e.g., clean water.[97] Overall, incorporating ES benefits into policy and decision making remains a difficulty.[98] This challenge appears as the lack of indicators and instruments integrating ES into policies.[99] However, these services will continue to diminish without legal status.[100] It is argued that these problems in traditional and current approaches to environmental law cannot be addressed by mere tweaking.[101] Thus, a radical shift in this approach is required.[102] Such a significant change can be accomplished by meaningful integration of the concept of ES into law and policy.

1.2.4. Operationalising Ecosystem Services

Sound ecosystem management must involve a utilitarian connection between ecosystems and human well-being while considering the intrinsic value of ecosystems in decision making.[103] Integrating ES in policy and decision making can become a powerful approach for evaluating different natural resources management strategies and aid more

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[89] ibid
[90] Robert M. Solow, 'Intergenerational Equity and Exhaustible Resources' (1974) 41 Review of Economic Studies 29
[91] David Markell, 'Symposium – Ecosystem Services' (2001) 20 Stan. Envtl. L.J. 309; James Salzman and others, 'Protecting Ecosystem Services: Science, Economics and Law' (2001) 20 SELJ 309; Daily and others (n 65)
[92] Markell (n 91)
[93] ibid
[94] Kai M. A. Chan and others, 'Conservation Planning for Ecosystem Services' (2006) 4 PLoS Biology 2138
[95] ibid
[96] Grunewald and Bastian (n 70)
[97] Heather Tallis and others, 'An Ecosystem Services Framework to Support Both Practical Conservation and Economic Development' (2008) 105 PNAS 9457
[98] Grunewald and Bastian (n 70)
[99] Chan and others (n 94)
[100] Bruce Pardy, 'Goods, Services and Systems: The Law and Policy of Ecosystem Services, by J.B. Ruhl, Steven E. Kraft and Christopher L. Lant' (2008) 46 OHLJ 445
[101] ibid
[102] ibid
[103] Millennium Ecosystem Assessment (n 79) 6

sustainable management and policy outcomes.[104] The Ecosystem Approach (EA) supports this notion. It was endorsed by the Convention of Biological Diversity (CBD)[105] as a strategy for the integrated management of natural and living resources, promoting sustainable use and conservation of these resources in a rightful manner while considering nature's intrinsic and anthropocentric value.[106] It acknowledges that human activities are dependent on ecosystems, but also affect them, because humans are a part of ecosystems.[107]

EA can be adopted by comprehending the impacts of management and policy changes on ecosystems in an intersectoral manner.[108] This practice requires a holistic and integrated understanding of the entire system through the prism of different disciplines.[109] Legal scholars should work with ecologists, economists, geographers and other social scientists to fully comprehend ES, to measure the social, economic and ecologic costs and benefits of the conservation and management strategies, and to produce more sustainable policy developments.[110]

Under EA, decisions are improved by considering the interactions among the parts of the system.[111] Thus, effects are measured on the system as a whole, not on the different parts of it.[112] That is to say, it is argued that environmental laws are less effective when they apply to particular elements, such as air, water, soil; or when their application is limited by jurisdictional boundaries.[113] The application of EA involves an emphasis on functional relationships and processes within ecosystems.[114] It also focuses on the use of adaptive management practices and the need to carry out management actions at multiple scales and the distribution of benefits from ES.[115] Overall, EA requires an integrated approach that reflects all ecosystem components, such as human activities, habitats and species, and physical processes.[116] Besides, it involves robust participation from

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[104] Adhikari and Hartemink (n 9)
[105] Convention on Biological Diversity (signed 5 June 1992, entered into force 29 December 1993) 1760 UNTS 79
[106] Millennium Ecosystem Assessment (n 79) 11
[107] PISCES, 'What Is the Ecosystem Approach?' (*Supporting Sustainable Seas*) <https://www.celticseaspartnership.com/wp-content/uploads/2014/10/PISCES_English_GUIDE_FINAL_singlepage.pdf> accessed 15 October 2018
[108] Millennium Ecosystem Assessment (n 79) 11
[109] Daily (n 81); Walters Nsoh and Colin T. Reid, 'Privatisation of Biodiversity: Who Can Sell Ecosystem Services?' (2013) 25 ELM 12
[110] Roy Haines-Young and Marion Potschin, 'The Links Between Biodiversity, Ecosystem Services and Human Well-being' in David G. Raffaelli and Christopher L. J. Frid (eds) *Ecosystem Ecology: A New Synthesis* (CUP 2010)
[111] Millennium Ecosystem Assessment (n 21)
[112] Bruce Pardy, 'Changing Nature: The Myth of the Inevitability of Ecosystem Management' (2003) 20 Pace Envtl. L. Rev. 675
[113] ibid
[114] Fanny Douvere, 'The Importance of Marine Spatial Planning in Advancing Ecosystem-Based Sea Use Management' (2008) 32 Marine Policy 762
[115] ibid
[116] PISCES (n 107)

stakeholders, which is crucial for more informed decisions.[117] The sustainable use of natural resources requires mechanisms, which adopt the concepts of freedom, justice, fairness and equity in the use of ES.[118] These mechanisms should be provided by functioning institutions.[119] Finally, the most significant requirement of EA is the consideration of ecosystem functions and ES.[120]

1.2.5. Ecosystem Services Approach

ES was envisioned as a metaphor to highlight the essential human needs offered by nature.[121] Hence, the concepts of ES is constructive for emphasising, measuring and valuing the level of dependency between humans and nature.[122] These services include all the benefits we obtain from ecosystems and can value both market and non-market ES.[123] Decision making can be positively impacted by such an approach as the importance of ES for humans and the environment can be evaluated by decision makers.[124] Considering ES will benefit strategic decisions about natural resources[125] as the concept of ES can reinforce effective decisions and trade-offs regarding these resources[126] through revealing the range and scale of impacts of ecosystem degradation.[127] Indeed, ES are essential to the ways environmental issues are addressed, the future of humanity and the management of ecosystems.[128] Overall, ES has a vast potential to fulfil that potential and any research or management decision under the ES banner requires a strong philosophical foundation, one that considers ethical, cultural and environmental benefits on the same level as economic ones.

As an inseparable part of EA, the Ecosystem Services Approach (ESA) seeks to incorporate the value of ES provided to humans by nature into decision making

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[117] ibid
[118] Millennium Ecosystem Assessment (n 79) 14
[119] ibid 14
[120] PISCES (n 107)
[121] Richard B. Norgaard, 'Ecosystem Services: From Eye-Opening Metaphor to Complexity Blinder' (2012) 69 Ecological Economics 1219
[122] Robert Costanza and others, 'Changes in the Global Value of Ecosystem Services' (2014) 26 Global Environmental Change 152
[123] Nicholas B. Comerford and others, 'Assessment and Evaluation of Soil Ecosystem Services' (2013) 54 Soil Horizons 1
[124] Adhikari and Hartemink (n 9)
[125] Anne D. Guerry and others, 'Natural Capital and Ecosystem Services Informing Decisions: From Promise to Practice' (2015) 112 PNAS 7349
[126] Ken J. Wallace, 'Classification of Ecosystem Services: Problems and Solutions' (2007) 139 Biological Conservation 235
[127] Marianne Kettunen and others, *Socio-Economic Importance of Ecosystem Services in the Nordic Countries: Synthesis in the Context of The Economics of Ecosystems and Biodiversity (TEEB)* (Nordic Council of Ministers 2012) 59
[128] Norgaard (n 121)

processes.[129] In theory, greater recognition of the range of anthropocentric benefits can increase the support for conservation and lead to an improved understanding of how these benefits of conservation can be maintained, enhanced and shared.[130]

The main aim of ESA is to protect and restore ES.[131] It is argued that this approach can reach its full potential through a four-step approach to integration:[132] educational, scientific, legal and economic steps.[133] Firstly, awareness and education are crucial for humans to understand the importance of ES in our lives.[134] Secondly, the linkage between functions of ecosystems and the provision of ES should be strengthened through science.[135] These concepts should also be mainstreamed through institutional design and regulatory instruments, so that they do not remain as abstract ideas.[136] Finally, it is crucial to understand the value of ES and the institutional barriers to their commodification.[137]

It is argued that there are four main issues in determining the service that needs greater protection and the type of protection.[138] First, it is essential to identify the service in terms of range, status and salience.[139] Besides, the economic benefits of the service should be assessed, which leads to its valuation.[140] This assessment includes the examination of the potential substitutes for that service.[141] Also, an examination of the obstacles to capturing the service's benefits should be completed.[142] Finally, regulatory development should be put in place for achieving the aim of protecting the service.[143]

1.2.6. The Classification of Ecosystem Services

As mentioned above, for the assessment purposes, ES must be identified, classified and economically valued.[144] To this date, ES have been classified in many studies[145] through commonly accepted classification frameworks, such as MEA[146] and

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[129] Wildlife and Countryside Link, 'The Ecosystem Services Approach and the Nature Directives' <https://www.wcl.org.uk/docs/Joint_Links_The_Eco_Ser_App_and_Nature_Directives.pdf> accessed 4 January 2019
[130] ibid
[131] Salzman and others (n 91)
[132] ibid
[133] ibid
[134] ibid
[135] ibid
[136] ibid
[137] ibid
[138] ibid
[139] ibid
[140] ibid
[141] ibid
[142] ibid
[143] ibid
[144] The Economics of Ecosystems & Biodiversity (TEEB), *The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations* (Routledge 2010)
[145] Millennium Ecosystem Assessment (n 79) 56
[146] Millennium Ecosystem Assessment, *Ecosystem and Human Well-being: Biodiversity Synthesis* (World Resources Institute 2005)

the Economics of Ecosystems and Biodiversity (TEEB).[147] Categories found in these are similar: provisioning, regulating, cultural services that directly affect humans, and supporting services that are needed to maintain other ES.[148] Provisioning services are the products obtained from ecosystems,[149] e.g., food, fibre, fuel, fresh water, genetic resources, animal products, biochemicals, natural medicines, and pharmaceuticals.[150] These are generally the most observable services. Regulating services are obtained from the regulation of ecosystem processes,[151] e.g., air quality maintenance, climate regulation, water regulation, erosion control, water regulation, water purification and waste treatment, regulation of human diseases, biological control, pollination, storm protection.[152] It is important to note that services, such as fresh water can be seen as a linkage between categories as it can be both provisioning and regulating services.[153] Cultural services are non-material benefits obtained through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences,[154] such as cultural diversity, spiritual and religious values, educational values, inspiration, social relations, sense of place, cultural heritage values, recreation and ecotourism.[155] It is important to note that cultural services are directly linked to human values and behaviour; thus, they are more likely to differ from individual to individual or from one community to another.[156] These benefits arising from ecosystem-human relationships are more conceptual than physical.[157] This feature also reflects the challenge of valuing cultural services.[158] Finally, supporting services, which are required to maintain the flow of other ES are not apparent services as their impacts on humans are either indirect or appear over a long period.[159] As an example, soil formation does not have a direct impact on humans, thus can be easily overlooked; however, it is crucial as it affects food production indirectly.[160]

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[147] TEEB (n 144)
[148] Millennium Ecosystem Assessment (n 79) 57
[149] ibid 57
[150] ibid 57
[151] ibid 57
[152] ibid 58
[153] ibid 57
[154] ibid 58
[155] ibid 59
[156] ibid 59
[157] Kai M. A. Chan, Terre Satterfield and Joshua Goldstein, ‘Rethinking Ecosystem Services to Better Address and Navigate Cultural Values’ (2012) 74 Ecological Economics 8
[158] N. Small, M. Munday and I. Durance, ‘The Challenge of Valuing Ecosystem Services that Have No Material Benefits’ (2017) 44 Global Environmental Change 57
[159] Millennium Ecosystem Assessment (n 79) 59
[160] ibid 59

It is important to note that some categories overlap.[161] MEA was critiqued for mixing processes for achieving services (means) and the services themselves (ends) in the same categories.[162] It is argued that ES classification frameworks must separate intermediate services (e.g., water regulation), final services (e.g., provision of clean water) and benefits (e.g., drinking water).[163] This criticism led to a further initiative by TEEB, distinguishing among the biophysical structure, functions, services, benefits and values.[164] There are apparent differences regarding supporting services in different frameworks.[165] In TEEB classification, these benefits are not classified as a separate category, but as a part of ecological processes.[166] Another widespread framework the Common International Classification of Ecosystem Services (CICES) does not recognise supporting services, viewing them as an ecosystem's underlying structures and processes.[167] These different perspectives are especially relevant to soil processes,[168] which are classified as supporting services by MEA.[169]

Apparently, information on ecological goods and services and their value is scattered through the literature.[170] Thus, ES research suffers from the challenges emerging from the plurality of interpretations of definitions and classifications.[171] These issues appear as inconsistencies in terminology and confusion in processes, final benefits and flows.[172] Until these terms and concepts are clarified, it is likely that sight of the basic premise of considering NC and processes from the services they support will be lost.[173] Therefore, studying these frameworks for classification is important as clarifying the distinction among different services and standardising the definitions of the concepts,

[161] ibid 57
[162] Wallace (n 126)
[163] James Boyd and Spencer Banzhaf, 'What Are Ecosystem Services? The Need for Standardized Environmental Accounting Units' (2007) 63 Ecological Economics 616; Fisher, Turner and Morling (n 69); Gudrun Schwilch and others, 'Operationalizing Ecosystem Services for the Mitigation of Soil Threats: A Proposed Framework' (2016) 67 Ecological Indicators 586
[164] TEEB (n 144); Schwilch and others (n 163)
[165] Millennium Ecosystem Assessment (n 79) 57
[166] Jón Örvar G. Jónsson and Brynhildur Davíðsdóttir, 'Classification and Valuation of Soil Ecosystem Services' (2016) 145 Agricultural Systems 24; TEEB (n 144)
[167] Roy Haines-Young and Marion Potschin, 'Common International Classification of Ecosystem Services (CICES): Consultation on Version 4, August-December 2012' (Report to the European Environment Agency) (2013) <https://cices.eu/content/uploads/sites/8/2012/07/CICES-V43_Revised-Final_Report_29012013.pdf> accessed 12 January 2018; Schwilch and others (n 163)
[168] Schwilch and others (n 163)
[169] Millennium Ecosystem Assessment (n 79)
[170] Rudolf S. De Groot, Matthew S. Wilson and Roelof M. J. Boumans, 'A Typology for the Classification, Description and Valuation of Ecosystem Functions, Goods And Services' (2002) 41 Ecological Economics 393
[171] Alessandra La Notte and others, 'Ecosystem Services Classification: A System Ecology Perspective of the Cascade Framework' (2017) 74 Ecol Indic. 392; De Groot, Wilson and Boumans (n 170)
[172] La Notte and others (n 171)
[173] Schwilch and others (n 163)

such as ecosystem functions, processes and services, are crucial to integrate them into policy instruments.[174]

1.2.7. The Valuation of Ecosystem Services

As discussed earlier, once an ES is identified, the second step should be its valuation to comprehend its economic benefits.[175] The valuation of ES is significant as it highlights the importance of unnoticed ecosystems and ecosystem functioning for human beings.[176] It helps to understand the impacts of changes in ecosystem functioning and in communicating value to a common reference, e.g., dollars.[177] This practice is important as most ES have no market value, and there are no markets for them to be exchanged, hence no direct price mechanisms to signal their scarcity or degradation.[178] Therefore, a monetary value estimation is important to demonstrate the magnitude of ES.[179]

The valuation of ES is defined as the process of expressing the value of an ecosystem good or service that provides a scientific observation or measurement.[180] It is an assessment of potential trade-offs toward achieving a certain goal.[181] Thus, the valuation of ES should be separated from environmental decision making.[182] It can influence decision and policy making processes at multiple levels.[183] Indeed, one of the major reasons of ES being absent in policy and decision making is mostly because these benefits are not fully captured in commercial markets or economically quantified.[184]

Apart from the value of nature as a whole, considering the economics of ecosystems is also crucial for revealing the financial consequences of conservation initiatives.[185] As discussed earlier, ES without a market value are overlooked in traditional decision making[186] leading to unfair and unsustainable decisions.[187] If merely the market value of the services was considered, the cost for protecting nature may overweigh the

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174 La Notte and others (n 171)
175 Salzman and others (n 91)
176 David A. Robinson and others, 'Natural Capital, Ecosystem Services, and Soil Change: Why Soil Science Must Embrace an Ecosystems Approach' (2012) 11 Vadose Zone Journal 5
177 ibid
178 Geoffrey Heal, 'Valuing Ecosystem Services' (2000) 3 Ecosystems 24
179 Costanza and others (n 122)
180 Stephen C. Farber, Robert Costanza and Matthew A. Wilson, 'Economic and Ecological Concepts for Valuing Ecosystem Services' (2002) 41 Ecological Economics 375
181 Costanza and others (n 179)
182 Costanza and others (n 69)
183 Schwilch and others (n 163)
184 Costanza and others (n 69)
185 Andrew Balmford and others, 'Bringing Ecosystem Services into the Real World: An Operational Framework for Assessing the Economic Consequences of Losing Wild Nature' (2011) 48 Environ Resource Econ 161
186 Ian J. Bateman and others, 'Bringing Ecosystem Services into Economic Decision making: Land Use in the United Kingdom' (2013) 341 Science 45; Stephen R. Carpenter and others, 'Science for Managing Ecosystem Services: Beyond the Millennium Ecosystem Assessment' (2009) 106 PNAS 1305
187 Andrew Balmford and others, 'Economic Reasons for Conserving Wild Nature' (2002) 297 Science 950; Daily (n 63)

benefits obtained from it.[188] When all the benefits provided from that piece of nature are measured, the value will increase drastically.[189] If the degradation of ecosystems continues, there is a point where the marginal benefits exceed the marginal costs of conservation efforts.[190] The marginal benefits, as mentioned before, increase when a service becomes scarcer.[191]

This anthropocentric and economic approach places humans and nature's pragmatic value in the centre of environmental protection.[192] However, this does not necessarily require ignoring the intrinsic value of nature.[193] It is recognised by many that nature has a non-monetary value which, on its own, rationalises conservation efforts.[194] Economic valuation, solely, is complementary to this notion.[195] In other words, if conservation turns out to result in financial profit, valuation adds an economic rationale to the moral rationale for conservation.[196] Otherwise, if conservation generates economic loss, valuation provides the net size of the bill for the conservation initiative.[197] However, it is important the note that if the main concern is to protect ES, valuation is neither necessary nor sufficient.[198] Indeed, there are many ES studies that does not involve valuation, but are still innovative and operational for integrating ES into decision and policy making.

1.2.8. Criticism of Ecosystem Services

Although the concept of ES has found great support and proponents in the literature, there are also critiques of the idea. To start with, it is criticised for its anthropocentric focus.[199] It is argued that the use of the concept will inevitably commodify nature.[200] It is also expected to oversimplify the existing environmental challenges in the public eye.[201] The significance of environmental protection in the public

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188 Pavan Sukhdev, 'Putting a Price on Nature: The Economics of Ecosystems and Biodiversity' (2010) 1 The Solutions Journal 34
189 ibid
190 Balmford and others (n 185)
191 ibid
192 John Alder and David Wilkinson, *Environmental Law and Ethics* (Macmillan Press 1999) 4
193 Andrew Balmford and others, 'The Economics of Ecosystems and Biodiversity: Scoping the Science' (2008) European Commission Final Report ENV/070307/2007/486089/ETU/B2, 6
194 ibid 6
195 ibid 6
196 ibid 6
197 ibid 6
198 Heal (n 178)
199 D. J. McCauley, 'Selling out on nature' (2006) 443 Nature 27; M. Sagoff, 'On the Economic Value of Ecosystem Services' (2008) 17 Environmental Values 239
200 Nicolas Kosoy and Esteve Corbera, 'Payments for Ecosystem Services as Commodity Fetishism' (2010) 69 Ecological Econ 1228
201 Roldan Muradian and others, 'Reconciling Theory and Practice: An Alternative Conceptual Framework for Understanding Payments for Environmental Services' (2010) 69 Ecological Econ 1202

perception would be diluted, and nature's intrinsic values would be overlooked if it is known how much a piece of nature costs.[202]

According to some researchers, overlooking these intrinsic values would also lead to a situation in which humans become less connected to nature.[203] Humans would become consumers[204] and nature would turn into a green box of consumption.[205] If these ecosystem benefits are viewed within the context of a transaction, the unclear relationship among beneficiaries and providers may generate further environmental equity and justice issues.[206]

It is noted that the lack of one combined ES definition and classification scheme leads to a situation where the concept is seen as rather abstract or vague.[207] The frameworks are mostly ambiguous.[208] Therefore, it is challenging to define the lines among ecosystem processes, functions, goods, services and benefits.[209]

Some argue that ES-based frameworks are generally using support of the tool of economic valuation and there are no limits for this kind of valuation. It is opined that if one begins valuing nature in economic terms, we might try to economically value everything, including the sun, wind, and gravity.[210]

There is also significant criticism on how to value these services as the valuation methods being used are too complex, ignore the interconnectedness of nature, mask ecological complexity and disregard non-economic values. The concern is that valuation would eventually lead to commodification and we cannot treat things that are not produced by us as commodities.[211] Similarly, financial tools, such as payment for ES, were critiqued as ES-based approaches assume that such remuneration will ensure ES provision, which may not be necessarily the case.[212]

Some researchers argued that commodification of these services would enable greater state and corporate control of the environment at the expense of poor and

[202] J. B. Ruhl, 'In Defense of Ecosystem Services' (2015) 32 Pace Environmental Law Review 306
[203] M. Robertson, 'Measurement and alienation: making a world of ecosystem services' (2012) 37 Trans. Inst. Br. Geogr. 386
[204] ibid
[205] D. Brockington, R. Duffy and J. Igoe, *Nature Unbound: Conservation, Capitalism and the Future of Protected Areas* (Earthscan 2008)
[206] J. Fairhead and others, 'Green Grabbing: a new appropriation of nature?' (2012) 39 J. Peasant Stud. 237
[207] A. M. Nahlik and others, 'Where is the consensus? A proposed foundation for moving ecosystem service concepts into practice' (2012) 77 Ecol. Econ. 27
[208] ibid
[209] ibid
[210] Sagoff (n 199)
[211] E. Turnhout and others, 'Rethinking biodiversity: from goods and services to "living with"' (2013) 6 Conserv Lett 154
[212] Fairhead and others (n 206)

vulnerable communities, such as indigenous people.[213] There is a risk of economic valuation of nature to contribute to the existing environmental justice issues.[214] The use of this concept, therefore, would reduce complex management decisions to simple economic accounting, which rejects the political aspect of these decisions that impact on society.[215] As it becomes unclear who decides how the resources are managed or who benefits from the decisions, ES valuation is argued to be in conflict with environmental justice.[216] A fairly relevant criticism for the concept is social injustices that might stem from the simple question of who the beneficiaries are, and which services are to be managed.[217]

It is argued that when economic valuation leads to commodification then appropriation of ES, property rights to these services or on the land that provide these services will be formalised.[218] This means that ecosystems that were previously in openly accessible regimes, or communal or public property regimes, have been turned into private property.[219] Although this has a potential for declining the trend of overexploitation, it may also lead to a somewhat unethical situation where only rich and powerful will obtain these benefits or will be paid to provide these services to beneficiaries.[220]

Another point of criticism is the potential conflict with biodiversity conservation efforts. It is believed by some that ES-based framework or conservation strategies might not necessarily offer protection for biodiversity or might even divert focus, attention and interest.[221] The limited evidence of win-win situations stemming from a close relationship between biodiversity and ES is the main concern.[222]

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213 Sharachchandra Lele, 'Environmentalisms, Justices and the Limits of Ecosystem Services Frameworks' in Thomas Sikor (ed), *The Justices and Injustices of Ecosystems Services* (Routledge 2013)
214 Brett Sylvester Matulis, 'The economic valuation of nature: A question of justice?' (2014) 104 Ecological Economics 155
215 ibid
216 ibid
217 Katie K. Arkema and others, 'Coastal Habitats Shield People and Property from Sea-Level Rise and Storms' (2013) 3 Nature Climate Change 913
218 Erik Gomez-Baggethun and Manuel Ruiz-Perez, 'Economic valuation and the commodification of ecosystem services' (2011) 35 Progress in Physical Geography: Earth and Environment 613
219 ibid
220 ibid
221 McCauley (n 199); B. Vira and W. M. Adams, 'Ecosystem services and conservation strategy: beware the silver bullet' (2009) 2 Conserv. Lett. 158
222 Bradley J. Cardinale and others, 'Effects of biodiversity on the functioning of trophic groups and ecosystems' (2006) 443 Nature 989

1.2.9. Ecosystem Disservices

A key criticism regarding the concept of ES[223] is the omission of the concept of ecosystem disservices (EDS), which is a result of the oversimplification of the field. EDS is defined as the functions of an ecosystem that are perceived as unfavourable by humans.[224] These are ecosystem functions that do not provide benefits to humans,[225] and potentially have a negative effect on their well-being and the environment.[226] The confusion about the definition and scope of ES also appears in EDS. Some argue that EDS are defined as end-products[227] whilst others classify EDS as functions or properties of ecosystems that cause harmful, unpleasant or unwanted effects.[228]

In some cases, EDS appear in the form of costs.[229] Recognising the fact that nature may kill or harm humans, e.g., through plagues, diseases, crop pests, or floods, humans have paid and accounted for the cost of these disservices, either through prevention (building levees or developing vaccines) or remediation measures (rebuilding after natural disasters, treating diseases, or applying herbicides).[230] EDS are not exclusively financial but can also take the form of social nuisances and even pollution.[231] Loss of biodiversity, loss of wildlife habitat, nutrient runoff, sedimentation of waterways, pesticide poisoning, and greenhouse gas (GHG) emissions can be seen as different forms of EDS.[232]

It is argued that the concept of EDS may lead to the exaggeration of the harms caused by nature.[233] However, these harms are already considered implicitly by market mechanisms without naming them as EDS.[234] Indeed, the complex nature of ecosystem functioning may result in services and disservices to be stemmed from the same

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223 McCauley (n 199)
224 Cynnamon Dobbs, Dave Kendal and Craig R. Nitschke, 'Multiple Ecosystem Services and Disservices of the Urban Forest Establishing Their Connections with Landscape Structure and Sociodemographics' (2014) 43 Ecological Indicators 44
225 Julie T. Shapiro and Andras Baldi, 'Accurate Accounting: How to Balance Ecosystem Services and Disservices' (2014) 7 Ecosystem Services 201
226 Jari Lyytimäki and Maija Sipilä, 'Hopping on One Leg – The Challenge of Ecosystem Disservices for Urban Green Management' (2009) 8 Urban Forestry & Urban Greening 309; Wei Zhang and others, 'Ecosystem Services and Dis-services to Agriculture' (2007) 64 Ecological Economics 253
227 Francisco J. Escobedo, Timm Kroeger and John E. Wagner, 'Urban Forests and Pollution Mitigation: Analyzing Ecosystem Services and Disservices' (2011) 159 Environmental Pollution 2078
228 Jari Lyytimäki, 'Ecosystem Disservices: Embrace the Catchword' (2015) 12 Ecosystem Services 136
229 Lyytimäki and Sipilä (n 226); Zhang and others (n 226)
230 Shapiro and Baldi (n 225)
231 Escobedo, Kroeger and Wagner (n 227); Cynnamon Dobbs, Francisco Escobedo and Wayne C. Zipperer, 'A Framework for Developing Urban Forest Ecosystem Services and Goods Indicators' (2011) 99 Landscape and Urban Planning 196; Lyytimäki and Sipilä (n 226); E. Gregory McPherson and others, 'Quantifying Urban Forest Structure, Function, and Value: The Chicago Urban Forest Climate Project' (1997) 1 Urban Ecosystems 49
232 Alison Power, 'Ecosystem Services and Agriculture: Tradeoffs and Synergies' (2010) 365 Phil. Trans. R. Soc. B 2959
233 Shapiro and Baldi (n 225); Lyytimäki (n 228)
234 Shapiro and Baldi (n 225); Lyytimäki (n 228)

provider.[235] Under such circumstances, quantifying the damage due to EDS occurs more quickly than valuing ES.[236] Following this main idea, additional arguments for intensive management and the exploitation of natural resources are presented to move away from this concept.[237] Similarly, Villa and others argued that the concept of EDS impedes a potentially constructive dialogue about conservation, thus posing a danger to conservation efforts.[238] They argued that the concept is overly simplistic and creates confusion, thus should be replaced with a more enhanced understanding of ES flow dynamics.[239]

It is important to highlight that the objective of mainstreaming EDS is not about emphasising the negatives but placing both ES and EDS under a common assessment framework.[240] This practice is required to establish an inclusive outline of the net effects of ecosystem functioning.[241] Ecosystems are balanced within themselves but if the policy is setup by focussing on anthropocentric elements, EDS must be considered alongside ES. Otherwise, it would not be possible to reach an appropriate result for valuation. Besides, ES studies should make the public aware of both concepts to keep the ethical standards of research practice high.

ES interactions are commonly analysed as synergies and trade-offs.[242] In such an analysis, trade-offs between ES and EDS should be evaluated in terms of spatial scale, temporal scale and reversibility.[243] This evaluation would aid decision making process by providing more effective methods for valuing ES, which would eventually increase the likelihood of win–win scenarios.[244] Therefore, incorporating EDS as well as ES into policies will aid the development of environmentally, economically and socially sustainable societies while enhancing ecological processes.[245] Research based on ES and EDS can act as an important tool to highlight current and future conditions of decisions about ecosystems.[246] It is important to note that such research will allow effective communication leading to improved public participation in decisions regarding

[235] Shapiro and Baldi (n 225)
[236] ibid
[237] Lyytimäki (n 228)
[238] Ferdinando Villa and others, 'The Misconception of Ecosystem Disservices: How a Catchy Term May Yield the Wrong Messages for Science and Society' (2014) 10 Ecosystem Services 52
[239] ibid
[240] Lyytimäki (n 228)
[241] ibid
[242] Dobbs, Kendal and Nitschke (n 224)
[243] Power (n 232)
[244] ibid
[245] Dobbs, Kendal and Nitschke (n 224)
[246] Louise Willemen and others, 'A Multi-Scale Modelling Approach for Analysing Landscape Service Dynamics' (2012) 100 Journal of Environmental Management 86

ecosystems.[247] More effective participation ultimately means stronger democracy and more empowered vulnerable communities in demanding environmental resources that will enhance their well-being.[248] This is an important aspect of equality, and ultimately a significant step towards a more sustainable future as reflected in SDGs.[249] These will be discussed further in chapter four.

EDS are inevitable by-products of the functioning of healthy ecosystems, yet knowledge on EDS is limited.[250] The concept could not attract sufficient attention in the literature. Although there are a large number of studies on ES and their value, there is a significantly smaller number of works on EDS, constituting a significant gap in research.[251] Alas, refusing to use the term does not eliminate the abovementioned harms and nuisances.[252] Essentially, the more research undertaken on EDS, the better these can be removed or managed, which means less harm to the resilience of ecosystems.[253] Indeed, knowledge development on this concept would convince the public to tolerate these damaging effects.[254]

1.2.10. Ecosystem Services and Soil

There is an increasing movement for integrating ES into soil policy.[255] It is argued that an anthropocentric approach in soil and land management would be an exceptional one.[256] One of the most comprehensive and clear classification frameworks for soil ES in the literature was presented by Dominati, Patterson and Mackay in 2010, introducing soils as NC, and building on the MEA classification framework.[257] They proposed a framework for the classification of soil ES, which was argued to be a powerful management tool for economists and policy makers to comprehend the provision of soil ES and to consider soil NC and values of soil more carefully.[258] Jónsson and Davíðsdóttir produced a literature review on soil ES classification frameworks and demonstrated the need for a

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[247] Dobbs, Kendal and Nitschke (n 224)
[248] Nicholas Freudenberg, Manuel Pastor and Barbara Israel, 'Strengthening Community Capacity to Participate in Making Decisions to Reduce Disproportionate Environmental Exposures' (2011) 101 Am J Public Health S123
[249] United Nations (n 11)
[250] Lyytimäki (n 228)
[251] Tenley M. Conway and Vivian Yip, 'Assessing Residents' Reactions to Urban Forest Disservices: A case study of a major storm event' (2016) 153 Landscape and Urban Planning 1
[252] Lyytimäki (n 228)
[253] ibid
[254] ibid
[255] Lucie Greiner and others, 'Soil Function Assessment: Review of Methods for Quantifying the Contributions of Soils to Ecosystem Services' (2017) 69 Land Use Policy 224
[256] Comerford and others (n 123)
[257] Jónsson and Davíðsdóttir (n 166); Estelle Dominati, Murray Patterson and Alec Mackay, 'A Framework for Classifying and Quantifying the Natural Capital and Ecosystem Services of Soils' (2010) 69 Ecological Economics 1858
[258] Dominati, Patterson and Mackay (n 257)

more comprehensive framework for the valuation of soil ES for informing decision making at multiple policy levels.[259]

There is at least one missing aspect in these classification frameworks, such as the complexity and characteristics of soil functioning,[260] the link between soil NC, functions and ES,[261] the categorisation of different services, the potential beneficiaries of soil ES,[262] a standardised definition for each soil ES[263] or the economic valuation of soil ES.[264] Indeed, soil is commonly valued in studies valuing the land or production.[265] Therefore, soil itself is not valued, which leads to the changes in soil functionality to be disregarded.[266] The literature suggests that there is a lack of consensus on a complete framework for soil ES classification and valuation.[267]

These existing frameworks do not have sufficient tools to explore the effects of land use and practices on soil ES.[268] It is crucial to define as many ecosystem aspects as possible in the classification frameworks, including the vital role of soils in delivering ES.[269] This objective has not been achieved, as the focus of the existing frameworks is mostly on above-ground component of ecosystems rather than the less visible ones below the surface.[270] Indeed, the concept of ES suffers from the fact that some services are not as visible as others. Therefore, soil ES other than the provisioning ones are overlooked in decisions regarding land use and management as these are commonly non-marketable.[271] However, more rational decisions require both marketable and non-marketable ES to be taken into consideration by policy and decision makers.[272]

Overall, there are key challenges that need to be addressed: Linking ES to soils as well as land management and ensuring that the framework is scientifically robust but

[259] Jónsson and Davíðsdóttir (n 166)
[260] Emmanuelle Garrigues and others, 'Soil Quality in Life Cycle Assessment: Towards Development of an Indicator' (2012) 18 Ecological Indicators 434
[261] Dominati and others (n 13)
[262] Jónsson and Davíðsdóttir (n 166)
[263] Dominati and others (n 13)
[264] Jónsson and Davíðsdóttir (n 166)
[265] Robinson and others (n 176)
[266] ibid
[267] Daily (n 69); Patrick Lavelle and others, 'Soil Invertebrates and Ecosystem Services' (2006) 42 European Journal of Soil Biology S3; Edmundo Barrios, 'Soil Biota, Ecosystem Services and Land Productivity' (2007) 64 Ecological Economics 269; Scott M. Swinton and others, 'Ecosystem Services and Agriculture: Cultivating Agricultural Ecosystems for Diverse Benefits' (2007) 64 Ecological Economics 245; Zhang and others (n 226); Harpinder S. Sandhu and others, 'The Future of Farming: The Value of Ecosystem Services in Conventional and Organic Arable Land – An Experimental Approach' (2008) 64 Ecological Economics 835; Dominati, Patterson and Mackay (n 232); Jónsson and Davíðsdóttir (n 166)
[268] Dominati, Patterson and Mackay (n 257)
[269] Jónsson and Davíðsdóttir (n 166)
[270] Dominati, Patterson and Mackay (n 257)
[271] Ghaley, Vesterdal and Porter (n 69)
[272] ibid

simple enough to be used with stakeholders at multiple scales to assess and value soil ES to mitigate and reverse soil threats.

Considering the increasing adverse impacts on soil NC affecting the flow of ES, using a complete economic valuation system to integrate ES into decision making is crucial.[273] Some scholars also suggested the development of frameworks to recognise the value of soil resources for many ES.[274] It is discussed that using an ES-based valuation method for land management can improve ES provision for sustaining land productivity.[275] Besides, understanding how soil functions and ES are valued can alter soil management, and inevitably, impact on the soil capacity to deliver ES.[276] It is argued that economic valuation should be factored into the current environmental policies to improve the effectiveness of these existing policies.[277]

Land use and soil management strategies that would lead to better trade-offs and synergies between economic outcomes and the provision of ES should be understood and integrated.[278] Indeed, interactions among ES are mostly analysed as trade-offs, which occur when one service is enhanced at the expense of another service; and synergies, which happen when provision of two services increase or decrease simultaneously.[279] Management strategies that integrate these relationships into decision making would get better results in risk management, investment, cost-saving, sustaining revenues, and overall environmental performance.[280] However, it is difficult for ES to have a significant impact in soil management until it becomes mainstreamed, which ultimately requires legislative underpinning.[281]

It is argued that the effectiveness of a legal framework for soil protection depends on the correct selection of appropriate ecological aspects and developing a legal structure through the implementation of these aspects.[282] Therefore, considering the integrated management of land, water and all living resources can be a solution.[283] Most importantly, the public must take into consideration how different aspects of the environment relate to

[273] Jónsson and Davíðsdóttir (n 166)
[274] Yong-guan Zhu and Andrew A. Meharg, 'Protecting Global Soil Resources for Ecosystem Services' (2017) 1 Ecosystem Health and Sustainability 11; Greiner and others (n 255)
[275] Ghaley, Vesterdal and Porter (n 69)
[276] Kenneth R. Olson and others, 'Soil Ecosystem Services and Intensified Cropping Systems' (2017) 72 Journal of Soil and Water Conservation 64; Zhu and Meharg (n 274)
[277] Ghaley, Vesterdal and Porter (n 69)
[278] Barrios (n 267)
[279] Dobbs, Kendal and Nitschke (n 224); Ciara Raudsepp-Hearne, Garry D. Peterson and Elena M. Bennett, 'Ecosystem Service Bundles for Analyzing Tradeoffs in Diverse Landscapes' (2010) 107 PNAS 5242
[280] 'Seven Things You Need to Know About Natural Capital' (*The ENDS Report*, 20 December 2017) <https://www.endsreport.com/article/58155/seven-things-you-need-to-know-about-natural-capital> accessed 28 December 2017
[281] ibid
[282] Hannam and Boer (n 30) 17
[283] ibid 17

each other and the role of soils in this relationship.[284] The concept of ES makes the role and functions of soils more visible, so it can be seen as a chance to link these functions to their significance for humans.[285] Thus, ES is an opportunity to promote the importance of soils in law and policy.[286] To fulfil the need for a comprehensive framework for soil ES that will inform decision and policy making at multiple levels for more sustainable soil management,[287] the flow of soil ES should be monitored and their value should be demonstrated.[288]

These steps require contributions from other disciplines, thus collaboration in research and policy making is essential.[289] The governance based on ES can only be achieved through interdisciplinary approaches.[290] It is not possible to generate an effective environmental policy without backing it up with scientific information,[291] hence soil scientists should engage with stakeholders from other disciplines, policy makers, communities and the public, and communicate more productively to improve the legal regime.[292] Such engagement can aid in building a link between soils and other sustainability issues, such as agriculture, climate change, protection of biodiversity and ecosystems.[293]

1.2.11. Soil Research

Today, ES research is widespread and promising.[294] However, soil is commonly overlooked in ES research[295] and valuation studies.[296] The efforts to understand soil have intensified through the methodological approach of soil quality indicators, which has

[284] Wyatt (n 31)
[285] Adrienne Grêt-Regamey and others, 'Soils and Their Contribution to Ecosystem Services' (2016) National Research Programme NRP 68
[286] ibid
[287] Jónsson and Davíðsdóttir (n 166)
[288] Ghaley, Vesterdal and Porter (n 69)
[289] Zhu and Meharg (n 274)
[290] Rachel Bardy Prado and others, 'Current Overview and Potential Applications of the Soil Ecosystem Services Approach in Brazil' (2016) 51 Pesq. Agropec. Bras. 1021
[291] Millennium Ecosystem Assessment (n 79) 1
[292] Wyatt (n 31)
[293] Luca Montanarella and Ivonne Lobos Alva, 'Putting Soils on the Agenda: The Three Rio Conventions and the Post-2015 Development Agenda' (2015) 15 Current Opinion in Environmental Sustainability 41
[294] Kenneth J. Bagstad and others, 'A Comparative Assessment of Decision-Support Tools for Ecosystem Services Quantification and Valuation' (2013) 5 ES e27; Christian Albert and others, 'Integrating Ecosystem Services in Landscape Planning: Requirements, Approaches and Impacts' (2014) 29 Landscape Ecol 1277; Nadia Sitas and others, 'Opportunities and Challenges for Mainstreaming Ecosystem Services in Development Planning: Perspectives From a Landscape Level' (2014) 29 Landscape Ecol. 1315; Susanne Frank and others, 'Making Use of the Ecosystem Services Concept in Regional Planning—Trade-Offs From Reducing Water Erosion' (2014) 29 Landscape Ecol. 1377; Igone Palacios-Agundez and others, 'Integrating Stakeholders' Demands and Scientific Knowledge on Ecosystem Services in Landscape Planning' (2014) 29 Landscape Ecol. 1423; Christine Fürst and others, 'Evaluating the Role of Ecosystem Services in Participatory Land Use Planning: Proposing a Balanced Score Card' (2014) 29 Landscape Ecol. 1435
[295] Allan Hewitt and others, 'Soil Natural Capital Quantification by the Stock Adequacy Method' (2015) 241-242 Geoderma 107
[296] Adhikari and Hartemink (n 9)

focused on soil processes and their contribution to soil functions and ES.[297] There are studies aiming to develop functioning tools to assess, map, model and valuate ES; however, there is a lack of research focus in considering soil ES at multiple scales.[298] Although there is an ample understanding of soil and a level of awareness of soil threats, information on soil processes, functions and ES are still incomplete;[299] and the complex systems of soil functioning and their relationship with anthropological activities and the impacts on ES are still not entirely understood.[300] Furthermore, only a few studies have linked ES to soil properties,[301] which affect soil processes and the soil's ability to function.[302] Additionally, the value of soil ES are not adequately considered or valued in policy and decision making.[303] Indeed, valuation studies for soil ES are mostly focused on agricultural aspects.[304] Also, TEEB classification excluded soil from their framework.[305] Such an omission from economic decision making can exacerbate soil degradation.[306] Considering the levels of soil degradation, soil itself should be a popular research topic. However, this is not the case as it has been less visible in the legal and scientific literature compared to other matters, such as climate change or air pollution.[307] Accordingly, soil research mostly has been funded indirectly through other research focuses, such as water protection and biodiversity conservation.[308] Therefore, the present study will contribute to the literature by studying soils from an anthropocentric perspective, and highlighting soil processes, functions and ES and significant soil threats.

1.3. Conclusion

The initiatives for protecting soils have failed for decades indicating the need for a shift in the focus of conservation efforts. The services provided by soils that benefit humans and the functions that enable this interaction are good reasons to protect soils. The necessary change in soil protection requires these anthropocentric concepts to be

[297] Bardy Prado and others (n 290)
[298] ibid
[299] Adhikari and Hartemink (n 9)
[300] Stolte and others (n 20)
[301] Adhikari and Hartemink (n 9)
[302] Ann McCauley, Clain Jones and Jeff Jacobsen, 'Basic Soil Properties' (*Montana State University*, January 2005) <http://landresources.montana.edu/swm/documents/Final_proof_SW1.pdf> accessed 6 April 2018
[303] Grêt-Regamey and others (n 285)
[304] Comerford and others (n 123)
[305] Rudolf De Groot and others, 'Integrating the Ecological and Economic Dimensions in Biodiversity and Ecosystem Service Valuation' (2010) <http://www.teebweb.org/wp-content/uploads/2013/04/D0-Chapter-1-Integrating-the-ecological-and-economic-dimensions-in-biodiversity-and-ecosystem-service-valuation.pdf> accessed 12 November 2017
[306] Jónsson and Davíðsdóttir (n 166)
[307] Gundula Prokop, 'The State of EU Soil Policy and Soil Related Research' (2005) 4 Reviews in Environmental Science and Bio/Technology 81
[308] ibid

fully understood, valued, considered in decision making and incorporated into policies. This integration can be achieved through collaboration among different disciplines, such as soil science, economics, law and other social sciences.

The present study aims to offer novel and innovative recommendations through the Ecosystem Services Framework, which has the potential to improve soil protection (chapters six and seven). This research also will be a significant contribution to the field for several reasons. Firstly, it will identify soil processes, functions and ES, which are vital for humans, examine the suggested frameworks for their definition and classification, and draw lessons from previous works for integrating ES into policies. Also, a complete analysis of these concepts, including EDS, and frameworks with a specific emphasis on soil will be a useful tool for future research. This step is crucial for achieving the aim of this study.

Secondly, recognising the fact that soil degradation is a significant problem in the UK, this study will analyse the effectiveness of soil protection legislation at the national level. The novel perception here is that the existing literature on soil protection legislation is commonly recognises legal aspects from a single perspective and ignores the safeguarding of soil functions and ES.

Thirdly, this study will use a multidisciplinary approach to move away from the shortcomings of a single viewpoint. Indeed, it is impossible to incorporate soil ES without understanding the scientific aspects of soils, economics or social impacts of soil degradation or ethical consideration of sharing benefits and sustainable development. Thus, the results and recommendations of this multidisciplinary research can be used in future policy making or, at least, can stimulate further research on the topic.

The objectives of this research are:

- To determine the soil processes, functions and ES, which are crucial to humans’ economic and societal needs, and ascertaining soil threats (chapter three)
- To introduce the UK soil policy and establish whether the existing laws and policies in the UK law fail to protect soils, soil functions and soil ES (chapters four and five)
- To critically appraise different methods for integrating the importance and value of soil ES into policy making through a holistic approach combining scientific, economic and societal insights and to develop a new framework integrating the findings identified in this research to address gaps in identified in chapter five (chapter six)

CHAPTER TWO

Methods

2.1. Introduction

This study examines environmental law and policy by adopting some aspects of black letter law methodology, which focuses on the letter of the law (using statutes, regulations and cases), rather than the law in action.[309] It implements legal reasoning and applies legal rules and norms to a set of factual aspects.[310] Therefore, this research falls under the category of 'law reform research' in Arthurs' legal research styles.[311] This style is seen as socio-legal research.[312]

This study, accordingly, is not a pure, academic legal research, such as fundamental research or legal theory research, but has aspects of an analysis of applied, real-life matters.[313] The aim of such a research is to facilitate a potential change, either in the law itself or in the manner of its administration.[314] Dealing with actual challenges can be the subject of a black letter law research as well. However, this study is not a research in law that requires a doctrinal methodology, but is a research about law.[315] Thus, it requires a multidisciplinary approach as black letter law methodology has its limitations, such as overseeing sociological implications[316] and critical approach to law.

This study, hence, uses a modified version of Environmental Law Methodology (ELM), which is developed through the involvement of arguments based on different disciplines, such as law, science and sociology.[317] Also, this methodology makes use of the deficits of legal systems in order to improve them.[318] The present study will achieve this through the critical analysis of the existing soil protection laws and the synthesis of the results.

This study, finally, recognises the weaknesses of a traditional literature review and considers that lessons can be learned from systematised review. The literature review found in this study adopts systematised review style and reports the process of the research undertaken to inform future research.

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309 Mike McConville and Wing Hong Chui, 'Introduction and Overview' in Mike McConville and Wing Hong Chui (eds), *Research Methods for Law* (2nd edn, Edinburgh University Press 2017)
310 Richard K. Neumann, Jr and Kristen Konrad Tiscione, *Legal Reasoning and Legal Writing* (7th edn, Wolters Kluwer 2013)
311 Harry William Arthurs, *Law and Learning: Report to the Social Sciences and Humanities Research Council of Canada by the Consultative Group on Research and Education in Law* (Ottawa: The Council 1983)
312 ibid
313 ibid
314 Paul Chynoweth, 'Legal Research in the Built Environment: A Methodological Framework' (2008) <http://usir.salford.ac.uk/12467/1/legal_research.pdf> accessed 21 December 2017
315 Arthurs (n 311)
316 ibid
317 Staffan Westerlund, *Fundamentals of Environmental Law Methodology* (Uppsala University 2007)
318 Aðalheiður Jóhannsdóttir, *The Significance of the Default: A Study in Environmental Law Methodology With Emphasis on Ecological Sustainability and International Biodiversity Law* (Uppsala University 2009) 78

This chapter aims to demonstrate the researcher's methodological basis for this study by introducing the elements of multidisciplinary approach, ELM and systematised review.

2.2. Multidisciplinary Approach

2.2.1. The Benefits of Multidisciplinary Approach

This study adopts a multidisciplinary approach that involves a combination of several disciplines to provide complementary contributions to achieve its aim.[319] It considers a particular problem or an observable phenomenon from multiple disciplinary standpoints.[320] The current research standard requires the application of knowledge from several disciplines to the solution of an existing matter or to comprehend the matter in totality.[321] It is argued that the presence of different viewpoints stimulates a confrontation of various scientific approaches with the aim of producing a logical picture of the problem, its explanations and potential solutions.[322] Indeed, staying in the boundaries of a single discipline carries a risk of turning research into an abstract formality.[323] It can be argued that today's complex environmental problems can only be unravelled through multidisciplinary research. Such an approach can, also, produce unusual results, novel inventions and fascinating theoretical insights through a more innovative, inductive and high-impact research as researchers inevitably become more familiar with perceptions from other fields.[324] Undeniably, it provides the researcher with more valuable data and broader perspectives that can correct the blind spots of individual research disciplines.[325] Certainly, it can help researchers from a certain discipline to comprehend the limitations and shortcomings of their own approach and the reasons why other views and findings are crucial.[326] Multidisciplinary research leads to new knowledge[327] and can be one of the most productive and inspiring of human pursuits.[328]

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[319] Gemma Carr, Daniel P. Loucks and Gunter Bloschl, 'Gaining Insight Into Interdisciplinary Research and Education Programmes: A Framework for Evaluation' (2018) 47 Research Policy 35
[320] Anton J. M. Schoot Uiterkamp and Charles Vlek, 'Practice and Outcomes of Multidisciplinary Research for Environmental Sustainability' (2007) 63 Journal of Social Issues 175
[321] Pradeep Kumar Pandey, 'Problems and Prospects of Multidisciplinary Approach in Legal Research' (2011) 1 Indian Journal of Humanities 46
[322] Schoot Uiterkamp and Vlek (n 320)
[323] Stuart S. Blume, *Interdisciplinarity in the Social Sciences* (Science Policy Support Group 1990)
[324] Haydee M. Cuevas and others, 'Benefits and Challenges of Multidisciplinary Project Teams: "Lessons Learned" for Researchers and Practitioners' (2012) 33 The ITEA Journal (International Test and Evaluation Association) <https://commons.erau.edu/publication/108> accessed 20 December 2018
[325] Dave Owen and Caroline Noblet, 'Interdisciplinary Research and Environmental Law' (2015) 41 Ecology Law Quarterly 887
[326] Schoot Uiterkamp and Vlek (n 320)
[327] Lawrence A. Baker, 'Perils and Pleasures of Multidisciplinary Research' (2006) 9 Urban Ecosystems 45
[328] Owen and Noblet (n 325)

2.2.2. The Challenges of Multidisciplinary Approach

Multidisciplinary research, on the other hand, has its own practical difficulties. Although researchers wish to find quick answers to plug into their own established research, it may not always be possible due to the complexity and nuance of another research discipline.[329] This situation arises where there is a lack of common language or it is difficult to understand new concepts or perspectives of others for the researcher.[330] An additional issue arises when it comes to switching the mindset of a researcher who comes from a different field.[331] However, in most cases, the advantages of multidisciplinary research outweigh these inherent weaknesses.[332]

2.2.3. The Need for a Multidisciplinary Approach

Multidisciplinary research was selected for this study for several reasons. As mentioned above, it reduces the flaws of overspecialisation and biased and dogmatic approach.[333] It is appropriate as this research mainly stays within its legal boundaries; however, would be restricted if it did not integrate knowledge from different disciplines. It is argued that law is not, nor can any discipline be, an insular one.[334] Indeed, in the field of law, a multidisciplinary approach is of utmost importance as the law cannot be confined to one aspect of life.[335] All legal regulations postulate actual circumstances of life to produce a particular outcome.[336] Therefore, the role of researchers from legal backgrounds as policy consultants can be limited as they are not specialised in other fields.[337] Thus, monodisciplinary research as a guidance for policy makers can be only partial.[338]

Law, indeed, should not be seen as strictly black letter.[339] This notion is especially important for environmental law, which is a field with multidisciplinary roots.[340] Environmental law scholars make use of scientific, economic and social studies while making legal arguments.[341] Therefore, incorporating science, economics and sociology becomes a unique characteristic of environmental law rather than demonstrating

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329 ibid
330 Schoot Uiterkamp and Vlek (n 320)
331 Pandey (n 321)
332 Cuevas and others (n 324)
333 Pandey (n 321)
334 B. S. Murty, 'Socio-Legal Research – Hurdles and Pitfalls' (1982) 24 Journal of the Indian Law Institute 253
335 Pandey (n 321)
336 Murty (n 334)
337 ibid
338 ibid
339 Ian Dobinson and Francis Johns, 'Legal Research as Qualitative Research' in Mike McConcille and Wing Hong Chui (eds), *Research Methods for Law* (2nd edn, Edinburgh University 2017)
340 Owen and Noblet (n 325)
341 ibid

multidisciplinarity.[342] Mainly, the key problems in the sphere of natural resources and their management cannot be addressed satisfactorily through a single research discipline as these commonly have multiple dimensions.[343] Also, sustainability, the touchstone concept of environmental law, has been at the centre of both the scientific disciplines such as physics, chemistry, and biology; and a broad range of environmental subdisciplines in sociology, economics, law and philosophy.[344] This perception also applies to the concept of ES. Indeed, ES requires insights from environmental and social sciences as well as economics. These grounds present the requisite for multidisciplinary research.[345] It is clear that environmental and social sciences should go hand in hand to facilitate comprehending the complex nature of the environmental problems.[346] Once the ways in which different contributions can be made from different disciplines are understood, it is promising to offer policy makers a more complete set of tools for tackling real-life challenges.[347]

2.3. Environmental Law Methodology

This research, specifically, uses a modified version of ELM endorsing a multidisciplinary approach. Involving science and sociology is inevitable in ELM as data from these disciplines are seen as tools to inform society, which leads to informing law makers and eventually transforms the legislation.[348]

ELM is based on the questions of how to achieve and maintain the objective of ecological sustainability,[349] which is defined as the conditions in the environment that are sufficient for sustaining mankind for infinite generations to come with dependable resilience.[350] In ELM, sustainable development is the principal objective but there are sub-objectives to achieve that.[351] These objectives should be addressed through rules, which are legally operational, otherwise, the environment remains unprotected.[352] ELM questions how laws could be more sustainable[353] and appreciates that a broad understanding of environmental consequences is required to achieve sustainable

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[342] ibid
[343] Willem Jannsen and Peter Goldsworthy, 'Multidisciplinary Research for Natural Resource Management: Conceptual and Practical Implications' (1996) 51 Agricultural Systems 259
[344] John Robinson, 'Squaring the Circle? Some Thoughts on the Idea of Sustainable Development' (2004) 48 Ecological Economics 369; Schoot Uiterkamp and Vlek (n 320)
[345] Schoot Uiterkamp and Vlek (n 320)
[346] ibid
[347] ibid
[348] Westerlund (n 317)
[349] ibid 1
[350] ibid 635
[351] Jóhannsdóttir (n 318) 85
[352] ibid 85
[353] ibid 299

development. This objective requires scientific perspective and consideration. Thus, ELM favours adopting a scientific method to monitor and evaluate for the purpose of reducing undesirable results.[354]

A socio-legal aspect in ELM is also crucial as one of its objectives is to understand how the law affects society.[355] Indeed, this methodology is not exhausted by the formulation and interpretation of legal rules, but rather is interested in correct and effective decisions that may be transferred to real-life situations.[356] ELM examines the law from two points.[357] Internally, it suggests going into the law, studying principles and doctrines about how the law shall be applied.[358] This is about how to apply law regarding environment and sustainability.[359] Externally, it advocates looking at the law, principles and doctrines from outside and analysing how the law is being applied. [360] This includes an analysis of how the law affects behaviour, economy and ecology, and how to structure implementation and develop environmental legal control.[361]

ELM was inspired by Eckhoff and Sundby's theory,[362] which was focused on evaluating legal systems and the effects on them by analysing what the systems consist of and how they operate as a whole.[363] In order to analyse how legal systems operate, using information and knowledge that has been developed by other disciplines is crucial.[364] It is argued that this theory was important for the development of ELM as Eckhoff and Sundby identified the importance of factors outside of legal systems.[365] Reactions or feedbacks, which explain how the system's focus is influenced by social, economic or other factors, provide the information that enables legal systems to react to changes.[366] Furthermore, Eckhoff and Sundby highlighted the risk of legal researchers depending on an insulated representation of legal systems and encouraged cross-sectoral communication.[367]

As mentioned before, ELM advocates observing the difference between the potential capacity of the law and its effectiveness and attempts to demonstrate how the

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[354] Westerlund (n 317)
[355] ibid
[356] Michael Decleris, *The Law of Sustainable Development – General Principles* (European Commission 2000) 31
[357] Westerlund (n 317) 511
[358] ibid 511
[359] ibid 524
[360] ibid 511
[361] ibid 529
[362] Torstein Eckhoff and Nils Kristian Sundby, *Legal Systems* (2nd edn, TANO Publishers 1991)
[363] Jóhannsdóttir (n 318) 95
[364] ibid 95
[365] ibid 95
[366] ibid 95
[367] ibid 95

legal system influences and affects the environment.[368] Additionally, it encourages analysing how authorities, businesses and individuals act, and examining whether the envisioned outcome is accomplished. This kind of ELM training is essential as self-assessment by law and policy makers is inherently problematic. It is argued that confining legal research to legal facts and findings that have already arisen carries the danger of conferring past experiences.[369] Therefore, ELM's theoretical foundation is based on the idea of proactive instruments and approaches, such as citizens' enforcement or the precautionary principle.[370]

Deficits also play an important role in ELM.[371] The failure of law can be explained by theorising various factors and functions of law.[372] These deficits can occur due to the fact that linear law is used for addressing the non-linear nature of environmental problems, which are not completely understood in the first place.[373] Indeed, ecosystems[374] and environmental impacts are rarely linear or reasonably foreseeable.[375] This characteristic of nature can create a considerable gap between the environmental objectives and the real-life results after the application and implementation of specific laws and practices of institutions.[376] It is argued that some factors are concerned with how individual provisions are structured,[377] others relate to how law is applied and enforced.[378] All these discussions have an instrumental approach to law and legal systems.[379] Decleris argued that changes to develop a more successful law and legal science could be inspired by these current faults.[380] It is important to describe deficits and understanding why they arise, as it clarifies how law actually works with respect to the environment and the legal system's effectiveness.[381] Thus, it becomes possible to understand why environmental objectives are not achieved.[382]

ELM endorses that concrete environmental objectives should not be changed or lowered.[383] Instead, institutions and legal instruments should be made more effective for

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[368] ibid 57
[369] ibid 73
[370] ibid 73
[371] ibid 78
[372] ibid 78
[373] ibid
[374] Westerlund (n 317) 516
[375] Jóhannsdóttir (n 318) 82
[376] ibid 82
[377] Jonas Ebbesson, *Compatibility of International and National Environmental Law* (Kluwer Law International 1996)
[378] Westerlund (n 317)
[379] Jóhannsdóttir (n 318) 103
[380] Decleris (n 356) 8-9
[381] Jóhannsdóttir (n 318) 78
[382] ibid 78
[383] ibid 81

more desirable results in practice.[384] Indeed, Decleris further discussed that legal systems must be dynamic and in continual movement and development due to a never-ending flow of information and decisions.[385] He emphasised that global environmental changes create serious threats to the current legal systems, thus, recommended more flexibility in decision making and new effective law and legal science inspired by the existing flaws.[386] Any system must be as advanced and complex as the matters it controls.[387] Decleris, as well as Westerlund, was inspired by Ashby,[388] who argued that control crisis rises when the problems become more complex than the controlling system which, in this case, is the legal system.[389]

It is clear that the existing legal system is failing to address environmental problems as soil degradation is nowhere near stopping. Therefore, the current laws and policies are not advanced enough to tackle this critical issue. To understand how law fails to operate effectively, this research will demonstrate how the existing law allows overlooking of the environmental objectives through the prism of sustainable development. This objective will be achieved by adopting some aspects of the black letter approach as the analysis will be made scrutinising the literature. As mentioned above, this research will present arguments based on various disciplines. Indeed, scientific insights will be used to understand ES, soils and the importance of robust soil protection. Furthermore, sociological aspects will be taken into consideration to understand the societal effects of the operation of the legal system. Finally, ES, an anthropocentric concept, will be at the centre of this research.

2.4. Systematised Review

This research has collected data through a systematised review with the aim of enhancing the quality and eliminating the limitations of traditional literature review. Systematised review reflects search results from more than one or two databases to catalogue studies after a comprehensive literature search. As the nature of this research does not allow the researcher to seek assistance from another reviewer or work in a team for selecting and analysing the studies, it should not be considered as a systematic review, but rather a systematised review, which attempts to incorporate some elements of systematic review without meeting all of the standards due to such limitations.

384 ibid 81
385 Decleris (n 356) 60
386 ibid 9
387 ibid
388 Jóhannsdóttir (n 318)
389 ibid

Systematic review is a specific method that selects and evaluates existing studies[390] in an explicit and transparent manner,[391] analyses and synthesises data, and reports the evidence in an approach that draws clear conclusions about what is and is not known.[392] It seeks to address a specified review question emerging from a policy or practice problem using existing studies.[393]

The first step of undertaking a systematic review is constructing a well-formulated, answerable question.[394] Based on this question, a list of keywords are generated.[395] The second step is to locate relevant studies.[396] This is achieved through the identification of databases.[397] By combining keywords and terms with conjunctions and prepositions, the results of the initial search is limited.[398] Additional filters, such as date of publication, language, type of publication, are applied to eliminate irrelevant or inapplicable results.[399] The next step is to appraise the results for their validity, importance and applicability.[400] This includes reviewing findings to state clearly the quality levels of the studies included in the review.[401] Once a piece of significant and valid evidence is found, a decision must be made if it is applicable to the certain problem that the research addresses.[402] Finally, the last step is to analyse and synthesise the findings.[403] The former is examining and dissecting individual studies and exploring how the components relate to each other.[404] The latter means putting findings together into a new arrangement and developing knowledge that is not apparent from the individual studies in isolation.[405]

Systematic review has a set of distinct principles differing from other review methods, such as being organised, transparent, explicit, replicable and updateable.[406] Systematic review has its roots in medical research, and is specifically used as a tool of

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390 Rob B. Briner and David Denyer, 'Systematic Review and Evidence Synthesis as a Practice and Scholarship Tool' (2012) <https://www.cebma.org/wp-content/uploads/Briner-Denyer-Systematic-Review-Evidence-Synthesis.pdf> accessed 29 January 2019
391 ibid
392 ibid
393 David Denyer and David Tranfield, 'Producing a Systematic Review' in David A. Buchanan and Alan Bryman (eds), *The Sage Handbook of Organizational Research Methods* (Sage 2009)
394 ibid
395 A. K. Akobeng, 'Principles of Evidence Based Medicine' (2005) 90 Arch Dis Child 837
396 Briner and Denyer (n 390)
397 Akobeng (n 395)
398 ibid
399 ibid
400 ibid
401 Briner and Denyer (n 390)
402 Akobeng (n 395)
403 Briner and Denyer (n 390)
404 ibid
405 ibid
406 ibid

evidence based medicine (EBM).[407] EBM is defined as a systematic approach to clinical problem solving that allows the integration of the best available evidence with clinical expertise and patient values.[408] It recognises the constant change in the research literature, and considers the need to critically appraise evidence.[409] The main idea behind this approach is the need to promote the practices that function and eliminate those that are ineffective.[410] Therefore, the general principles of systematic review can be used as a paradigm for legal and scientific research.

Systematic review is a commonly preferred method for reviewing the existing literature for several reasons.[411] Traditional methods, such as literature review contain a risk of bias as these are commonly of poor quality, because researchers mostly use informal methods to select, collect and analyse studies in a subjective manner that reinforce their views on the topic.[412] One of the most challenging problems with traditional literature review is their being prone to bias as the sources of literature are the well-known ones, and selection criteria and conclusions are subjective.[413] Systematic review is seen as an efficient method for eliminating bias by including both supporting and opposing arguments.[414] This aspect also improves the reliability and accuracy of conclusions.[415]

Additionally, literature review authors usually refrain from revealing the criteria for the selection of studies included.[416] Therefore, readers are not given the opportunity to assess any potential bias.[417] On the other hand, systematic review is explicit on the central question and the methods for searching studies.[418] In systematic review, the review question is being asked in a precise manner with inclusion and exclusion criteria.[419] Indeed, revealing this criteria will help eliminating bias.[420] This is an essential practice as the validity of the review depends on the validity of the selected studies.[421] Besides, systematic review methods for data collection are seen as searches of several specified

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[407] Akobeng (n 395)
[408] ibid
[409] ibid
[410] ibid
[411] A. K. Akobeng, 'Understanding Systematic Reviews and Meta-analysis' (2005) 90 Arch Dis Child 845
[412] ibid
[413] Robert H. Fletcher and Suzanne W. Fletcher, 'Evidence-Based Approach to the Medical Literature' (1997) 12 J Gen Intern Med S5
[414] Akobeng (n 411)
[415] ibid
[416] ibid
[417] ibid
[418] ibid
[419] Priscilla Robinson and John Lowe, 'Literature Reviews vs Systematic Reviews' (2015) 39 Australian and New Zealand Journal of Public Health 103
[420] Akobeng (n 411)
[421] ibid

databases using precise search terms.[422] If only one database is searched, relevant studies may be neglected.[423] Similarly, overlooking grey literature, i.e., where publishing is not the primary activity of the producing body,[424] depending on the question, might create misconception.[425] The objective of systematic review is to minimise bias through exhaustive literature searches of published and unpublished works.[426] It is discussed that including grey literature (e.g., working documents, conference papers, pre-prints and statistical documents)[427] will broaden the scope of the relevant studies.[428]

Systematic review also synthesises the literature systematically.[429] As mentioned before, the aim of synthesising the literature is to combine the findings to attain a level of conceptual development beyond that achieved in an individual study or a traditional approach.[430] This would improve methodological rigour and highlight opportunities for further research.[431] Indeed, the significance of conducting EBM and systematic review was proven in medical practice when traditional methods for a treatment which were initially over focused were then abandoned resulting in a beneficial outcome for the patient.[432]

Systematic review advocates that the search should not be limited to one language.[433] It is opined that searches limited to the English language would restrict the scope of studies and fail the efforts to avoid the publication bias occurring due to language selection.[434]

It is argued that the studies included in the review should be selected and appraised by at least two reviewers for a more independent assessment and a less biased collection.[435] Therefore, systematic review are commonly undertaken by a team of reviewers.[436]

Learning lessons from the principles of systematic review, this systematised review research adopted some elements of systematic review and had to exclude other

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[422] Robinson and Lowe (n 419)
[423] Akobeng (n 411)
[424] Quenby Mahood, Dwayne Van Eerd and Emma Irvin, 'Searching for Grey Literature for Systematic Reviews: Challenges and Benefits' (2014) 5 Res. Syn. Meth. 221
[425] Robinson and Lowe (n 419)
[426] David Tranfield, David Denver and Palminder Smart, 'Towards a Methodology for Developing Evidence: Informed Management Knowledge by Means of Systematic Review' (2003) 14 British Journal of Management 207
[427] Briner and Denyer (n 390)
[428] Mahood, Van Eerd and Irvin (n 424)
[429] Akobeng (n 411)
[430] Rona Campbell and others, 'Evaluating Meta-Ethnography: A Synthesis of Qualitative Research on Lay Experiences of Diabetes and Diabetes Care' (2003) 56 Soc Sci Med 671
[431] Briner and Denyer (n 390)
[432] A. K. Akobeng, 'Evidence in Practice' (2005) 90 Arch Dis Child 849
[433] Akobeng (n 411)
[434] ibid
[435] ibid
[436] ibid

aspects. Incorporating the principal notion of EBM, this research seeks to apply the best available evidence to a policy problem and favour the functional practices while excluding the ineffective ones[437] with the aim of building a two-sided argument through a literature review.[438]

The importance of undertaking a review of the existing studies lies within the need to eliminate partial, haphazard and opinion-driven research.[439] To remove bias, which is inherent within the traditional literature review, this study extracted data by searching and synthesising studies that support different views.

It is also important to reveal the criteria for the selection of studies included and to limit the reinforcement of the researcher's views. In chapters one, three, four, and five, the search strategy has involved criteria for selecting studies according to their importance, relevance and applicability. Knowledge and information about concepts, such as soil and ES, are continually evolving. Thus, the continual and organised review and revisit of the current, up-to-date literature throughout this research becomes a crucial practice. Besides, integrating scientific evidence to legal aspects constitutes a significant part of this research.

In chapter three, echoing the multidisciplinary elements of this research, the search terms were determined and searched on several scientific databases, namely Science Direct, Academic Search Complete, Emerald Insight, Environment Complete, GreenFILE. The terms searched on these databases are 'soil', 'soil protection', 'soil conservation', 'soil ecosystem services', 'soil functions', 'soil processes', 'soil properties', 'soil threats', 'soil erosion', 'soil contamination', 'soil pollution', 'soil sealing', 'soil compaction', 'soil organic matter loss', 'soil salinization', and 'desertification'. The number of hits can be found in the Appendix I.

The exclusion criteria in chapter three are reflected through the focus on the most recent material (published after 2000) due to the fast-changing nature of the field. The exceptions of these search criteria were the importance and relevance of the works. The contribution to the overall discussion is also considered. Both highly influential and profoundly relevant studies in the research field were included in the literature review, despite the publication date.

For the analysis in chapters four and five, black letter law methodology is adopted. Data collection for this analysis involves international, EU and UK official government

[437] Akobeng (n 395)
[438] Briner and Denyer (n 390)
[439] ibid

documents, reports and guidance, statutes, books, journals, working papers and online legal databases. A number of search terms are determined and searched on several legal databases, namely LexisNexis, HeinOnline, Westlaw, JSTOR, and the ENDS Report. The terms searched on these databases are 'soil', 'soil protection', 'soil legislation', 'soil law', 'soil conservation', 'international soil legislation', 'European soil legislation', 'UK soil legislation', 'soil policy', 'ecosystem services', 'ecosystem disservices', 'soil ecosystem services', 'soil functions', 'soil processes', 'soil properties', 'ecosystem management', 'soil threats', 'soil erosion', 'soil contamination', 'soil pollution', 'soil sealing', 'soil compaction', 'soil organic matter loss', 'soil salinization', and 'desertification'. The number of hits can be found in the Appendix I.

The exclusion criteria for chapters four and five supports the notion that law and policy are constantly evolving. Indeed, this legal analysis was generally based on the most recent literature (published after 2000). Where highly significant and relevant studies are found, these were also considered in the legal analysis.

In chapter six, the search strategy indicates the multidisciplinary approach. Data collection for this analysis involves identifying search terms and searching these on several legal and scientific databases, namely LexisNexis, HeinOnline, Westlaw, JSTOR, Science Direct, Academic Research Complete, Emerald Insight, the ENDS Report, Environment Complete, GreenFILE. The terms searched on these databases are 'soil', 'soil protection', 'soil legislation', 'soil law', 'soil conservation', 'soil policy', 'ecosystem services', 'ecosystem disservices', 'soil ecosystem services', 'ecosystem services approach', 'ecosystem approach', 'ecosystem management'. The number of hits can be found in the Appendix I.

In chapter six, the exclusion criterion is the date of the publication. Again, the recent literature (published after 2000) is considered for data extraction. Where highly significant and relevant studies are found, their importance for the discussion was recognised.

An overall exclusion criterion for chapters three, four, five and six and the literature review in chapter one comes across as a limitation in the scope of studies to be included due to the language barrier. Translation of these academic works can be time-consuming, costly and, in some cases, even inaccurate. Therefore, the exclusion of non-English sources had to be recognised.

2.5. Conclusion

This chapter has outlined the methodology adopted for this research and justified this selection. Considering the nature of this research, a multidisciplinary approach was taken. As mentioned, environmental law has multidisciplinary roots, and requires a level of understanding of other disciplines. Indeed, this study gathered scientific data and considered sociological aspects and economics as well as law. Thus, ELM was seen as the most appropriate methodology for this research as it favours a multidisciplinary approach and supports the use of the scientific practice to monitor and evaluate the desired environmental objectives. It also justifies a socio-legal study of laws from multiple perspectives – internal and external – which provides the most realistic analysis. This approach is significant as this research is interested in finding out how the law is structured but also how it is implemented and how it affects society and the environment. Finally, this chapter introduced systematic review, reflected the adoption of systematised review and presented the research strategy for each chapter.

CHAPTER THREE

The Importance of Soil

3.1. Introduction

To consider the concept of ES as a tool for a more advanced and sustainable policy for soil issues, it is crucial to demonstrate the importance of soil, soil processes, functions and ES for human survival and well-being. This step will allow for reflection on the potential approaches for integrating ES into soil protection at multiple policy levels in the later stages of this research.

Studying soils requires a holistic approach involving knowledge from other disciplines, such as biology, chemistry, geology, physics, anthropology, economics, sociology, medicine and so on.[440] However, the principal aim of this research is not to study soil science, but to understand why and how soils should be protected adequately from a legal perspective. Thus, the aim of this chapter is to determine the soil processes, functions and ES, which are crucial to fulfil the economic and societal needs of humans, and to ascertain soil threats for reflecting the need for robust soil protection. This chapter answers the questions of why soils are essential for our survival and well-being and what poses a threat to soils.

3.2. Soil and Its Properties

Soil is a highly complex and variable material,[441] which is seen as the central processing unit of the terrestrial environment.[442] It sustains physical and chemical transformations that are crucial to terrestrial life.[443] Soil circulates chemical elements (e.g., nutrient cycles), water and energy for human benefit if managed well.[444] It is also the main foundation for the Earth's biodiversity[445] as there are more species living in soils than above ground.[446]

Soil is a structured combination of organic and mineral matter.[447] It can be defined as a sand-slit-clay matrix that contains living and dead organic matter in addition to gases and liquids.[448] Its four major components are air, water, mineral matter and organic

[440] Eric C. Brevik and others, 'The Interdisciplinary Nature of Soil' (2015) 1 Soil 117
[441] Andrew Porteous, *Dictionary of Environmental Science and Technology* (3rd edn, Wiley 2000) 564
[442] Pedro A. Sanchez, 'Tropical Soil Fertility Research: Towards the Second Paradigm' (1994) 1 Transactions 15th World Congress of Soil Science 65
[443] Jónsson and Davíðsdóttir (n 166)
[444] Luca Montanarella and others, 'World's Soils are Under Threat' (2016) 2 Soil 79
[445] Jónsson and Davíðsdóttir (n 166)
[446] Blum (n 18)
[447] Daniel D. Richter and Daniel Markewitz, 'How Deep is Soil?' (1995) 45 BioScience 600
[448] David C. Coleman, Mac A. Callaham and D. A. Crossley, Jr., *Fundamentals of Soil Ecology* (3rd edn, Academic Press 2017) 9.

matter,[449] which supports life.[450] The combinations of these elements determine soil properties.[451]

Soil properties can be classified as physical and chemical properties.[452] The former includes soil colour, texture (the proportions of sand, silt and clay), structure, horizonation, consistence, water holding capacity and bulk density[453] (a measure of how compact or dense soil is).[454] The latter includes soil pH, salinity, sodicity[455] and composition of other chemicals.

Soil properties influence how soils function in an ecosystem, and affect the behaviour of soils with regards to plant growth, hydrology and agricultural and engineering uses.[456] Thus, knowledge of individual soils and soil properties is vital as humanity's survival and well-being are closely related to how the problems are being solved at different locations with different types of soils.[457] Indeed, some soil properties are inherent while others can be managed.[458] More sustainable land-use decisions can be made considering the differences among soil properties in different sites.[459] Therefore, comprehending soil properties and their relationship is crucial for soil management, highlighting the importance of including scientific knowledge into decision making.[460]

3.3. Soil Processes

Soil is produced by and its formation is reactive to organisms, climate, geologic processes, the aboveground atmosphere,[461] and anthropologic activities, such as land use and farming practices.[462] Climate affects the rate of weathering and organic decomposition, living organisms influence soil formation, topography affects drainage, erosion and deposition, parent material minerals form the basis of soil, and time alters soil properties.[463]

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[449] Brady and Weil (n 1) 13
[450] Porteous (n 441) 564
[451] Brady and Weil (n 1) 13
[452] 'Soils and Soil Physical Properties' <https://casfs.ucsc.edu/about/publications/Teaching-Organic-Farming/PDF-downloads/2.1-soilphysical.pdf> accessed 6 April 2018
[453] ibid
[454] 'Soil Physical Properties' <http://broome.soil.ncsu.edu/ssc012/Lecture/topic8.htm> accessed 6 April 2018
[455] Brady and Weil (n 1) 140
[456] ibid 98
[457] ibid 96
[458] Ian Lynn and others, *Land Use Capability Survey Handbook – a New Zealand handbook for the classification of land* (3rd edn, AgResearch, Landcare Research, GNS Science 2009)
[459] Brady and Weil (n 1) 57
[460] ibid 24
[461] Richter and Markewitz (n 488)
[462] Estelle Dominati, Alec Mackay and Murray Patterson, 'Modelling the Provision of Ecosystem Services from Soil Natural Capital' (2010) <https://www.iuss.org/19th%20WCSS/Symposium/pdf/1841.pdf> accessed 12 April 2018
[463] Queensland Government, 'How Soils Form' (8 October 2013) <https://www.qld.gov.au/environment/land/soil/soil-explained/forms> accessed 4 April 2018

Soil processes are closely related to soil properties, such as soil organic carbon, soil pH, soil biota, soil structure and aggregation and soil temperature.[464] Soil properties affect the intensity at which these processes occur and are products of these processes.[465] Indeed, soil formation is a supporting ES[466] (some argue that it is a supporting ecosystem process)[467] that gradually develop and maintain soil properties and provide the maintenance of the dynamic equilibriums underpinning soil natural capital.[468]

These various interactions of geological, hydrological and atmospheric factors[469] interact with each other and produce different types of soils[470] through four categories of soil processes.[471] These are a series of actions that generate results[472] and are classified as additions, losses, transformations and translocations.[473]

Additions describe the process of materials being added to soil profile.[474] These materials can be various, such as new mineral materials deposited by wind or water,[475] decomposing vegetation or organic matter from leaves or dust from the atmosphere.[476]

Losses occur through the action of wind or water, or uptake by plants.[477] The result is that soil particles, such as sand, silt, clay, and organic matter or chemical compounds can be eroded, leached, or harvested from the soil.[478] Erosion of surface material or leaching to groundwater can be given as examples of losses.[479] This occurrence can be a significant problem as these processes alter the chemical and physical character of the soil.[480]

Transformations are the chemical weathering of sand or silt and subsequent formation of clay minerals and change of coarse organic matter into decay resistant organic compounds, i.e., humus.[481] Another example of a transformation is the oxidation of elements in the soil, such as the oxidation of iron from Fe^{2+} to Fe^{3+}, which changes the

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464 Adhikari and Hartemink (n 9)
465 Dominati, Mackay and Patterson (n 462)
466 Finvers (n 86); Adhikari and Hartemink (n 9)
467 Dominati, Mackay and Patterson (n 462)
468 ibid
469 Coleman, Callaham and Crossley (n 448) 9
470 Queensland Government (n 463)
471 M. Krzic and others, 'Soil Formation and Soil Processes' (*The University of British Columbia*, 2008) <http://processes.soilweb.ca/> accessed 4 April 2018
472 Michael C. Duniway, Brandon T. Bestelmeyer and Arlene Tugel, 'Soil Processes and Properties That Distinguish Ecological Sites and States' 32 Rangelands 9
473 Krzic and others (n 471)
474 'Soil Genesis and Development, Lesson 4 - Soil Profile Development' (*Plant & Soil Sciences eLibrary)* <http://passel.unl.edu/pages/informationmodule.php?idinformationmodule=1130447025&topicorder=3&maxto=5> accessed 23 May 2018
475 ibid
476 Krzic and others (n 471)
477 'Soil Genesis and Development, Lesson 4 - Soil Profile Development' (n 474)
478 ibid
479 Krzic and others (n 471)
480 'Soil Genesis and Development, Lesson 4 - Soil Profile Development' (n 474)
481 Krzic and others (n 471); 'Soil Genesis and Development, Lesson 4 - Soil Profile Development' (n 474)

soil colour from grey to orange.[482] This situation is particularly common when waterlogged soils drain and become aerated again.[483]

Finally, translocation, on the one hand, mixes and adds materials and on the other separates and concentrates them.[484] It is the movement of organic or mineral soil elements within the profile and between horizons.[485] The downward movement of soil components is called eluviation, and illuviation is the deposition or accumulation of materials that has been washed down from the upper layer to the lower horizon of the soil through the process of eluviation.[486] This movement can be from one horizon to another, either up or down.[487] Such movements are carried out either by soil organisms, particularly worms and ants (bioturbation)[488] or by a mechanical effect, commonly the action of water transporting materials.[489]

These forming processes are extremely slow;[490] hence, soil formation can take thousands or millions of years.[491] It is not recoverable within a human lifespan and thus is a non-renewable natural resource.[492] However, anthropocentric activities alter soil formation processes rapidly and far-reachingly.[493] Potential threats through forced changes in soil temperature, nutrient competition, soil water[494] or rainfall pattern[495] may affect soil processes and eventually soil functions.[496] Overall, soil processes are crucial for maintaining ecosystem functioning and the continuous flow of several ES.[497]

3.4. Soil Functions

Soils are dynamic three-dimensional regulatory systems that generate a multitude of environmental, social and economic functions.[498] A significant initiative for soil

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482 Christopher Craft, *Creating and Restoring Wetlands: From Theory and* Practice (Elsevier 2015) 29
483 ibid 29
484 'Translocation' <http://www.edafologia.net/miclogia/translow.htm> accessed 13 May 2018
485 'Soil Genesis and Development, Lesson 4 - Soil Profile Development' (n 474)
486 Willy Verheye, 'Soils and Soil Sciences' in W. H. Verheye (ed), *Land Use, Land Cover and Soil Sciences* (UNESCO-EOLSS Publishers 2007)
487 Krzic and others (n 471)
488 Murray K. Gingras and A. George Pemberton and Michael Smith, 'Bioturbation: Reworking Sediments for Better or Worse' (2015) 26 Oilfield Review 46
489 'Translocation' (n 484)
490 Queensland Government (n 463)
491 Rebecca Hirsch, *Soil – Rocks and Minerals* (ABDO 2014) 16; David Pimentel and others, 'Economic and Environmental Benefits of Biodiversity' (1997) 47 BioScience 747
492 Food and Agriculture Organization of the United Nations, 'Soil Is a Non-Renewable Resource' <http://www.fao.org/3/a-i4373e.pdf> accessed 14 May 2018
493 Jonathan Sandor, Charles Lee Burras and Michael L. Thompson, 'Factors of Soil Formation: Human Impacts,' in Daniel Hillel (ed) *Encyclopedia of Soils in the Environment* (Academic Press 2005)
494 Arvin R. Mosier, 'Soil Processes and Global Change' (1998) 27 Biology and Fertility of Soils 221
495 Bridget A. Emmett and others, 'The Response of Soil Processes to Climate Change: Results from Manipulation Studies of Shrublands Across an Environmental Gradient' (2004) 7 Ecosystems 625
496 ibid
497 Jorg Rombke and others, 'Legislation and Ecological Quality Assessment of Soil: Implementation of Ecological Indication Systems in Europe' (2005) 62 Ecotoxicology and Environmental Safety 201
498 Blum (n 18)

functions was the European Commission's Soil Protection Strategy.[499] This strategy was not adopted; however, it drew the public's attention to soil functions, and placed this concept on the political agenda.[500] Soil functions in the strategy were outlined as: production of food and biomass, storage, filtering and transformation of compounds, habitats for living creatures and gene pools, the physical and cultural environment, source of raw materials, carbon pool, and the archive of geological and archaeological heritage.[501]

It is important to note that the Commission's classification is not the only framework available. There are multiple classifications for soil functions in the literature. The ground-breaking work of Blum categorised soil functions into two groups:[502] Ecological and non-ecological functions.[503] Ecological functions are shown as biomass production, protection of humans and the environment and gene reservoir.[504] The second group comprises of the physical basis for human activities, source of raw materials and geogenic and cultural heritage.[505]

Some of these classification studies are not precisely focused on soil. However, ecosystem function classifications also apply to soils. A commonly accepted framework by De Groot, Wilson and Boumans grouped ecosystem functions in four categories:[506] Regulation functions that regulate essential ecological processes and life support systems, habitat functions that provide refuge and reproduction habitat to wild plants and animals, production functions that deliver food, raw materials, medicinal resources, and information functions that offer opportunities for reflection, cognitive development, recreation and aesthetic experience.[507] They identified twenty-three functions in these four primary categories, specified the corresponding processes and services, and remarked that processes and services do not always show a one-to-one correspondence.[508] As mentioned before, soil formation was categorised as a supporting process by some authors,[509] while others categorised it as a supporting ES.[510] De Groot, Wilson and Boumans characterised soil formation as a regulation function that occurs as a result of a

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[499] European Commission, 'Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions – Thematic Strategy for Soil Protection' (Communication) COM (2006) 231 final
[500] Greiner and others (n 255)
[501] European Commission (n 499)
[502] Blum (n 18)
[503] ibid
[504] ibid
[505] ibid
[506] De Groot, Wilson and Boumans (n 170)
[507] ibid
[508] ibid
[509] Dominati, Mackay and Patterson (n 462)
[510] Finvers (n 86); Adhikari and Hartemink (n 9)

number of processes, e.g., weathering of rock and accumulation of SOM.[511] They argued that this function produces ES, such as the maintenance of natural productive soils.[512] Similarly, soil retention is categorised as a regulation function that provides ES such as prevention of damage from erosion.[513]

The lack of consensus on classification schemes and terminology of these concepts are striking in the literature.[514] To avoid confusion, it is essential to establish the meaning of these concepts, emphasise the difference between them, and describe the relationship with each other.[515] To achieve this, the present study provides a classification table for soil functions and ES, which is adapted from a range of studies[516] (Table 3.1.). This table classifies soil functions and relevant ES into four categories in line with the common approach in the literature.[517] As mentioned, soil functions support and determine the delivery of ES, which are the final goods or products that directly impact on humans.[518]

[511] De Groot, Wilson and Boumans (n 170)
[512] ibid
[513] ibid
[514] Schwilch and others (n 163)
[515] ibid
[516] Costanza and others (n 69); Millennium Ecosystem Assessment (n 79); Barrios (n 267); Phillip Haygarth and Karl Ritz, 'The Future of Soils and Land Use in the UK: Soil systems for the provision of land-based ecosystem services' (2009) 26 Land Use Policy S187
[517] Costanza and others (n 69), Millennium Ecosystem Assessment (n 79)
[518] Millennium Ecosystem Assessment (n 21)

Table 3.1. The relationship between soil ecosystem services and soil functions.

This table shows main soil ES and how these services are related to soil functions. This table also categorises these services under four different groups, namely provisioning, regulating, cultural and supporting services, adopting the approach from MEA classification[519] and considering other significant works in the field.

	Group	Ecosystem Services	Soil Functions	Examples
1	Provisioning	Food production	Provisioning plant growth	Provisioning for crops and livestock for farming
2	Provisioning	Water storage	Retention of water in landscape	Retention of water in pore network
3	Provisioning	Platform	Supporting structure for human occupation	Housing, industry, infrastructure
4	Provisioning	Biomass and raw materials	Provisioning source materials	Topsoil, mineral, aggregates extraction, fodder, fuel, timber
5	Provisioning	Biodiversity, gene pool and genetic resources	Sources of unique biological materials and products	Medical products, genes for resistance to pathogens and pests, ornamental species
6	Provisioning	Refugia/refuge	Providing habitat for resident and transient populations	Habitat for migratory species, regional habitats for locally harvested species
7	Regulating	Water quality regulation	Filtration and buffering of water	Clean drinking water for humans and good ecological status of rivers, lakes and seas
8	Regulating	Water supply regulation	Regulation of hydrological flows	Provisioning of water for agricultural (e.g., irrigation) or industrial (e.g., milling) processes, transportation, flood control
9	Regulating	Gas and climate regulation	Regulation of atmospheric chemical composition and global temperature, precipitation, and other climatic processes	CO_2/O_2 balance, O_3 for UVB protection, and SO_x levels, GHG regulation
10	Regulating	Carbon sequestration	Trapping of carbon as a storage area	Storing carbon for long periods
11	Regulating	Erosion control and sediment retention	Soil and colloid retention within an ecosystem	Prevention of loss of soil by wind, runoff, or other removal processes, retention of soil on hillslopes and in wetlands
12	Cultural	Recreation	Providing a platform for recreational activities	Eco-tourism, sports
13	Cultural	Cognitive	Providing opportunities for non-commercial uses	Aesthetic, educational, spiritual or scientific value of an ecosystem
14	Cultural	Heritage	Preserving archaeological record of terrestrial occupancy	Preservation or destruction of archaeological records of early civilisations
15	Supporting	Primary production	Supporting terrestrial vegetation	Support for principal photoautotrophs, which are organisms that carry out photosynthesis
16	Supporting	Nutrient cycling	Storage, internal cycling, processing and acquisition of nutrients	Nitrogen fixation, N, P and other elemental or nutrient cycles

[519] ibid

3.5. The Relationship Among Soil Processes, Properties, Functions and Ecosystem Services

MEA classified ES into four categories: those associated with the provision of goods, those that support life on the planet, those derived from benefits of regulation of ecosystem processes and those cultural services that are not associated with material benefits.[520] Soil processes support the provision of some ES through maintaining healthy and functioning soils,[521] and represent the capacity of soils to function to deliver these services.[522]

Soil functions are essential for the biosphere.[523] The capacity of soils to provide ES is essentially determined by its functions, and each individual soil function offers a soil-related contribution to ES.[524] Indeed, soil functions are directly linked to ES,[525] they support[526] and determine the delivery of these services[527] and thus, vital for accommodating the essential needs and demands of human-beings.[528] The concept of soil functions is accepted to place value on the role soils play in sustaining the wellbeing of humans and of society in general.[529] However, it is important to emphasise that ecosystem functions occur whether or not there are any humans who may benefit from them,[530] which is a significant difference between services and functions.

Distinguishing the terms 'function' and 'process' is difficult.[531] Inevitably, debate revolves around the definitions of these concepts.[532] The traditional definition of ecosystem function is the role the ecosystem plays in the environment, however recently,[533] especially in soil science,[534] the term has been used as a synonym for 'ecosystem process'.[535]

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520 Millennium Ecosystem Assessment (n 79)
521 Dominati, Patterson and Mackay (n 257)
522 Schwilch and others (n 163)
523 Raffaela M. Balestrini and others, 'Plant-Soil Biota Interactions' in Eldor A. Paul (ed), *Soil Microbiology, Ecology and Biochemistry* (4th edn, Academic Press 2015)
524 Bouma (n 13); Greiner and others (n 255)
525 Bouma (n 13)
526 Ian Hannam and Ben Boer, *Drafting Legislation for Sustainable* Soils (IUCN 2004); Adhikari and Hartemink (n 9)
527 Adhikari and Hartemink (n 9)
528 Bhim B. Ghaley, John R. Porter and Harpinder S. Sandhu, 'Soil-based Ecosystem Services: A Synthesis of Nutrient Cycling and Carbon Sequestration Assessment Methods' (2014) 10 Intl J Biodiversity Sci Eco Serv Mgt 177
529 Greiner and others (n 255); Bouma (n 13); Haygarth and Ritz (n 516)
530 Heather Tallis and Stephen Polasky, 'Mapping and Valuing Ecosystem Services as an Approach for Conservation and Natural-Resource Management' (2009) 265 Annals of the New York Academy of Sciences 1162
531 Dominati, Patterson and Mackay (n 257)
532 ibid
533 Wallace (n 126)
534 Dominati, Patterson and Mackay (n 257)
535 Wallace (n 126)

One of the most common confusions is that there is no clear distinction between ecosystem functions and services.[536] Functions are the intermediate means that are necessary and beneficial to the end product of ES.[537] On the other hand, ES refer to the final services provided by ecosystem conditions and processes that are direct benefit to human beings.[538] When the classification framework blurs the ends with the means,[539] e.g., when intermediate and final ES are shown within the same class[540] double-counting occurs resulting in inaccurate during ES valuation and measurement.[541] Not all the frameworks classify these concepts under the same scheme resulting in inconsistency, which is the main reason of double-counting.[542]

Another problem is that these frameworks do not do justice to the role of soils in the provision of ES.[543] The most striking example of this is that soil is excluded in the commonly-accepted TEEB classification framework.[544] The review of the existing literature on ES studies shows the following: Both soils and soil ES are commonly disregarded in ES research.[545] This neglect results in soil ES being overlooked in policy and decision making.[546] While some regulating services, such as carbon sequestration, climate and gas regulation, are studied.[547] Cultural services are mostly absent in ES studies.[548] Most studies in ES research focused particularly on provisioning ES relating to soil physio-chemical properties, ignoring other ES.[549] Supporting services are commonly subject to research related to physio-chemical and biological properties.[550] It can be argued that the vital contribution of soils to human well-being beyond food-production needs more appreciation,[551] which requires linking soils to their services and functions in ES frameworks.[552]

[536] Bo-Jie Fu and others, 'Double Counting in Ecosystem Services Valuation: Causes and Countermeasures' (2011) 26 Ecological Research 1
[537] ibid
[538] ibid
[539] Jónsson and Davíðsdóttir (n 166)
[540] ibid
[541] Dominati, Patterson and Mackay (n 257)
[542] Fu and others (n 536)
[543] Dominati, Patterson and Mackay (n 257)
[544] Jónsson and Davíðsdóttir (n 166)
[545] Adhikari and Hartemink (n 9)
[546] Dominati, Patterson and Mackay (n 257)
[547] Adhikari and Hartemink (n 9)
[548] ibid
[549] ibid
[550] ibid
[551] Alex McBratney, Damien J. Field and Andrea Koch, 'The Dimensions of Soil Security' (2014) 213 Geoderma 203
[552] Dominati and others (n 13); Robinson and others (n 176)

However, only a few studies have linked soil properties to ES.[553] As mentioned before, soil functions are driven[554] and affected by soil properties.[555] Therefore, soil ES are dependent on soil properties and their complex and various interactions.[556] Accordingly, ES are highly influenced by the soil's use and management, which is determined considering soil properties.[557] Overall, the successful management of soil requires a good understanding of,[558] and more focus on these relationships in ES frameworks. [559]

As discussed, policy makers and society must recognise that soil regulates many natural processes and provides essential functions and services.[560] The role of soils to fulfil vital functions for humans and the environment should be reflected in the policy and decision making.[561] There is a need for scientific knowledge and perception in developing such frameworks as natural resource management policies cannot be developed relied on mere legal understanding. Indeed, scientists can provide scenarios and clarify which impacts may occur when specific options are selected.[562]

The absence of soil ES in policy and ES studies[563] threaten the flow of these ES.[564] This neglect may inevitably jeopardise sustainability.[565] In the ES community, soils are frequently referred to as 'NC stocks' to value and quantify their contributions to ES.[566] NC is seen as a stock through its several functions, a flow of goods and services into the future.[567] It is maintained that the economies of the Earth would grind to a halt without ES which makes their total value infinite.[568] Indeed, no NC implies zero human welfare because it is not feasible to substitute manufactured capital for NC.[569] Therefore, the value of these ES to humans is immense.[570] Potential changes in NC and ES will alter the costs or benefits of maintaining human welfare for future generations.[571]

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553 Adhikari and Hartemink (n 9)
554 Manuel Delgado-Baquerizo and others, 'Relative Importance of Soil Properties and Microbial Community for Soil Functionality: Insights From a Microbial Swap Experiment' (2016) 30 Functional Ecology 1862
555 Brady and Weil (n 1) 24
556 Adhikari and Hartemink (n 9)
557 ibid
558 Brady and Weil (n 1) 24
559 Adhikari and Hartemink (n 9)
560 Greiner and others (n 255)
561 ibid
562 Blum (n 18)
563 Grêt-Regamey and others (n 285)
564 Bardy Prado and others (n 290)
565 Costanza and others (n 69)
566 Hewitt and others (n 295); Robinson, Lebron and Vereecken (n 13)
567 Costanza and others (n 69); Jónsson and Davíðsdóttir (n 166)
568 Costanza and others (n 69)
569 ibid
570 ibid
571 Norgaard (n 121); Costanza and others (n 69)

Soil, undeniably, is a critical element to global sustainability issues, such as climate change, biodiversity loss, water, food and energy security and hunger eradication.[572] However, SDGs for the period 2015–2030 did not give sufficient consideration to the significance of soils and its services.[573] It is argued that future soil and ES research should focus on soil functions considering sustainability and SDGs,[574] and including soil in environmental policy for societal benefits and environmental sustainability is needed.[575]

ES can be used as a tool to link the functions of soil and human well-being.[576] As ES provide a significant amount of the total contributions to human well-being,[577] NC stock that provides ES must be considered in making decisions[578] through reflecting the importance and value of ES by applying ES research results to real-world issues.[579] In order to achieve this, the ES framework must be made credible, replicable and scalable.[580] Especially, ES quantifications must be transparent and accurate so that they can be accepted and applied with confidence by policy makers.[581] This step requires consensus on a common classification and valuation framework to eliminate the abovementioned challenges.

Thus far, this chapter highlighted the importance of soil and soil ES.[582] Any risks to soils also threaten ecosystem sustainability,[583] the delivery of ES,[584] and eventually the well-being of the current and future generations.[585] The next section will provide an overview of significant soil threats that put soils under pressure.

3.6. Threats Against Soils

Soil degradation is defined as the decline in soil condition[586] and the change in soil health status resulting in a reduced ecosystem capacity to provide goods and

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572 Hartemink and McBratney (n 24); Bouma and McBratney (n 9)
573 Adhikari and Hartemink (n 9); Bouma and McBratney (n 9)
574 Adhikari and Hartemink (n 9)
575 Bouma (n 13); Daily et al. (1997); Dominati and others (n 13); Robinson, Lebron and Vereecken (n 13); Adhikari and Hartemink (n 9)
576 Grêt-Regamey and others (n 285)
577 Costanza and others (n 69)
578 ibid
579 Daily and others (n 65)
580 ibid
581 Greiner and others (n 255)
582 Jónsson and Davíðsdóttir (n 166)
583 Adhikari and Hartemink (n 9)
584 ibid
585 Costanza and others (n 69); Haygarth and Ritz (n 516); Barrios (n 267)
586 Office of Environment and Heritage, ‘Soil Degradation’ (July 2018) <https://www.environment.nsw.gov.au/topics/land-and-soil/soil-degradation> 12 February 2019

services.[587] Soil degradation is a serious global development issue.[588] Indeed, land degradation neutrality is suggested as a target in the SDGs.[589] However, a third of all soils are already considered degraded, mainly due to wind and water erosion, pollution, sealing, compaction, SOM and nutrient depletion, salinisation and desertification.[590] Improper management of soils causes more vulnerability to soil degradation,[591] and worsens soil properties.[592] Accordingly, these threats risk soil processes and functions, thereby the continuous flow of ES.[593] Changes in soil functions remain for extended periods of time, and the efforts to restore deteriorated soil very often fail.[594]

Eliminating soil threats for sustainable soils, continuous soil functions and the flow of soil ES is thus essential.[595] As soil degradation cannot be accounted for only by natural reasons, social, economic and political dynamics should be regulated.[596] Indeed, the adverse impacts of these threats are argued to be intensified in future, unless individuals, the private sector, governments and international organisations do not take actions to halt soil degradation.[597]

The rest of this chapter will provide a brief description of significant soil threats and an overview of their impacts on soil and soil ES.

3.6.1. Soil Erosion

Erosion can be described as wearing away of the land surface by physical forces, such as rainfall, flowing water, wind, ice, temperature change, and gravity that scrape, separate and remove solid particles that are sediments from one point.[598] Although it is a natural process,[599] it can be intensified by unsustainable agricultural and management

587 Food and Agriculture Organization of the United Nations, 'Soil Degradation' (*FAO Soils Portal*) <http://www.fao.org/soils-portal/soil-degradation-restoration/en/> accessed 10 February 2019
588 Chen Jie and others, 'Soil degradation: a global problem endangering sustainable development' (2002) 12 Journal of Geographical Sciences 243
589 ibid
590 Food and Agriculture Organization of the United Nations (n 16)
591 Gunal and others (n 18)
592 Rainer Horn and others, 'Soil Compaction Processes and Their Effects on the Structure of Arable Soils and the Environment' (1995) 35 Soil and Tillage Research 23
593 Food and Agriculture Organization of the United Nations (n 588)
594 Horn and others (n 592)
595 Gunal and others (n 18)
596 ibid
597 Montanarella and others (n 444)
598 Ezio Rusco, Luca Montanarella and Claudio Bosco, 'Soil Erosion: A Main Threat to the Soils in Europe' in Gergely Tóth, Luca Montanarella and Ezio Rusco (eds) *Threats to Soil* (2008) JRC Scientific and Technical Reports EUR 23438 <http://publications.jrc.ec.europa.eu/repository/bitstream/JRC46574/eur_23438.pdf> accessed 12 April 2018; Alexandre Marco da Silva, Clayton Alcarde Alvares and Claudia Hitomi Watanabe, 'Natural Potential for Erosion for Brazilian Territory' in Danilo Godone (ed) *Soil Erosion Studies* (IntechOpen 2011)
599 'Threats to the Soil' (*The Environmental Literacy Council*) <https://enviroliteracy.org/land-use/soil/threats-to-the-soil/> accessed 9 July 2018

practices, such as overgrazing, deforestation or construction activities.[600] Erosional changes impact a large part of the Earth surface, and its acceleration is one of the most serious threats to soil.[601]

There are several on-site effects of erosion,[602] which interact with each other.[603] When soil is lost from agricultural land, soil structure breaks down and cultivable soil depth reduces.[604] As SOM level is highest in the upper part of the soil, microbial activity that is dependent on it and which is essential to soil processes, is diminished.[605] Thus, erosion reduces soil quality through loss of SOM, and declines soil fertility.[606] Inevitably, productivity is lost as vegetative growth is impeded.[607] The decrease in soil fertility also has economic effects, such as increasing the expenditures on fertilisers to maintain yields.[608] Otherwise, the decrease in productivity can result in the abandonment of land reducing food production and risking food security.[609] Additionally, erosion leads to the reduction in soil moisture resulting in more drought-prone soil[610] and it also decreases the abundance of soil biota and biodiversity.[611] Finally, anthropocentric perturbation such as tillage, i.e., mechanical modification of soil structure,[612] intensifies the impacts of erosion.[613] It loosens the soil and leaves bare soil after ploughing, placing soil particles at risk of being blown or washed away by the action of wind and rain.[614] The latter has additional implications for the aquatic environment, especially when gravel beds that fish need to spawn in is clogged with the eroded soil.[615]

Erosion, indeed, has off-site impacts on the environment.[616] The motion of sediments can block irrigation canals, shortens the lifespan of reservoirs, reduce the capacity of rivers and drainage ditches, and increase the danger of flood.[617] Sediments can be harmful for waterbodies as it is, in fact, a pollutant increasing the nitrogen and

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600 Panos Panagos and others, ‘Estimating the Soil Erosion Cover-Management Factor at the European Scale’ (2015) 48 Land Use Policy 38; Rusco, Montanarella and Bosco (n 598); Glæsner, Helming and de Vries (n 43)
601 Danilo Godone (ed), *Soil Erosion Studies* (IntechOpen 2011)
602 R. P. C. Morgan, *Soil Erosion and Conservation* (3rd edn, Wiley 2009) 1
603 David Pimentel, ‘Soil Erosion: A Food and Environmental Threat’ (2006) 8 Environment, Development and Sustainability 119
604 Morgan (n 602) 1
605 ibid 1
606 ibid 1
607 ibid 1
608 ibid 1
609 ibid 1
610 Pimentel (n 603)
611 ibid
612 ‘Tillage’ (*Soil Quality for Environmental Health*) <http://soilquality.org/practices/tillage.html> accessed 2 February 2019
613 Rattan Lal, ‘Soil Degradation by Erosion’ (2001) 12 Land Degradation and Development 519
614 ‘Frequent tillage and its impact on soil quality’ <https://crops.extension.iastate.edu/encyclopedia/frequent-tillage-and-its-impact-soil-quality> accessed 15 July 2021
615 ibid
616 Morgan (n 602) 1
617 ibid 1

phosphorus levels.[618] Furthermore, erosion is seen as a contributor of climate change[619] as throughout the process of the breakdown of soil aggregates, the carbon that is held between the primary particles of soil is released and oxidised into the atmosphere as CO_2.[620]

Erosion is not only resulted in soil and SOM loss,[621] or intensified pollution and desertification,[622] but also causes loss of most soil functions[623] and ES which are mostly overlooked in the assessments of the significance of erosion.[624] These impacts result in threats to soil ES and aquatic ES.[625] In the twentieth century, the main concern was the effects on food production.[626] However, now there are additional concerns, such as reduction of soil carbon, the movement of nitrogen, the removal of phosphorus in soluble and particulate forms and the reduction of landscape quality due to erosion.[627] The most destructive impacts of erosion are seen on soil biodiversity and physical platform for human occupation.[628] The impacts of erosion on other ES can be found in Table 3.2.

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[618] ibid 1
[619] ibid 1
[620] ibid 1
[621] 'Organic Matter Decline' (*Sustainable Agriculture and Soil Conservation – Soil Degradation Processes*) Fact Sheet No.3 <https://esdac.jrc.ec.europa.eu/projects/SOCO/FactSheets/ENFactSheet-03.pdf> accessed 10 February 2019
[622] Gudrun Schwilch and others, 'Soil Functions & Ecosystem Services' (2015) <http://eprints.glos.ac.uk/3581/7/Soil%20Functions%20%26%20Ecosystem%20Services.pdf> accessed 2 December 2018
[623] Lal (n 613)
[624] Gary S. Bilotta, Magdalena Grove and Simon Marius Mudd, 'Assessing the Significance of Soil Erosion' (2012) 37 Trans Inst Br Geogr NS 342
[625] ibid
[626] Morgan (n 602) vii
[627] ibid vii
[628] Schwilch and others (n 622)

Table 3.2. Interaction among main soil threats and soil ecosystem services.

This table shows the interaction between the soil threats studied in this research and soil ES introduced in Table 3.1., considering significant works in the field.[629] These interactions are presented as high negative influence (- - -), medium negative influence (- -), low negative influence (-), negative influence but level not known (-?), no evident data (?), no apparent influence (x), potential positive influence (+).

Ecosystem Services	Soil Threats						
	Erosion	Pollution	Sealing	Compaction	Organic Matter Loss	Salinisation	Desertification
Food production	- -	- - -	- - -	- - -	- - -	- - -	- - -
Water storage	-	- -	- - -	- - -	- - -	-	- - -
Platform	- - -	x	+	x	x	-	-
Biomass and raw materials	- -	-	+	x	-	x	-
Biodiversity, gene pool and genetic resources	- - -	- - -	- - -	-	- - -	- - -	- - -
Refugia/refuge	-?	-?	-?	-?	-?	-?	-?
Water quality regulation	-	- -	- - -	- - -	- - -	-	- - -
Water supply regulation	-	- -	- - -	- - -	- - -	-	- - -
Gas and climate regulation	-?	-?	-?	- - -	- - -	-?	-?
Carbon sequestration	-?	-?	-?	-?	-?	-?	-?
Erosion control and sediment retention	-?	-?	-?	-?	-?	-?	-?
Recreation	-?	-?	?	x	x	x	?
Cognitive	-?	-?	?	?	x	x	?
Heritage	-	x	- +	x	- - -	x	-

[629] Gilles Grandjean and others, 'DIGISOIL: An Integrated System of Data Collection Technologies for Mapping Soil Properties' in R.A. Viscarra Rossel and others (eds), *Proximal Soil Sensing Progress in Soil Science 1* (Springer 2010); Schwilch and others (n 622)

Primary production	- -	- - -	- - -	- - -	- - -	- - -	- - -
Nutrient cycling	-?	-?	-?	-?	-?	-?	-?

3.6.2. Soil Pollution

Soils are both the source and sink of contaminants.[630] Contamination occurs when a substance is released into soils.[631] This may or may not be harmful.[632] However, if the concentration of the contaminants rises above a certain level, and the presence of these substances place adverse effects on soil organisms, soil pollution occurs.[633] However, there is confusion over the definition and correct use of the terms of ‘contamination’ and ‘pollution’. For the purposes of this research, considering the interchangeable use of contamination and pollution in legal documents, these terms will be used in the manner as described.

Soil can be polluted by agrochemical sources (e.g., fertilisers, pesticides, and manure), urban sources (e.g., electric power stations, gas works, transport, sewage sludge, and waste disposal), industrial sources (e.g., mining and smelting), atmospheric sources (e.g., wind-blown pollutants) and incidental sources (e.g., explosive, poisonous gases, accidents).[634]

There are serious environmental consequences of pollution, such as impeded metabolic processes, reduced plant growth, toxicity and eventually plant death.[635] Also, evidence shows that the heavy use of contaminants threatens food security and clean water provision.[636] These toxic elements accumulate within living organisms and enter the human system through the food chain, where they can cause perturbation to biological reactions, long-lasting harm to vital organs or even death.[637] In addition to the risks to human health through industrial waste contaminating drinking water, soil and food,[638] pollution may cause loss and reduction of other soil functions, such as the productivity

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[630] Zhu and Meharg (n 274)
[631] ‘Soil Contamination’ (*RECARE*) <https://www.recare-hub.eu/soil-threats/contamination#what> accessed 13 April 2018
[632] Food and Agriculture Organization of the United Nations, ‘Soil Pollution: A Hidden Reality’ (2018) <http://www.fao.org/3/I9183EN/i9183en.pdf> accessed 4 July 2018
[633] ibid; Armando C. Duarte, Anabela Cachada and Teresa Rocha-Santos, *Soil Pollution: From Monitoring to Remediation* (Academic Press 2018); Hannah Shayler, Murray McBride and Ellen Harrison, ‘Sources and Impacts of Contaminants in Soils’ (*Cornell Waste Management Institute*, 15 April 2009) <http://cwmi.css.cornell.edu/sourcesandimpacts.pdf> accessed 13 April 2018
[634] Ibrahim A. Mirsal, *Soil Pollution: Origin, Monitoring and Remediation* (Springer 2004) 138
[635] Food and Agriculture Organization of the United Nations (n 632)
[636] ibid
[637] B. A. Stewart and others (eds), *Advances in Soil Science, Volume 9* (illustrated edn, Springer 2012)
[638] Panos Panagos and others, ‘Contaminated Sites in Europe: Review of the Current Situation Based on Data Collected through a European Network’ (2013) Journal of Environmental and Public Health Article ID 158764 <https://www.hindawi.com/journals/jeph/2013/158764/> accessed 14 April 2018

and capacity of soil to support, store and filter substances and to transform contaminants in soil water.[639] Especially, as some contaminants such as heavy metals do not disintegrate through physical processes, and remain in the ecosystem for an extended period of time, a significant risk for the well-being of both the existing and future generations occurs.[640] Finally, there is a strong correlation between pollution and erosion. A decline in aggregate stability and loss of SOM caused by soil contaminants intensifies the erodibility of soils.[641] Overall, pollution has adverse impacts (as seen in Table 3.2.); however, its most significant influence is on biodiversity and food and biomass production.[642]

3.6.3. Soil Sealing

Soil sealing, another significant and irreversible cause of soil degradation,[643] is the covering[644] or destruction of the ground by a partly or entirely impermeable material, such as asphalt and concrete.[645] Significant causes of sealing are the need for new housing, business locations and transport infrastructure.[646]

In earlier times, land use was mostly determined by the functions that natural soil could perform.[647] Due to technological developments, this relationship between soil functions and land use has vanished to an extent,[648] as there are competing interests in land use due to the fact that sealed areas have exceptional contributions to the gross national product of a country.[649]

Sealing, on the other hand, has adverse impacts on soils.[650] Often the most fertile soils are sealed,[651] thus commonly productive agricultural land is impacted upon.[652] This outcome poses an additional risk of flooding, landslides and water scarcity.[653] Sealing as a result of construction work may lead to soil compaction due to the use of heavy

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639 'Soil Contamination' (n 631)
640 A. Kassasi and others, 'Soil Contamination by Heavy Metals: Measurements From a Closed Unlined Landfill' (2008) 99 Bioresource Technology 8578
641 'Soil Contamination' (n 631)
642 Schwilch and others (n 622)
643 'Soil Sealing' (*RECARE*) <https://www.recare-hub.eu/soil-threats/sealing> accessed 13 April 2018
644 European Commission, 'Soil Sealing' (*Environment,* 8 June 2016) <http://ec.europa.eu/environment/soil/sealing_guidelines.htm> accessed 14 April 2018
645 European Commission (n 644)
646 ibid
647 Riccardo Scalenghe and Franco Ajmone Marsan, 'The Anthropogenic Sealing of Soils in Urban Areas' (2009) 90 Landscape and Urban Planning 1
648 ibid
649 Wolfgang Burghardt, 'Soil Sealing and Soil Properties Related to Sealing' in E. Frossard, W. E. H. Blum and B. P. Warkentin (eds), *Function of Soils for Human Societies and the Environment* (Geological Society of London 2006)
650 ibid
651 ibid
652 European Commission (n 644)
653 ibid

machinery.[654] Besides, urbanisation is found elevating the contents of pollutants in the soil, whilst in some cases sealing inactivates or prevents dispersion of the contaminants.[655]

Sealing also causes partial or total loss of soils[656] and inevitably, has major impacts on many soil functions and related ES[657] (Table 3.2.). The highest negative influence of sealing is seen on food and biomass production, storing, filtering and buffering of water and soil biodiversity.[658] It is also worth mentioning that sealing has positive effects on a number of soil functions, namely platform for human occupation.[659] Also, sealing can positively contribute to cultural heritage, whilst destroying the existing archaeological record.[660]

3.6.4. Soil Compaction

Compaction is the compression of soil particles into a smaller volume reducing the size of pore space available for water and air,[661] bringing them into closer contact with each other, thereby increasing the bulk density (the mass of dry soil per unit volume).[662] Location and rationalising compaction can be difficult as it may show no apparent marks on the soil surface.[663]

Both natural soil-forming processes and anthropocentric activities can lead to compaction.[664] These anthropocentric reasons include inappropriate overuse of heavy machinery in agricultural practices,[665] intensive cropping or grazing, short crop rotations,[666] or tillage equipment during soil cultivation.[667] It can also occur in building sites and recreational areas.[668] Inappropriate soil management intensifies its adverse impacts.[669]

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[654] ibid
[655] Schwilch and others (n 622)
[656] Burghardt (n 649)
[657] European Commission (n 644); Martina Artmann, 'Assessment of Soil Sealing Management Responses, Strategies, and Targets Toward Ecologically Sustainable Urban Land Use Management' (2014) 43 AMBIO 530
[658] Schwilch and others (n 622)
[659] ibid
[660] ibid
[661] 'Agricultural Soil Compaction: Causes and Management' (*Alberta Agriculture and Forestry*, October 2010) <https://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex13331> accessed 13 July 2018
[662] *Glossary of Soil Science Terms* (spi edn, Soil Science Society of America 2008) 8
[663] M. A. Hamza and W. K. Anderson, 'Soil Compaction in Cropping Systems: A Review of the Nature, Causes and Possible Solutions' (2005) 82 Soil & Tillage Research 121
[664] 'Agricultural Soil Compaction: Causes and Management' (n 661)
[665] Environment & Resources Authority, 'Soil Degradation Threats' <https://era.org.mt/topic/soil-degradation-threats/> accessed 9 July 2018
[666] Hamza and Anderson (n 663)
[667] 'Agricultural Soil Compaction: Causes and Management' (n 661)
[668] Environment & Resources Authority (n 665)
[669] Hamza and Anderson (n 663)

Soil compaction inevitably affects soil physical properties, such as pore size distribution and pore continuity.[670] As most soil functions and ES relate to the characteristics of the soil pore system, compaction adversely influence most soil functions and ES (Table 3.2.).[671] It has adverse impacts on soil physical fertility, mainly storage and supply of water and nutrients.[672] It also increases bulk density and soil strength, and decreases porosity, decreased soil water infiltration, and water holding capacity,[673] and soil aeration.[674] These negative effects can also reduce fertiliser efficiency,[675] and weaken crop emergence, root penetration, crop nutrient and water uptake, leading to depressed crop yield.[676] Thus, compaction is argued to be a major threat to agricultural productivity.[677] Moreover, compacted soil may contribute to global warming due to increased emission of GHG, such as carbon dioxide, methane and nitrous oxide.[678] In sum, compaction has dramatic economic and environmental consequences in world agriculture.[679] Compaction can also increase the risk of soil erosion by altering the infiltration and storage capacities of soil.[680] It also results in increased vulnerability to desertification. In addition, compaction can also have an adverse effect on hydraulic conductivity preventing salt from being leached from surface layers and intensify an existing salinisation issue.[681]

3.6.5. Soil Organic Matter Loss

SOM is defined as the living component of the soil (roots, micro-organisms, animals and plants)[682] and its total organic content after exclusion of non-decayed remains of plants and animals.[683] SOM loss occurs due to two types of factors:[684] natural factors, such as climate, soil parent material, land cover or vegetation and anthropocentric factors,

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670 Horn and others (n 592)
671 Jill L. Edmondson and others, 'Are Soils in Urban Ecosystems Compacted? A Citywide Analysis' (2011) 7 Biol. Lett. 771; Stolte and others (n 20)
672 Hamza and Anderson (n 663)
673 ibid
674 Ewa A. Czyz, 'Effects of Traffic on Soil Aeration, Bulk Density and Growth of Spring Barley' (2004) 79 Soil and Tillage Research 153
675 Hamza and Anderson (n 663)
676 'Agricultural Soil Compaction: Causes and Management' (n 661)
677 Environment & Resources Authority (n 665)
678 Horn and others (n 592)
679 B.D. Soane and C. van Ouwerkerk, 'Chapter 1 - Soil Compaction Problems in World Agriculture' (1994) 11 Developments in Agricultural Engineering 1
680 'Agricultural Soil Compaction: Causes and Management' (n 661)
681 'Soil Compaction' (*RECARE*) <http://www.recare-hub.eu/soil-threats/compaction> accessed 18 April 2018
682 Agriculture Victoria, 'Organic Matter' (*Victorian Resources Online*, 31 January 2019) <http://vro.agriculture.vic.gov.au/dpi/vro/vrosite.nsf/pages/soilhealth_organic#> accessed 12 February 2019
683 'What Is Loss of Organic Matter in Mineral Soils?' (*RECARE*) <http://www.recare-hub.eu/soil-threats/loss-of-organic-matter-in-mineral-soils> accessed 13 April 2018
684 Environment & Resources Authority (n 665)

such as land use, soil management and degradation.[685] Therefore, choosing the right land use options and effective management of soils can prevent or reverse SOM loss.

It is argued that the global level of existing SOM should be increased or at least stabilised[686] because, there is evidence that SOM is critical for soil health, productivity[687] and fertility.[688] Hence, the maintenance of SOM levels is crucial to the sustained productivity of agricultural systems.[689] SOM is a fundamental contributor to soil quality as it mediates several chemical, physical, and biological processes and is thus essential to the capacity of soils to function successfully.[690] SOM stores and supplies nutrients and food for soil organisms,[691] produces energy for soil microbes, stabilises soil structure, builds soil biodiversity,[692] and increases the capacity to store water and carbon from the atmosphere.[693] Healthy soils can mitigate climate change through their carbon storage function.[694] Carbon that is not used for plant growth is circulated through the roots of a plant which deposit carbon.[695] If undisturbed, stored carbon can remain locked away for a long period of time.[696] On the other hand, higher temperatures due to climate change may lead to more vegetation growth and more carbon stored in the soils, but it may increase decomposition and mineralisation of SOM reducing organic carbon content.[697] Also, the increasing concentration of carbon dioxide in the atmosphere may cause the microbes in the soil to work faster to break down SOM leading to more carbon dioxide release due to increased temperature.[698]

Decline in SOM levels contributes to decreased water infiltration capacity of soil, leading to increased run-off and erosion.[699] Loss of SOM results in soil compaction, as

[685] ibid
[686] Montanarella and others (n 444)
[687] Agriculture Victoria (n 682)
[688] Jeffrey A. Baldock and Paul N. Nelson, ‘Soil Organic Matter’ in Malcolm E. Sumner (ed) *Handbook of Soil Science* (illustrated edn, CRC Press 1999)
[689] Food and Agriculture Organization of the United Nations, ‘Chapter 8 – Conclusions’ <http://www.fao.org/3/a0100e/a0100e0b.htm#bm11> accessed 12 February 2019
[690] S. A. Quideau and others, ‘Soil Organic Matter Processes: Characterization by ^{13}C NMR and ^{14}C Measurements’ (2000) 138 Forest Ecology and Management 19
[691] Food and Agriculture Organization of the United Nations, ‘Chapter 2 - Organic Matter Decomposition and the Soil Food Web’ <http://www.fao.org/3/a0100e/a0100e05.htm> accessed 12 February 2019
[692] Agriculture Victoria (n 682)
[693] Food and Agriculture Organization of the United Nations (n 691)
[694] European Environment Agency, ‘Soil and Climate Change’ (30 June 2015) <https://www.eea.europa.eu/signals/signals-2015/articles/soil-and-climate-change> accessed 10 February 2019; Rajib Karmakar and others, ‘Potential Effects of Climate Change on Soil Properties: A Review’ (2016) 4 Science International 51
[695] European Environment Agency (n 694)
[696] ibid
[697] ibid
[698] ibid
[699] ‘Organic Matter Decline’ (n 621)

SOM improves the soil structure in terms of total porosity and pore size distribution.[700] SOM decline in mineral soils also leads to compaction and desertification.[701]

Loss of SOM, therefore, generates significant impacts on soil functions and ES. (Table 3.2.) Its most critical influences are seen on food and biomass production, water storage, filtering, buffering, carbon storage and soil biodiversity as well as cultural heritage.[702]

3.6.6. Soil Salinisation

All irrigation water contains dissolved salts acquired as it passed over and through the land.[703] These salts are usually in low concentration in the water.[704] Evaporation of water from the soil leaves the salts behind, and increases the concentration of salts in the soil over time.[705] Salinisation occurs when water-soluble salts accumulate in the soil to a level that adversely impacts the environment and agricultural production due to several causes, such as irrigation or overexploitation of groundwater.[706]

Initially, salinisation affects the metabolism of soil organisms, and decreases soil productivity.[707] However, in later stages, it may destroy all vegetation and other organisms in the soil leading to the transformation of fertile and productive land into desertified lands.[708]

Salinisation distresses many other aspects of human life[709] through changes in the chemical composition of natural water resources, such as lakes, rivers, and groundwater,[710] which leads to degradation of the quality of water supply to the domestic and agriculture sectors.[711] Accordingly, it contributes to the collapse of agricultural and fishery industries, leads to the change of local climatic conditions, eventually causes severe health problems.[712] Finally, as salinisation is linked to continuous wetness and the lack of surface cover, it increases the vulnerability of soils to erosion.[713] Also, it

[700] 'What Is Loss of Organic Matter in Mineral Soils?' (n 683)
[701] Schwilch and others (n 622)
[702] ibid
[703] 'Salinity' <https://forages.oregonstate.edu/ssis/soils/characteristics/salinity> accessed 15 July 2021
[704] ibid
[705] ibid
[706] 'What is Salinization?' (*RECARE*) <https://www.recare-hub.eu/soil-threats/salinization> accessed 12 February 2019
[707] ibid
[708] ibid
[709] W. D. Williams, 'Salinization: Unplumbed Salt in a Parched Landscape' (2001) 43 Water Sci Technol 85
[710] ibid
[711] A. Vengosh, 'Salinization and Saline Environments' (2003) 9 Treatise on Geochemistry 1
[712] ibid
[713] 'What is Salinization?' (n 706)

contributes to SOM decline, pollution and desertification.[714] Salinisation threatens some soil functions and related ES (Table 3.2.). Its most important adverse impacts are seen on food and biomass production and soil biodiversity.[715]

3.6.7. Desertification

Desertification is the process that productive soils lose moisture, plants and wildlife, and transform into hyper-arid or desert conditions.[716] This transformation may occur naturally or through anthropocentric influences.[717] Indeed, desertification may have several underlying reasons which involve a complex interplay among biophysical and human dimensions.[718] Human influences usually fall into two categories: direct influences that can be seen as salinisation and the overuse or misuse of land for agricultural purposes, deforestation; and indirect influences, such as climate change.[719]

The United Nations (UN) portrays desertification as one of the most important global change issues facing mankind.[720] This is due to its threatening impacts on human populations, such as food security, economics, sustainability; and the environment, such as poor water quality, dust storms, trace gas emissions to the atmosphere.[721] It renders rural people more vulnerable to food shortages, the vagaries of weather and natural disasters.[722]

Desertification leads to diminished food production, soil infertility and reduced water quality.[723] It decreases the sustainability of arid lands.[724] Inevitably, agriculturally productive soils become barren; hence, more prone to erosion and other types of land degradation.[725] This major threat has also societal consequences, such as increased poverty, loss in livelihoods and obliging affected people to migrate.[726] These impacts of

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714 Schwilch and others (n 622)
715 ibid
716 Matt Rovero, 'Nutrient Cycling Causes and Impacts of Desertification' (2017) <https://www.sciencedirect.com/science/article/pii/B9780124095489106694> accessed 9 February 2019
717 ibid
718 James F. Reynolds and others, 'Natural and Human Dimensions of Land Degradation in Drylands: Causes and Consequences' in Josep G. Canadell, Diane E. Pataki and Louis F. Pitalka (eds) *Terrestrial Ecosystems in a Changing World* (Springer 2007)
719 Rovero (n 716)
720 Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (17 June 1994, 26 December 1996) 1954 UNTS 3
721 Reynolds and others (n 718)
722 Food and Agriculture Organization of the United Nations, 'Desertification, Drought and Their Consequences' <http://www.fao.org/3/x5317e/x5317e01.htm> accessed 12 February 2019
723 European Court of Auditors, 'Desertification in the EU' (June 2018) <https://www.eca.europa.eu/Lists/ECADocuments/BP_DESERTIFICATION/BP_DESERTIFICATION_EN.pdf> accessed 11 February 2019
724 V. P. Tchakerian, 'Hydrology, Floods and Droughts – Deserts and Desertification' in Geral R. North, John Pyle and Fuqing Zhang (eds) *Encyclopedia of Atmospheric Sciences* (2nd edn, Academic Press 2015)
725 ibid
726 European Court of Auditors (n 723)

desertification are more destructive for the countries that have difficulties to adapt or mitigate them.[727] It is important to note that desertification negatively affects all other soil threats, most commonly SOM decline, salinisation and erosion as a result of decrease in vegetative cover and plant roots.[728]

Desertification also implies a rupture in the provision of several soil functions and reduces the capacity of terrestrial ecosystems to deliver goods and services (Table 3.2.).[729] Its most destructive effects are on food and biomass production, water storage, filtering, buffering and soil biodiversity.[730]

3.6.8. Summary

This section provided a brief description of soil threats and their impacts on soil functions and ES. The level of impacts assessed are not always consistent in the studies considered, and there is much uncertainty regarding these impacts. Especially, other than provisioning services, there is a lack of data on the impacts of soil threats on ES (Table 3.2., rows 10-14).

For the purposes of this study, this section aimed to establish the range of influences on soil functions and ES. It is apparent that vital ecosystem functions that contribute to the provision of multiple ES are under serious risk from soil threats resulting from the changes they generate on soil properties, such as the removal of topsoil, nutrient and porosity.[731] Table 3.2. demonstrates that SOM loss, compaction, sealing, pollution and erosion are the most harmful threats on soil ES respectively. Also, the most vulnerable ES to soil threats are food production, water storage and primary production. In addition, all threats have either direct or indirect influences on soil functions and ES as these threats commonly trigger or worsen each other. These functions and ES must be subject to more effective policies and decisions in order to ensure their protection from the wide-ranging effects of soil threats.[732]

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727 Jose Luis Rubio, 'Conclusions' in J. L. Rubio and V. Andreu (eds*), Human and Socioeconomic Consequences of Desertification* (Las Palmas de Gran Canaria: Universidad de Las Palmas de Gran Canaria, Servicio de Publicaciones 2009)
728 Schwilch and others (n 622)
729 Rubio (n 727)
730 Schwilch and others (n 622)
731 A. S. Gregory and others, 'A Review of the Impacts of Degradation Threats on Soil Properties in the UK' (2015) 31 Soil Use & Management 1
732 M. Nijnik M, R. W. Slee and A. Nijnik, 'Biomass Production: Impacts on Other Ecosystem Services' in P. Pelkonen and others (eds), *What Science Can Tell Us: Forest Bioenergy for Europe* (4th edn, European Forestry Institute 2014); Andras Makó and others, 'Mapping the Storing and Filtering Capacity of European Soils' (2017) JRC Technical Reports <https://esdac.jrc.ec.europa.eu/public_path/shared_folder/dataset/40_storing_filtering/LB-NA-28392-EN-N_.pdf> accessed 2 February 2019; Unai Pascual and others, 'On the Value of Soil Biodiversity and Ecosystem Services' (2015) 15 Ecosystem Services 11

3.7. Conclusion

Soil is an incredibly complex, variable and non-renewable natural resource.[733] It is the NC that provides the flow[734] of most terrestrial ES,[735] which are the benefits that humans obtain from ecosystems for survival and well-being.[736] This makes soil ES a valuable aspect of human life and the economy.[737]

Soil, indeed, is available for use, but also for abuse of civilisation.[738] Due to this fact, a third of all soils worldwide are considered degraded due to erosion, pollution, sealing, compaction, loss of SOM, salinisation and desertification.[739] As established in this chapter, soil degradation inherently reduces or eliminates soil functions and inevitably the provision of relevant ES. Minimising or eliminating soil degradation is critical to maintain these services[740] and is considerably more cost-effective than rehabilitating soils after degradation has occurred.[741]

Sustainable management of soils is crucial for increasing their productivity and resistance to adverse impacts.[742] However, soil is difficult to manage due to several reasons. Firstly, industrialisation and technological developments, presenting additional trade-offs, increase the difficulty of making sustainable decisions regarding soil management.[743] Therefore, soil and soil ES (especially other than provisioning services) are commonly overlooked in ES and valuation studies.[744] Secondly, soil protection has not seen progress as fast as air or water protection in global, regional or national environmental law and policy, due to the lack of information and incoherent administration.[745] Finally, private ownership issues regarding soil cause additional difficulties and implications in legislation.[746]

This chapter aimed to advocate the need for a robust soil protection by emphasising the importance of soils through soil processes, functions and ES, which are crucial to humans' economic and societal needs, and by studying threats that risk soils

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733 'EU Soil policy' (n 39)
734 Dominati, Patterson and Mackay (n 257)
735 Finvers (n 86)
736 Millennium Ecosystem Assessment (n 79) 3
737 Gretchen C. Daily and others, 'Ecosystem Services: Benefits Supplied to Human Societies by Natural Ecosystems' (Spring 1997) Issues in Ecology Number 2
738 Daniel Hillel, *Out of the Earth: Civilization and the Life of the Soil* (The Free Press 1991)
739 Food and Agriculture Organization of the United Nations (n 16)
740 Food and Agriculture Organization of the United Nations (n 25)
741 Food and Agriculture Organization of the United Nations, Revised World Soil Charter (June 2015) C 2015/31, Principle 10
742 Anatolii Semenovich Kerzhentsev, 'Soil Functionality and Ecosystem Sustainability' (2010) 80 Herald of the Russian Academy of Sciences 360
743 Hillel (n 738)
744 Hewitt and others (n 295)
745 ibid
746 ibid

and the continuous flow of soil ES. It can be concluded that the functions and ES of soils are essential for human life and these soil functions face the risk of degradation due to the abovementioned threats.

Numerous studies have been undertaken to understand how the concept of ES and their value can be operationalised for more sustainable decisions and policies regarding soils. Although the relationship between soil degradation and soil ES has been well reviewed for policy makers,[747] this relationship is hardly reflected in and integrated into policy and decision making.[748] The rest of this research is mainly concerned with the question of how soils should be protected from a legal perspective. A high level protection requires better understanding, recognition and integration of the importance and value of soil and soil ES into environmental law and policy.[749] This research aims to offer framework recommendations for integrating ES to address gaps that will be identified in chapter five. Thus, the next chapter will offer a brief introduction to the UK soil policy and ascertain the reasons why soils have been disregarded in the UK law and policy.

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[747] John McDonagh, Michael Stocking and Yuelai Lu, 'Global Impacts of Land Degradation' (2006) <https://research-portal.uea.ac.uk/en/publications/global-impacts-of-land-degradation> accessed 3 February 2019

[748] Zhanguo Bai and others, 'Land Degradation and Ecosystem Services' in R. Lal and others (eds), *Ecosystem Services and Carbon Sequestration in the Biosphere* (Springer 2013)

[749] Philippe C. Baveye, Jacques Baveye and John Gowdy, 'Soil "Ecosystem" Services and Natural Capital: Critical Appraisal of Research on Uncertain Ground' (2016) 4 Front. Environ. Sci. 1

CHAPTER FOUR

The Context of the United Kingdom Soil Policy

4.1. Introduction

Chapter three highlighted the importance of protecting soils and their ES and presented significant soil threats. The importance of soil reflects the need for its protection through robust laws and policies. This chapter aims to offer a brief introduction to the UK soil policy and set the scene for the critical analysis of the effectiveness of the existing UK legislation in the next chapter. This chapter will determine the UK's soil-related international obligations, study the impact of the European policy on the UK soil policy, and ascertain the reasons why soils have been disregarded in the UK law and policy.

4.2. The United Kingdom Soil Policy

In the UK, soils have degraded over the last 200 years, mainly resulting from the intensification of agricultural practices, industrial pollution, unsustainable waste management and development.[750] UK soils continue to face threats, such as erosion by wind and rain, compaction, pollution and SOM decline.[751] In 2010, soil degradation in the UK was calculated to cost £1.2 billion every year.[752] Despite this, soil is argued to have been omitted in the UK law in recent decades.[753] The validity of this argument will be analysed in detail. In addition to national law, the UK has several international obligations relevant to soil protection.

4.2.1. International Obligations

Soil should be considered as a common concern of humankind, which requires international efforts besides regional and national regulations.[754] Thus, soil protection, as well as sustainable use of other natural resources and protection of the natural environment, is embedded in many international legal instruments that the UK is a part of.

The most soil focused international instrument, the Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (UNCCD),[755] aims to combat desertification and to achieve a land

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[750] Department for Environment, Food and Rural Affairs (n 53)
[751] ibid; 'UK Soil Degradation' (*POSTNOTE 265*, July 2006) <https://www.parliament.uk/documents/post/postpn265.pdf> accessed 4 June 2019
[752] Environment Agency, 'The State of the Environment: Soil' (June 2019) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/805926/State_of_the_environment_soil_report.pdf> accessed 4 June 2019
[753] ibid
[754] Ben Boer, Harald Ginzky and Irene L. Heuser, 'International Soil Protection Law: History, Concepts and Latest Developments' in Harald Ginzky and others (eds) *International Yearbook of Soil Law and Policy 2016* (Springer 2017)
[755] United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (17 June 1994, 26 December 1996) 1954 UNTS 3

degradation-neutral world consistent with the 2030 Agenda for Sustainable Development and is the only legally binding international agreement linking the environment and development to sustainable land management.[756] Even though some countries, e.g., the UK, do not belong to a regional annex or are not directly affected by desertification, there are common obligations that must be complied with by all parties.[757] These are generally related to the international cooperation aspects of the Convention.[758] As a party, the UK's has several obligations, such as supporting affected countries through monetary resources, knowledge or technology.[759] Although UNCCD is legally binding, there are no automatic sanctions for the parties who fail to meet their obligations, which reflects the issue with enforcement hindering the effectiveness of the Convention.[760]

The UK is also a party to the United Nations Framework Convention on Climate Change (UNFCCC),[761] which aims to combat climate change, but also provides a set of provisions that provide indirect protection for soils. Soil is a significant store of carbon, storing three times more carbon than found in the atmosphere.[762] Therefore, any climate change action should have a particular focus on soil. The UK is particularly important in this sense, as peatlands and grasslands, the most carbon-rich soils, are widespread in the country. Following the Paris Agreement, the UK has taken the initiative to apply technologies for removing GHG through certain soil management options, such as no-till agriculture, manures and composts, to increase SOM content.[763] These agreements are notable for their potential to combat climate change effectively. However, providing a satisfactory level of protection for soils is not achievable through these instruments. This is partly because of the fact that they suffer from a lack of enforcement due to their soft law nature, which generates an additional compliance issue.

Another agreement that the UK is a party to is CBD.[764] The UK's delivery of the CBD commitments and the Strategic Plan for Biodiversity 2011-2020 is guided by the

[756] 'About the Convention' (*United Nations Convention to Combat Desertification*) <https://www.unccd.int/convention/about-convention> accessed 01 May 2019
[757] Mark S. Reed and Lindsay C. Stringer, *Land Degradation, Desertification and Climate Change: Anticipating, assessing and adapting to future change* (Routledge 2016) 23
[758] ibid 23
[759] ibid 23
[760] ibid 23
[761] United Nations Framework Convention on Climate Change, (signed 4 June 1992, entered into force 21 March 1994) 1771 UNTS 107
[762] T. A. Ontl and L. A. Schulte, 'Soil Carbon Storage' (2012) 3 Nature Education Knowledge 35
[763] Committee on Climate Change, 'UK climate action following the Paris Agreement' (October 2016) < https://www.theccc.org.uk/wp-content/uploads/2016/10/UK-climate-action-following-the-Paris-Agreement-Committee-on-Climate-Change-October-2016.pdf> accessed 5 September 2019
[764] United Nations Convention on Biological Diversity (signed 5 June 1992, entered into force 29 December 1993) 1760 UNTS 79

UK Post-2010 Biodiversity Framework.[765] The framework supersedes earlier approaches under the UK Biodiversity Action Plan (1992–2012).[766] This framework outlines how the UK contributes to achieving the Aichi Biodiversity Targets[767] and recognises the activities needed to complement national biodiversity strategies.[768] CBD is specifically significant for establishing the EA as discussed above, which confirms that governance mechanisms balance the use of natural resources with their conservation.[769] Although the text of the Convention does not contain a specific reference to soils, the importance of soil and agricultural biodiversity is later recognised at COP 3 Decision III/11 on conservation and sustainable use of agricultural biological diversity.[770] The UK has been submitting its national reports in this direction; however, according to the latest national report, most set targets are currently not met.[771] As with UNFCCC, CBD suffers from the weakness of non-binding national obligations. Indeed, CBD was created as a hard law instrument, yet its approach is relatively soft, and its focus is global biodiversity targets that are not backed up by obligations.[772] This characteristic indicates that it is not an instrument that obliges states to take action and limits its effectiveness.[773]

There are several fundamental but non-binding environmental instruments (e.g., Brundtland Report,[774] Stockholm Declaration[775] and Rio Declaration[776]) that established and set the foundation of international environmental law through a number of principles, such as sustainable development and the precautionary principle. However, again, the non-binding nature of these documents obstructs achieving the full effect of these principles. Indeed, despite the anticipations for these principles to have legal status, their

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765 JNCC, 'Convention on Biological Diversity (CBD)' (18 April 2019) <https://jncc.gov.uk/our-work/convention-on-biological-diversity-cbd/#implementation-in-the-uk> accessed 5 September 2019
766 ibid
767 'Aichi Biodiversity Targets' (*Convention on Biological Diversity*) <https://www.cbd.int/sp/targets/> accessed 7 May 2019
768 JNCC (n 765)
769 Parliamentary Office of Science and Technology, 'The Ecosystem Approach' (2011) POSTnote 11/377
770 'Introduction' (*Convention on Biological Diversity*) <https://www.cbd.int/agro/soil.shtml> accessed 7 May 2019; 'COP 3 Decision III/11' (*Convention on Biological Diversity*) <https://www.cbd.int/decision/cop/default.shtml?id=7107> accessed 7 May 2019
771 JNCC, 'Sixth National Report to the United Nations Convention on Biological Diversity: United Kingdom of Great Britain and Northern Ireland. Overview of the UK Assessments of Progress for the Aichi Targets' (January 2019) <https://jncc.gov.uk/our-work/united-kingdom-s-6th-national-report-to-the-convention-on-biological-diversity/> accessed 5 September 2019
772 Stuart R. Harrop and Diana Pritchard, 'A hard instrument goes soft: the implications of the Convention on Biological Diversity's current trajectory' (2011) *21* Global Environmental Change 474
773 ibid
774 'Report of the World Commission on Environment and Development: Our Common Future' (1987) <http://www.un-documents.net/our-common-future.pdf> accessed 7 June 2019
775 United Nations General Assembly, United Nations Conference on the Human Environment, (1972) UN Doc A/RES/2994
776 United Nations Conference on Environment and Development, Rio Declaration on Environment and Development (1992) UN Doc A/CONF.151/26

non-binding state does not translate into precise and binding international legal obligations.[777]

There are other initiatives for soil protection at international level. Voluntary Guidelines for Sustainable Soil Management are designed to inform strategic and context-specific decision making,[778] and elaborate principles set by the revised World Soil Charter.[779] The World Soil Charter established principles for the optimum use of soils to improve their productivity and safeguard them for future generations.[780] Besides the basic principles, some sections needed revision and updates in light of the recent scientific findings and fast-changing conditions.[781] These initiatives are promising and beneficial; however, suffer from ineffectiveness due to their non-binding nature.

Among the UK's international commitments, SDGs are exceptional.[782] The 2030 Agenda for Sustainable Development, adopted by all UN Member States in 2015, have explicit references to soil protection. Most of these SDGs are directly or indirectly linked to the protection of soils.[783] It has objectives, such as:

- ensuring sustainable food production systems and implementing resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality;[784]

- substantially reducing the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination;[785]

- sustainable cities and communities through sustainable urbanisation with an indicator of ratio of land consumption rate to population growth rate;[786]

- achieving the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and

[777] 'Preparations for the Rio +20 Summit - Environmental Audit Committee' (*www.parliament.uk*, 26 October 2011) <https://publications.parliament.uk/pa/cm201012/cmselect/cmenvaud/1026/1026vw21.htm> accessed 10 June 2019
[778] Food and Agriculture Organization of the United Nations, 'Voluntary Guidelines for Sustainable Soil Management' (2017) <http://www.fao.org/3/a-bl813e.pdf> accessed 5 September 2019
[779] Food and Agriculture Organization of the United Nations (n 741)
[780] Luca Montanarella, 'The Global Soil Partnership' (2015) IOP Conf. Ser.: Earth Environ. Sci. 25 012001 <https://iopscience.iop.org/article/10.1088/1755-1315/25/1/012001/pdf> accessed 12 September 2019
[781] ibid
[782] 'Implementing the Sustainable Development Goals - December 2017' (*GOV.UK*) <https://www.gov.uk/government/publications/implementing-the-sustainable-development-goals/implementing-the-sustainable-development-goals> accessed 10 June 2019
[783] United Nations (n 11) SDG 1, 2, 6, 7, 8, 9, 11, 12, 13, 15
[784] SDG 2.4
[785] SDG 3.9
[786] SDG 11.3

significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment;[787]

- combatting desertification, restoring degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world.[788]

Although SDGs are not legally binding, they put considerable pressure on national governments. This impact is explicit as the UK government recognised the duty of being at the forefront for delivering these goals as it was at the forefront of negotiations.[789] The UK government's approach is to deliver SDGs through relevant departments' plans.[790] It is argued that the government has not achieved the full integration of SDGs into its plans, policies or programmes.[791] Also, the interconnected aspects of the natural environment and ecosystems are not being reflected in separate departmental plans.[792] Regarding soils, the Department for Environment, Food and Rural Affairs (DEFRA)'s departmental plan presented two main points: restoring vulnerable peatlands and work with the industry to end peat use in horticultural products, and designing a new environmental land management scheme to deliver outcomes from the 25 Year Environment Plan, which emphasised its commitment to delivering SDGs.[793]

4.2.2. European Law

As most of the current UK environmental laws are originated from the European law, the majority of legal analysis presented in the next chapter will comprise of the analysis of European legal instruments. Soil protection at the Union level commonly offers preventive, but non-binding or low binding instruments.[794] Binding quantitative targets or limit values for polluting substances have been rarely set so far for soil protection.[795] Moreover, soil threats are not comprehensively addressed.[796] Provisions with direct relevance to soils are good practices, information measures and objectives.[797] Also, the EU's ambitious objectives are not nearly achieved as the EU soil law is scattered

[787] SDG 12.4
[788] SDG 15.3
[789] 'Implementing the Sustainable Development Goals - December 2017' (n 782)
[790] ibid
[791] Campaign to Protect Rural England, 'Back to the land: rethinking our approach to soil' (December 2018) <https://www.cpre.org.uk/resources/farming-and-food/farming/item/5013-back-to-the-land-rethinking-our-approach-to-soil> accessed 18 July 2019
[792] ibid
[793] ibid
[794] Paleari (n 49)
[795] ibid
[796] ibid
[797] ibid

across different areas of environmental law and falls short in terms of robust soil protection.[798] European policies that are focused on agriculture, water, waste, chemicals, and prevention of industrial pollution contribute to soil protection; however, this protection is merely indirect.[799] Indeed, soil mostly has been a secondary concern for European legislators. Therefore, these laws are not sufficient to ensure an adequate level of soil protection.[800] These will be discussed below in detail.

Only a few Member States have specific legislation on soil protection and soil is not a focus of a comprehensive and coherent set of rules in the EU.[801] The UK's departure from the EU, thus, can be seen as a unique opportunity[802] to move away from this ineffective and fragmented European soil policy and to adopt a more robust framework to achieve the UK government's 25 Year Environment Plan, which requires sustainable management and restoration of soils.[803]

4.2.3. National Policy

Soil protection legislation has a complex structure in the UK.[804] The UK government has drafted plans for the sustainable management of soils by 2030, such as designing and delivering a new environmental land management system, working with farmers to use fertilisers efficiently, protecting crops while reducing the environmental impact of pesticides, and improving soil health.[805] This plan has a focus on the growing problems of waste and soil degradation through the prism of sustainable development.[806] The government also strives to set high standards in protecting and increasing NC and using this approach as a tool in decision making.[807]

On the other hand, there is no specific soil protection legal instrument and the existing provisions scattered through the framework are commonly focused on other environmental media.[808] As mentioned before, this fragmented soil framework is

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798 ibid
799 European Commission, 'Soil' (*Environment,* 7 August 2019) <https://ec.europa.eu/environment/soil/index_en.htm> accessed 13 August 2019
800 ibid
801 ibid
802 Dieter Helm, 'Agriculture After Brexit' (2017) 33 Oxford Review of Economic Policy S124; Nature Friendly Farming Network, 'Nature Friendly Farming – The Future of Farming in the UK' <https://www.nffn.org.uk/wp-content/uploads/2018/01/NFFN-Report-FINAL-NXPowerLite-Copy.pdf> accessed 7 June 2019
803 HM Government, 'A Green Future: Our 25 Year Plan to Improve the Environment' <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/693158/25-year-environment-plan.pdf> accessed 2 June 2019
804 Petra Stankovics, Gergely Tóth and Zoltan Tóth, 'Identifying Gaps between the Legislative Tools of Soil Protection in the EU Member States for a Common European Soil Protection Legislation' (2018) 10 Sustainability 2886
805 HM Government (n 803)
806 ibid
807 ibid
808 Stankovics, Tóth and Tóth (n 804)

inherited from the EU, and these provisions have a potential to provide indirect protection for soils; however, considering the importance of soils, indirect protection is not sufficient. In the UK, legislation that provides protection for soils fails to address all soil threats and is mostly focused on agriculture and contaminated land. Agriculture is comprehensively regulated through the Common Agriculture Policy (CAP) and England and Wales have a number of programmes focusing on soil protection, such as CAP cross compliance (CC), Environmental Stewardship, the England Catchment Sensitive Farming Delivery Initiative, the Code of Good Agricultural Practice, Tir Gofal Stewardship Scheme.[809] Besides, the existing current legislation requires farmers to comply with CC soil management standards.[810] These standards are the Good Agricultural and Environmental Conditions (GAEC) and Statutory Management Requirements (SMR).[811] Contaminated land in the UK is often seen as a historical issue, yet with emerging technology, new chemicals and waste management practices are developed that generate new environmental risks and regulatory challenges.[812] There are a number of key legal instruments regarding contaminated land, such as the Environmental Protection Act 1990 (EPA) and Environmental Liability Directive.[813] These legal instruments will be analysed below.

The need for a comprehensive legislative framework that is specifically for soils is also vital to protect soil functions and ES. Indeed, soil threats interact with soil functions and ES in a complex way; hence, fragmented soil legislation fails to ensure functioning soils.[814] The legislative framework should be comprehensive and specific enough to pinpoint soil threats, pressures, practices and how these interact with soil multifunctionality.

As mentioned, the UK's environmental policy is commonly focused on other environmental media and providing indirect protection for soils or non-binding legal instruments, such as codes of practice and guidance documents. Non-statutory guidance is a document that is not provided for in legislation. Technical guidance, similar to non-statutory guidance, is not provided for in legislation. It is more detailed and technical than non-statutory guidance. The courts are not bound by guidance; however, statutory guidance and code of practice must be taken into account by the courts. It is argued that

[809] ibid
[810] ibid
[811] ibid
[812] Environment Agency (n 752)
[813] Directive 2004/35/CE of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage [2004] OJ L 143/56 (hereinafter 'Environmental Liability Directive'),
[814] Paleari (n 49)

even non-statutory guidance has a specific level of legal effect in practice, such as setting or influencing the standards by which compliance with statutory or common law duties will be determined by the courts.[815]

Before beginning the analysis of legal instruments, it is essential to see how the UK soil policy has been shaped throughout the years. The UK government has employed a number of initiatives for protection of soils. In 2009, it published 'Protecting our Water, Soil and Air: A Code of Good Agricultural Practice for farmers, growers and land managers'.[816] The Code replaces the separate Water, Air and Soil Codes published by the Ministry of Agriculture, Fisheries and Food and the Welsh Office Agriculture Department (last revised in 1998).[817] This Code is a practical guide to support farmers, growers and land managers for protecting the environment and help them to meet legal obligations, such as CC.[818] However, it does not set out obligations for soil protection and considering the available evidence, the use of such voluntary measures, such as the previous Soil Code, have been unsuccessful in protecting soils.[819]

In 2009, the Environment Agency produced 'A Guide to using Soil Guideline Values', which is a non-statutory technical guidance to regulators and their advisors in support of the statutory regimes addressing land contamination.[820] This guide provides relevant, appropriate, authoritative and science-based generic criteria to assess long-term risks to human health from soil chemical contamination.[821] They are trigger values, which indicate that there should be further risk assessments where concentrations in soil exceed the given value.[822] However, the Environment Agency has withdrawn the guidelines value for mercury and nickel and the associated supporting reports, and confirmed that there would be no updates on these guidelines. Indeed, only a handful of out 1,000s of potential pollutants are covered. Thus, these guides are incomplete.

Another 2009 document is 'The Construction Code of Practice for the Sustainable Use of Soils on Construction Sites'.[823] This document aims to assist those are involved in

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815 *A (A Child)* [2016] EWCA Civ 759
816 Department for Environment, Food and Rural Affairs, 'Protecting our Water, Soil and Air – A Code of Good Agricultural Practice for farmers, growers and land managers'(2009) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/268691/pb13558-cogap-131223.pdf> accessed 10 September 2018
817 ibid
818 ibid
819 Bell (n 27)
820 Environment Agency, 'Using science to create a better place – Using Soil Guideline Values' (2009) (SC050021/SGV) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/297676/scho0309bpqm-e-e.pdf> accessed 5 September 2019
821 ibid
822 ibid
823 Department for Environment, Food and Rural Affairs, 'Construction Code of Practice for the Sustainable Use of Soils on Construction Sites' (2009)

the construction sector to protect the soil resources they work with. It is rather distinctive for its specific focus on soil functions and ES.[824] Nevertheless, it merely provides a set of guidelines and is not legislatively binding;[825] therefore, it is not effectively protecting soils from sealing due to construction.

Finally, in 2009, 'Safeguarding our Soils: A Strategy for England' was published. This strategy was later superseded by 'The Natural Environment White Paper'[826] in 2011, which ensures that soils are managed sustainably, and peat use is reduced to zero by 2030.[827] This document highlighted the government's objective of undertaking a research programme on how soil degradation can affect the soil's ability to support vital ES,[828] which shows that soil ES research is of key importance. White papers are policy documents that are produced by the government that set out their proposals for future legislation.[829] Thus, this document has no legally binding power until it is incorporated into legislation. Indeed, its objective of ending peat use in horticulture has not been carried through.[830] It is argued that this failure was because this document relied on voluntary initiatives, which broadly failed, instead of action.[831] This document also did not consider soil sealing, which is a significant soil threat in the UK.[832]

In 2012, 'Contaminated Land Statutory Guidance' was published to explain how local authorities should implement the regime, including how they should decide whether land is contaminated land in the legal sense of the term.[833] This guidance must be taken into consideration whilst reading EPA 1990.[834] It also explains the remediation provisions of Part IIA of the Act, such as the goals of remediation, and how regulators should ensure that remediation requirements are reasonable.[835] As it is a statutory guidance, it has binding effect on authorities.[836] In relation to this, DEFRA published the 'Technical

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<https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/716510/pb13298-code-of-practice-090910.pdf> accessed 5 September 2019

[824] ibid

[825] ibid

[826] HM Government, 'The Natural Choice: securing the value of nature' (2011) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/228842/8082.pdf> accessed 5 September 2019

[827] ibid

[828] ibid

[829] 'White Papers' (*www.parliament.uk*) <https://www.parliament.uk/site-information/glossary/white-paper/> accessed 5 September 2019

[830] Campaign to Protect Rural England (n 791)

[831] ibid

[832] ibid

[833] Department for Environment, Food and Rural Affairs, 'Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance' (2012) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/223705/pb13735cont-land-guidance.pdf> accessed 5 September 2019

[834] ibid

[835] ibid

[836] ibid

Guidance Sheet on normal levels of contaminants in English soils' in 2012 as a result of a project for investigating the levels of a number of contaminants in soils, namely arsenic, asbestos, benzo[a]pyrene, lead, cadmium, copper, mercury, nickel.[837] This guidance gives an indication as to contaminant concentrations that can be expected in soils based on results from samples collected across England.[838] However, it does not contain all of the contaminants in soil.

'The IUCN UK Peatland Code' (latest version 2017) is a voluntary certification standard for the UK peatland projects wishing to market the climate benefits of peatland restoration.[839] It aims to facilitate the sponsorship of peat restoration.[840] The Code introduces best practice requirements, which include a standard method for quantification of GHG benefit.[841] This step is significant for protecting peatlands, which occupy 12% of the UK land area. Peatlands have a role in reducing flood risk and supporting biodiversity. Besides, in the UK alone, an estimated 3.2 billion tonnes of carbon are stored in peatlands.[842] However, when improperly managed, peatlands can be a net source of GHG emissions rather than a net sink. Therefore, the Peatland Code is an important initiative; however, its voluntary nature impacts on its effectiveness in protecting soils.[843] Also, it is exceptional for its inclusion of associated ES benefits of restoration as a selling point.[844]

In 2017, the UK Forestry Standard (UKFS) was published, which is the reference standard for sustainable forest management at the national policy level.[845] As soil is a fundamental component of forest ecosystems, UKFS introduces soil-related requirements, namely waste management, control of pesticides and soil protection.[846] Furthermore, there are soil-related guidelines in the document that focus on factors that are important for forests and soils.[847] These are portrayed as acidification (continuous loss of acid neutralising capacity manifested by increasing hydrogen ion concentrations or

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[837] British Geographical Survey, 'Normal background concentrations (NBCs) of contaminants in English and Welsh soils' <https://www.bgs.ac.uk/gbase/NBCDefraProject.html> accessed 5 September 2019
[838] Department for Environment, Food and Rural Affairs, 'Technical Guidance Sheet on normal levels of contaminants in English soils' (TGS02, July 2012) <http://randd.defra.gov.uk/Document.aspx?Document=10333_TGS_Pb_FINAL.PDF> accessed 5 September 2019
[839] International Union for Conservation of Nature, 'Peatland Code' (March 2017) <https://www.iucn-uk-peatlandprogramme.org/funding-finance/peatland-code> accessed 6 September 2019
[840] ibid
[841] ibid
[842] UK Centre for Ecology & Hydrology, 'Peatlands Factsheet' <https://www.ceh.ac.uk/sites/default/files/Peatland%20factsheet.pdf> accessed 15 July 2020
[843] International Union for Conservation of Nature (n 839)
[844] ibid
[845] Forestry Commission, 'The UK Forestry Standard' (2017) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/687147/The_UK_Forestry_Standard.pdf> accessed 2 June 2020
[846] ibid
[847] ibid

declining alkalinity), contamination, compaction, disturbance (any activity that mixes or moves soil material), erosion, fertility (the availability and balance of nutrients required for plant growth) and SOM.[848] It also recognises an ecosystem approach and reflects the importance of ES provided by healthy soils and forests.[849] It emphasises the statutory requirements and good forestry practice requirements by introducing a set of non-binding guidelines.[850]

In 2018, 'Sewage sludge in agriculture: code of practice for England, Wales and Northern Ireland' was published.[851] This Code encourages sludge users (e.g., farmers) to follow good agricultural practice, avoid causing pollution and public nuisance and look after the land.[852] Again, it is a non-binding guidance document with a voluntary nature, supporting statutory requirements of the Sludge (Use in Agriculture) Regulations 1989 (Table 5.3.).

In 2018, an imperative document, 'A Green Future: Our 25 Year Plan to Improve the Environment' (the Plan) was published.[853] The approach adopted by the government in this policy instrument is the sustainable management of soils by 2030 through developing management options that incorporate NC thinking.[854] This approach is not specifically focused on soil protection, nevertheless, has objectives of improving soil health, restoring and protecting peatlands, through developing a soil health index and ending peat use in horticulture by 2030.[855] However, the Plan fails to deliver a direct strategy of action for all soils and does not explain what sustainably managing soil means.[856] Indeed, the concept of 'appropriate or sustainable management' is unclear in the document. This Plan supports the argument that soil is not at the forefront of the environmental policy.[857] Rather than emphasising that soil is a NC asset, the Plan remains vague on urban soils and soil sealing from built development as a form of degradation.[858] It is also silent on how to address SDG 11 and sustainable land consumption.[859] Overall, the Plan does not provide an action plan for SDGs. Additionally, despite early ambitions

[848] ibid
[849] ibid
[850] ibid
[851] Department for Environment, Food and Rural Affairs, 'Sewage sludge in agriculture: code of practice for England, Wales and Northern Ireland' (23 May 2018) <https://www.gov.uk/government/publications/sewage-sludge-in-agriculture-code-of-practice/sewage-sludge-in-agriculture-code-of-practice-for-england-wales-and-northern-ireland> accessed 6 September 2019
[852] ibid
[853] HM Government (n 803)
[854] ibid
[855] ibid
[856] Campaign to Protect Rural England (n 791)
[857] ibid
[858] ibid
[859] ibid

in the DEFRA Soil Strategy to cut losses, soil carbon has largely been overlooked.[860] The Plan limits what may be done for lowland peat soils, even though peatland restoration is vital as a part of SDGs and fighting climate change.[861] As a whole, the Plan was criticised for falling short on details.[862] Indeed, it introduces several policy aims and objectives without sufficient details and no legal underpinning for protection aspects.[863] Considering these opinions, it can be argued that it is unlikely to achieve the sustainable management of all soils in the timeframe given without a robust action plan.

Finally, in 2019, 'National Planning Policy Framework' was published stating that development should preferentially be in areas of poorer quality agricultural soil.[864] It also delivers some advances, such as recognising the benefits from NC and ES.[865] It acknowledges sustainable development and its three pillars (i.e., economic, social and environmental),[866] which should be at the forefront of planning policies. From a soil perspective, it suggests that planning policies and decisions should contribute to and enhance the natural and local environment by protecting and enhancing valued landscapes, sites of biodiversity or geological value and soils.[867] It also aims to prevent any development creating unacceptable risks to the natural environment and unacceptable levels of soil pollution.[868] However, it is silent on what unacceptable risk or level is, which makes these objectives somewhat vague and unachievable.

Despite the measures introduced in recent years through CAP (such as, greening payments and CC, which will be discussed below), SOM loss and erosion addressed at national level by the UK Forestry Standard.[869] Furthermore, the state of soils is monitored through the Countryside Survey, which assesses the long term status of the UK's countryside with the objective of providing a set of data on environmental issues to policy makers.[870] On top of this, each country in the UK has other instruments in place to address

860 ibid
861 ibid
862 Paul de Zylva, '25-year environment plan falls short' (*Friends of the Earth*, 25 January 2018) <https://friendsoftheearth.uk/nature/25year-environment-plan-falls-short> accessed 1 September 2019
863 ibid
864 Ministry of Housing, Communities & Local Government, 'National Planning Policy Framework' (February 2019) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/810197/NPPF_Feb_2019_revised.pdf> accessed 9 September 2019
865 ibid
866 ibid
867 ibid
868 ibid
869 Forestry Commission (n 845)
870 'Policy and Planning' (*Countryside Survey*) <https://countrysidesurvey.org.uk/content/policy-and-planning#eco> accessed 16 June 2020

soil threats[871] (the England Catchment Sensitive Farming Programme[872] and the Wales Glastir Monitoring and Evaluation Programme).[873]

Overall, it is clear that the UK government and relevant departments have been taking significant initiatives and producing influential works for protecting soils at the national policy. This is promising; however, the UK soils still suffer from a lack of comprehensive and robust legislative framework for protection, which is supported by binding requirements. In fact, soil has been overlooked in the UK environmental policy and has not drawn attention as much as water and air. Now, it is crucial to identify the reasons why soil is ignored in the UK legislation in order to provide recommendations later in this study. Following this, a comprehensive analysis of relevant legislative instruments will be provided in the next chapter.

4.2.4. Why is Soil Ignored?

Both in international and national policy, soil has recently started to become a priority.[874] This has happened after more than fifty years of mismanagement and neglect.[875] Soil was seen as a factory floor or servant for humankind, thus it has been challenging to switch focus to critical soil degradation until the mid-20th century.[876] This approach disregarded off-site and non-market benefits provided by soil.[877] As a result of a productionist approach, it was believed that the worst that could happen to soil was infertility.[878] Since the 1930s, mechanisation and heavy use of artificial compounds changed the face of agriculture.[879] During and after the Second World War, Britain focused on increasing productivity and expansion,[880] which made drainage, machinery and inputs more mainstream.[881] This approach and the fear of upcoming food shortages paved the way for the Agriculture Act 1947. This will be discussed below. The productionist policy highlighted the maximisation of domestic production in the interests

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[871] Silvia Ronchi and others, 'Policy instruments for soil protection among the EU member states: A comparative analysis' (2019) 82 Land Use Policy 763

[872] Department for Environment, Food and Rural Affairs, Environment Agency and Natural England, 'Catchment Sensitive Farming: reduce water and air pollution' (*GOV.UK*, 9 September 2014) <https://www.gov.uk/guidance/catchment-sensitive-farming-reduce-agricultural-water-pollution#training-and-advice> accessed 12 September 2019

[873] 'Glastir Monitoring and Evaluation Programme' <https://gmep.wales/> accessed 13 July 2020

[874] Soil Association, 'Soil management on organic farms' <https://www.soilassociation.org/media/4332/sa-tech-guide-soil.pdf> accessed 22 August 2019

[875] ibid

[876] B. W. Clapp, *An Environmental History of Britain since the Industrial Revolution* (Longman 1994) 103

[877] 'Securing UK Soil Health' (n 60)

[878] Clapp (n 876) 103

[879] ibid 103

[880] ibid 103

[881] Anna Krzywoszynska, 'Making Soils Count in UK Policy' (*Soil Care Network*) <https://www.soilcarenetwork.com/single-post/2017/10/25/making-soils-count-in-uk-policy> accessed 22 August 2019

of food security, which was the argument used for justifying the payment of subsidies to farmers.[882] When Britain became a member of the European Economic Community (EEC) in 1973, the way that subsidies were paid was changed, but not their extent.[883] Until then productionist perceptions had little to no consideration of environmental concerns. With the growth of the environmental movement from the 1960s onwards, an alternative viewpoint arose.[884] Significantly, the beginning of the 21st century witnessed major changes in both the form and content of agricultural policy that reflect a shift towards a politics of collective consumption and consumer preferences away from price towards quality.[885] In this changing era, different soil related issues have been visible on the agenda, however only problems related to pollution or flooding were focused on.[886] Arguably, the 2013-2014 floods put soils on the policy agenda.[887]

Even though soil policy is mostly focused on pollution prevention through restrictions, actually soil requires a policy that benefits from the key aspects of sustainable development. As mentioned before, soil formation is such a long process, especially in comparison to human lifespan, which makes soil a non-renewable natural resource. A sustainable soil policy must consider future generations as well as the existing one and maintain the provision of ES from this valuable resource for their survival and wellbeing. As anthropocentric pressures on soil resources reach critical limits, ensuring intergenerational equity and sustainability becomes more challenging.[888] Successful soil protection cannot be achieved through merely restrictive and preventative measures as these do not provide sufficient protection without the overarching aim of sustainability. This aim requires effective implementation of SDGs and an international collaborative effort. Nevertheless, there are barriers in front of achieving this.

To begin with, as mentioned earlier, the UK environmental policy is largely implementation of European law and the EU has the competence to legislate on environmental matters.[889] Over the past four decades, the Union has introduced laws and policies tackling issues, such as industrial and agricultural pollution, waste, water quality,

[882] Wyn Grant, 'Agricultural Policy' in Peter Dorey (ed), *Developments in British Public Policy* (Sage 2005)
[883] ibid
[884] ibid
[885] ibid
[886] Krzywoszynska (n 881)
[887] ibid; ADAS, 'Impact of 2014 Winter Floods on Agriculture in England' (4 June 2014) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/401235/RFI7086_Flood_Impacts_Report__2_.pdf> accessed 12 September 2019
[888] Food and Agriculture Organization of the United Nations (n 25)
[889] 'The EU Referendum and the UK Environment: An Expert Review' <https://www.brexitenvironment.co.uk/wp-content/uploads/dlm_uploads/2017/07/Executive-summary-EU-referendum-UK-environment.pdf> accessed 15 July 2021

air quality, nature conservation and climate change.[890] According to the subsidiarity principle, intervention by the EU is allowed in case the objectives of an action cannot be satisfactorily achieved by the Member States by reason of the scale and effects of the proposed action.[891] This principle is in place to safeguard the capacity of the Member States to take action in areas in which the EU does not have exclusive competence.[892] It can be argued that as the UK had not provided sufficient soil protection, the EU could have the authority to go on with a Union level legislation addressing soil degradation. Such a step was taken in 2006; however, the EU's Soil Thematic Directive was blocked by a number of states, including the UK, as they claimed that soil is not a cross-border issue so the EU had no right to regulate soil[893] using the subsidiarity principle argument.[894] Blocking states were concerned about the additional policy requirements, inevitable extra costs for soil protection and limitations to development.[895] The UK also argued that 'disproportionate' cost along with negligible environmental benefit.[896] Another argument presented by the UK was that the problem could be addressed best at a local level.[897] However, the UK has not passed recent national legislation to address soil degradation.[898]

Another reason why soil is ignored in policy is that there is an obvious information deficit. It is acknowledged that further research is needed, especially in SOM and its role in improving structural stability and the breakdown of pollutants, as well as a more established monitoring system particularly for the use of fertilisers.[899] It is important to note that research should be undertaken with a specific focus on soil processes, functions and ES.[900] Even though there was not enough integrated and good quality data on soils in the UK,[901] there has been some recent significant developments. In 2014, the UK Soil Observatory launched a website containing 115 layers of soil data.[902] This tool allows the public, researchers and policy makers to obtain information about soil and land use in the

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[890] ibid
[891] European Parliament Liaison Office in the United Kingdom, 'The principle of subsidiarity' <https://www.europarl.europa.eu/factsheets/en/sheet/7/the-principle-of-subsidiarity> accessed 9 June 2019
[892] ibid
[893] Stankovics, Tóth and Tóth (n 804)
[894] 'EU soil protection law blocked by UK, France and Germany' (*EURACTIV*, 21 December 2007) <https://www.euractiv.com/section/climate-environment/news/eu-soil-protection-law-blocked-by-uk-france-and-germany/> accessed 10 June 2019
[895] Stankovics, Tóth and Tóth (n 804)
[896] 'EU soil protection law blocked by UK, France and Germany' (n 894)
[897] Stankovics, Tóth and Tóth (n 804)
[898] ibid
[899] Bell (n 27)
[900] Philippe C. Baveye, 'Grand challenges in the research on soil processes' (2015) 3 Front. Environ. Sci. 10
[901] Bell (n 27)
[902] 'UKSO UK Soil Observatory' <http://www.ukso.org> accessed 11 June 2019

UK.[903] This practice can lead to more informed decisions related to soil. Also, the Land Information System (LandIS) was developed to provide a computerised database repository comprising of geospatial components, 'mapping unit' geometry and related georeferenced materials, such as satellite imagery and meteorological observations.[904] First commenced in the 1970s, this database has been holding the digital representation of soil information from England and Wales over the past 60-70 years.[905] These are promising; though, not sufficient as soil should be at the forefront of environmental research as regularly as climate change, air and water pollution. Indeed, a sustainable soil policy will benefit from further research focus and up-to-date soil information. This information will also enhance the results of studies on SDGs, specifically the ones related to food security, water scarcity, climate change, and biodiversity loss and health threats.[906]

It is also important to note that not every management strategy fits every soil type. Different types of soils cover different areas and these different soil types require unique protection and management. Indeed, soils vary on national, regional and field scales and optimum management practices will vary from place to place, depending on soil type, land use and climate.[907] The UK has over 700 soil types, determined by variations in geology, climate, plant and animal ecology and land use.[908] Regardless of the culture or landscape setting, knowledge of soil is the basis for sustainable soil management[909] as information is crucial to identify the problems that need to be addressed.[910] From the practitioners' and decision makers' point of view, soil is a specifically difficult area to regulate as its science is extremely complex. Research outcomes must be comprehensible and useful to decision makers and land managers who are the ultimate stewards of soil quality and soil health.[911] To overcome this, knowledge and information should be translated and transferred.[912] Indeed, this process is problematic as information that soil

903 'About the UK Soil Observatory (UKSO)' (*UK Soil Observatory*) <http://www.ukso.org/about.html> accessed 11 June 2019
904 S. H. Hallett and others, 'Developments in land information systems: examples demonstrating land resource management capabilities and options' (2017) 33 Soil Use and Management 514
905 'LandIS Overview' (*LandIS*) <http://www.landis.org.uk/overview/index.cfm> accessed 6 September 2019
906 Saskia D. Keestra and others, 'The Significance of Soils and Soil Science Towards Realization of the United Nations Sustainable Development Goals' (2016) 2 Soil 111
907 'Securing UK Soil Health' (n 60)
908 ibid
909 Food and Agriculture Organization of the United Nations (n 25)
910 Bell (n 27)
911 John W. Doran and Michael R. Zeiss, 'Soil Health and Sustainability: Managing the Biotic Component of Soil Quality' (2000) 15 Applied Soil Ecology 3
912 Keestra and others (n 906)

scientists obtain is rarely transferred to decision making.[913] This issue reflects the need for more interdisciplinary research and interpretation of research results into management options and decision making. Especially, technical areas, such as assessing soil quality, require collaboration among all disciplines of science to examine and interpret their results in the context of land management strategies, interactions, and trade-offs.[914]

Another reason why soil is ignored in policy is that regulating, managing and monitoring soil can be challenging as land is subject to private ownership.[915] There is tension in the legal status of soil as it can be viewed as a private good subject to property rights and a public good attributable to its role as a provider for public assets, such as ES.[916] It is still a matter of question whether soil is of common heritage as it is not a free public good.[917] This confusion hinders the process of offering robust protection for soils through environmental law.[918]

Another challenge appears as that soil has not been at the centre of attention from the public's perspective. The public mostly views soil, unlike air and water, already dirty, underestimating the fact that soil degradation is a critical issue. Raising awareness is a key step in this sense. ES can be used as an effective communication tool for highlighting the importance of soil and what this valuable resource does for humans.

4.3. Conclusion

So far, it has been made clear that the UK soils suffer from an absence of robust legal protection. This problem is due to the lack of interest in the international arena as well as the European law's ineffectiveness. The issues include the non-binding nature of international legislation, scattered and indirect nature of the EU soil laws and UK national laws being majorly in the shape of guidance or standards, which fail to introduce binding objectives or targets. This chapter also established numerous reasons behind this insufficient legal protection. Information on soils is incomplete which makes soils difficult to manage and regulate. The importance of soils and the threats against them also go unnoticed by the public and regulators. Over the past decade, soil policy demonstrates

[913] Keith Shepherd, 'How soil scientists can do a better job of making their research useful' (*The Conversation*, 14 August 2018) <http://theconversation.com/how-soil-scientists-can-do-a-better-job-of-making-their-research-useful-99219> accessed 6 September 2019
[914] D. L. Karlen and others, 'Soil Quality: A Concept, Definition, and Framework for Evaluation' (1997) 61 Soil Sci. Soc. Am. J. 4
[915] Maylis Desrousseaux, 'The Soil: A Strange Legal Notion' in Guillaume Dhérissard (ed), *Soils as a Key Component of the Critical Zone 2: Societal Issues, Volume 2* (Wiley 2018)
[916] Anna Krzywoszynska, 'Soil: Private Asset or Public Good?' (*Sustainable Soils Alliance*) <https://static1.squarespace.com/static/58cff61c414fb598d9e947ca/t/5ca4b8eda4222f9623b1a94f/1554299118256/Economics+of+Soil+Event+Report.pdf> accessed 11 June 2019
[917] Harald Ginzky and others (eds), *International Yearbook of Soil Law and Policy 2017* (Springer 2017) 466
[918] ibid 466

good intent; however, it is too early to see the potential impact of some broad commitments and whether they will have the funding, regulatory powers and legislative underpinning.[919] Considering the challenges soils face, it can be argued that there is an urgency of action in this policy area.[920]

The next chapter will provide an in-depth analysis of the national law and implemented European law in terms of their effectiveness for protecting soils. This analysis will be achieved through focusing on the main pressures on the UK soils and studying how the existing legal framework responds to them.

[919] Campaign to Protect Rural England (n 791)
[920] ibid

CHAPTER FIVE

A Critical Analysis of the United Kingdom Legislation

5.1. Introduction

The previous chapter offered a brief introduction to the UK soil policy and ascertained the reasons why soils have been disregarded in the UK. This chapter will introduce the main pressures on the UK soils and analyse the effectiveness of national and EU-based legal instruments from a soil and soil ES protection point of view. This inclusion is inevitable as the majority of the UK environmental laws stem from European law. This analysis will also establish the level of protection provided for soils. Following this approach, this chapter will identify critical gaps in the existing framework.

For this analysis, a pressure-based approach was selected because analysing laws from a perspective, which aims to understand how they respond to the existing pressures is crucial to assess their effectiveness. This analysis provides a unique contribution though using this approach, but also by providing a comprehensive and detailed assessment of the selected UK soil protection laws. The lack of such an analysis constitutes a significant gap in the literature as a result of the fact that soils are less attractive in research similar to the trends in law making.

This analysis again has a unique component of ES-based analysis in which how laws consider the importance of soil ES is studied. This element is critical in this legal analysis, mainly when soil protection laws are being analysed, because land protection is not sufficient for soil protection and soil functions and ES may be at risk whilst land is seemed as legally protected.

Soil degradation in England and Wales costs an estimated £1.2 billion per year.[921] It has been argued that there is clear evidence that there could be no topsoil left in the next 60 years unless appropriate steps are taken to reverse the ongoing trends of pressures.[922] Soil protection is inseparably related to land use as diverse land uses generate different pressures on soils.[923] Land use can be rural (agriculture, forestry, open land and water, minerals and landfill, outdoor recreation); or urban (residential, transport, industry and commerce or community services).[924] The primary land use in the UK is agriculture,[925] which can lead to further erosion, pollution, compaction or desertification (Table 5.1.). Also, industrial activities and waste management impacts cause degradation of soil quality as a result of pollution and compaction (Table 5.1.).[926] Finally, the loss of

[921] Nature Friendly Farming Network (n 802)
[922] ibid
[923] Bell (n 27)
[924] 'Basic ideas - Land use patterns in Britain' <http://resources.hwb.wales.gov.uk/VTC/env-sci/wI8_landuse_uk.htm> accessed 6 June 2019
[925] Bell (n 27)
[926] ibid

soils to development and construction industry can be seen as another significant pressure in the UK, which would cause sealing (Table 5.1.).[927]

The analysis presented in this chapter has a particular focus on the pressures on the UK soils and preventative law. The UK law contains other legislative instruments, which have a reactive approach to environmental protection, such as the Regulatory Enforcement and Sanctions Act 2008 or Agricultural Land (Removal of Surface Soil) Act 1953. For the purposes of this research, these laws are not considered in this analysis.

As mentioned at the beginning of this study, the UK abbreviation is used for England and Wales. Therefore, the legal analysis presented in this chapter is focused on English and Welsh law and relevant EU law. The discrepancy among English and Welsh laws and Scotland and Northern Ireland is outside the scope of this research.

[927] ibid

Table 5.1. Soil Threats-Causes-Pressures.

This table shows a number of causes of soil threats and whether these threats are in a direct (D) and indirect (I) relationship with the key pressures on the UK soils.

	Erosion	Contamination	Sealing	Compaction	Organic Matter Loss	Salinisation	Desertification
Main Causes	• water and wind • deforestation and loss of vegetation cover • climate change • forest fires • overgrazing • conversion of land to agriculture • unsustainable agriculture practices	• atmospheric sources • industrial works • unsustainable waste management and landfills • incidental sources • unsustainable farming practices and agrochemical sources • urban sources	• need for new houses, business locations and infrastructures • unsustainable urbanisation	• intensive cropping and grazing • heavy machinery in agriculture • pedestrian tourism and recreational sites • climate change	• deforestation • forest fires • conversion of land to agriculture • unsustainable agriculture practices and soil management • climate change	• irrigation • overexploitation of ground water • maintenance of roads with salt • climate change	• overuse or misuse of land for agriculture • deforestation • climate change
Relationship with Related Pressure 1 – Agriculture	D	D	-	D	I	I	D
Relationship with Related Pressure 2 – Industrial Activities and Waste Management	I	D	I	D	I	I	I
Relationship with Related Pressure 3 – Development	I	I	D	I	I	I	I

5.2. Agriculture

5.2.1. Importance of Agriculture for the United Kingdom

Agriculture has a major focus in the existing policy as agricultural practice in the UK uses most of the country's land area.[928] Utilised agricultural area, which represents "the total area taken up by arable land, permanent grassland, permanent crops and kitchen gardens used by the holding, regardless of the type of tenure or of whether it is used as a part of common land",[929] was approximately 17.5 million hectares, covering 72% of the UK land area in June 2018.[930] Additionally, farming is seen as the bedrock of the UK's leading manufacturing sector, food and drink, which contributes £122 billion to the UK economy.[931] In addition to being vital for food production, agriculture shapes the landscape and provides important recreational, spiritual and other cultural ES.[932] It provides recreational activities to an estimated value of £200m for farms and nearly £300m a year for woods.[933] Therefore, agriculture is closely linked to human well-being and the economy.[934] However, agricultural soils are facing ongoing degradation and DEFRA aims to successfully address degradation in agricultural soils in order to achieve their vision.[935] This section will analyse where laws fail to address the threats related to this significant pressure.

5.2.2. Directly Related Threats

Although soil degradation is a physical process, the fundamental causes are found in the social, economic, political and cultural context in which farmers operate.[936] Agricultural practices also have a potential to improve soils. Indeed, SOM can

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[928] Department for Environment, Food and Rural Affairs, 'Farming Statistics – Provisional Crop Areas, Yields and Livestock Populations' (11 October 2018) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/747210/structure-jun2018prov-UK-11oct18.pdf> accessed 4 June 2019

[929] 'Glossary: Utilised Agricultural Area (UAA)' (*Eurostat Statistics Explained*, 13 October 2017) <https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Utilised_agricultural_area_(UAA)> accessed 4 June 2019

[930] Department for Environment, Food and Rural Affairs (n 928)

[931] 'Contributing to the Economy' (*Countryside*, 3 May 2019) <https://www.countrysideonline.co.uk/food-and-farming/contributing-to-the-economy/> accessed 4 June 2019

[932] Department for Environment, Food and Rural Affairs, Department of Agriculture, Environment and Rural Affairs (Northern Ireland), Welsh Assembly Government The Department for Rural Affairs and Heritage, The Scottish Government Rural and Environment Science and Analytical Services, 'Agriculture in the United Kingdom 2017' (2018) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/741062/AUK-2017-18sep18.pdf> accessed 6 June 2019

[933] HM Government (n 803)

[934] J. B. Ruhl, 'Farms, Their Environmental Harms, and Environmental Law' (2000) 27 Ecology Law Quarterly 263

[935] Department for Environment, Food and Rural Affairs (n 53)

[936] Helena Posthumus and others, 'Soil conservation in two English catchments: Linking soil management with policies' (2011) 22 Land Degrad. Develop. 97

be increased through the use of minimum tillage,[937] crop residues, manures, and moderate use of fertilisers.[938] Some modern farming methods (conventional farming) are also seen as efficient for producing high crop yields.[939]

In today's world, the main goal is to produce more provisioning services, e.g., agricultural products and raw materials.[940] As mentioned above, there are also regulating, cultural and supporting services delivered by agricultural landscapes.[941] However, agricultural management is not commonly aimed at enhancing or sustaining the production of these services.[942]

It is proven that agricultural practices also pollute and degrade the environment[943] as agriculture becomes more intensive, with the use of heavier machinery, fields increasing in size and more focus on maximising yield (Table 5.1.).[944] In a nutshell, farms pollute ground water, surface water, air and soils,[945] affect wildlife and add to sedimentation in lake and rivers.[946] As soil degradation is a natural process accelerated by anthropological activities,[947] these practices have additional implications, such as interacting with soil threats[948] mentioned in chapter three. Indeed, in the UK, agricultural intensification creates further soil degradation, which in the past has been generally prevented by using less intensive agricultural practices.[949] The damage is heightened due to the combination of land conversion, farming practices and off-site effects of fertilisers and pesticides.[950] Agricultural practices are one of the main and direct causes of desertification, however, this particular threat is not considered in this chapter as it is not a one of the significant trends in the UK. Overall, it can be argued that intensive agriculture has a significant likelihood of worsening soil threats.

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[937] Silke Skytte Johannsen and Patrick Armitage, 'Agricultural Practice and the Effects of Agricultural Land-Use on Water Quality' (2010) 28 Freshwater Forum 45
[938] Environment Agency (n 752)
[939] Johannsen and Armitage (n 937)
[940] Boris T. Van Zanten and others, 'European agricultural landscapes, common agricultural policy and ecosystem services: a review' (2014) 34 Agron. Sustain. Dev. 309
[941] ibid
[942] ibid
[943] Ruhl (n 934)
[944] Environment Agency (n 752)
[945] Ruhl (n 934)
[946] ibid
[947] 'UK Soil Degradation' (n 751)
[948] Ruhl (n 934)
[949] Johannsen and Armitage (n 937)
[950] Ruhl (n 934)

5.2.2.1. Erosion

Topsoil, which is the richest in SOM and most fertile layer of soil, is frequently the first layer to be lost to threats, such as erosion.[951] Its loss weakens root development and heightens the danger of soil drying out or being saturated.[952] In that case, irrigation and nutrients are needed to compensate and maintain yields.[953]

In England and Wales, over 2 million hectares of soil are at risk of erosion.[954] Annually, 2.9 million tonnes of topsoil are being lost to erosion.[955] The total annual cost of erosion is about £177 million a year.[956]

As mentioned in chapter three, erosion is a natural soil degradation process. However, efforts to tackle large complex resource problems, such as erosion, are hindered through anthropocentric trade-offs.[957] Indeed, agricultural management practices used for reducing the risk of erosion are under examination for their role in increasing leaching of nitrates or pesticides to groundwater and such.[958]

Agricultural intensification has led to an increase in erosion rates.[959] Most apparently, tillage, the mechanical manipulation of the soil,[960] when intensified, makes soils more susceptible to erosion.[961] Other adverse impacts are reduced soil moisture reserves, disruption of soil structure, accelerated SOM decomposition,[962] degradation in soil health through causing poor biological, chemical, and physical properties.[963] Another major concern regarding tillage is that it drastically alters soil functions.[964] Therefore, tillage can be good practice; however, intensified tillage can do more harm than good.[965] In addition, other intensified agricultural outcomes, such as continuous increase in field sizes, over-grazing and use of footpaths make soils more susceptible to erosion.[966] Uncertainty about determining best approaches for improving the effects of farming

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951 Campaign to Protect Rural England (n 791)
952 ibid
953 ibid
954 Environment Agency (n 752)
955 ibid
956 ibid
957 National Research Council, *Soil and Water Quality: An Agenda for Agriculture* (The National Academies Press 1993) 35
958 ibid 35
959 Environment Agency (n 752)
960 Humberto Blanco-Canqui and Rattan Lal, *Principles of Soil Conservation and Management* (Springer 2008) 109
961 Environment Agency (n 752)
962 'Cropping Practices to Reduce Nutrient Losses in Runoff' <https://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/epw11920/$FILE/8-2.pdf> accessed 7 June 2019
963 Mahdi M. Al-Kaisi and Birl Lowery (eds), *Soil Health and Intensification of Agroecosytems* (Academic Press 2017) 109
964 Blanco-Canqui and Lal (n 960) 109
965 T. J. Townsend, S. J. Ramsden and P. Wilson, 'How do we cultivate in England? Tillage practices in crop production systems' (2016) 32 Soil Use and Management 106
966 Environment Agency (n 752)

systems on soils while limiting the harmful ones make policy development more challenging.[967]

5.2.2.2. Compaction

Another potential reason of accelerated erosion is compaction, which is significantly influenced by tillage practice itself, wheel traffic from heavy machinery use and heavy livestock.[968] Compaction is a critical issue on agricultural land;[969] around 3.9 million hectares of agricultural land are facing the threat of compaction in England and Wales.[970] The estimated total cost of compaction is £472 million per year, nearly 3 times greater than that of erosion.[971]

Compaction potentially impacts soil fertility and water resources, and increases the risk of flooding.[972] Indeed, less porous soil is more difficult for plant roots to penetrate and can waterlog more easily.[973] Waterlogging causes lower soil microbial activity, which restricts the recycling and nutrient availability.[974] Compacted soils require more fuel usage, labour and much more nitrogen fertiliser to maintain yields leading to further pollution.[975]

5.2.2.3. Pollution

Eroded soils, as mentioned before, can lead to major pollution incidents[976] and contribute to diffuse pollution in controlled waters with raised levels of silt, nutrients and pesticides.[977] Erosion also causes nutrient loss,[978] which leads to a greater need for agricultural products. To support the increased demand for food and other agricultural products, the consumption of pesticides, herbicides,[979] and cheap inorganic fertilisers has increased drastically.[980] In 2016, about 16,600 tonnes of pesticides and herbicides were

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[967] National Research Council (n 957) 35
[968] Bell (n 27)
[969] Environment Agency (n 752)
[970] ibid
[971] ibid
[972] ibid
[973] Campaign to Protect Rural England (n 791)
[974] ibid
[975] ibid
[976] ibid
[977] Bell (n 27)
[978] Janvier Bigabwa Bashagaluke and others, ‘Soil Nutrient Loss Through Erosion: Impact of Different Cropping Systems and Soil Amendments in Ghana’ 13 PLoS ONE e0208250
[979] Ruhl (n 934)
[980] Johannsen and Armitage (n 937)

used on British farms.[981] Due to increased chemical usage, around 300,000 hectares of land are contaminated in the UK.[982]

In addition to soil pollution, there is another increasing concern: water pollution from agriculture.[983] When pollutants leach into groundwater and surface waters as a result of rainfall, soil infiltration and surface runoff, diffuse pollution occurs. Diffuse pollution is different from point source pollution where pollutants enter a river course at a specific site (e.g., pipe discharge). For diffuse pollution to occur, there must be a recent or past activity on soils, such as the use of fertiliser in agriculture and forestry, pesticides from a wide range of land uses, contaminants from roads and paved areas and atmospheric deposition of contaminants arising from industry.[984]

Potentially toxic elements (PTEs) or heavy metals[985] found in soils can be listed as zinc, copper, nickel, lead, cadmium, chromium and mercury.[986] These elements represent both essential and toxic elements.[987] Beyond a certain threshold value, all elements are considered as toxic.[988] Indeed, pollution arises when PTEs are in such amounts that they increase the natural levels in soil.[989] The effects are clearly seen in plant health where the level of PTEs exceeds plant's tolerance threshold.[990] These also affect human health adversely.[991] Soil microbes, which are central to all life on Earth due to their huge diversity in form and function, are even more vulnerable than plants.[992] Microbial and enzymatic activity, which reflects soil quality, is affected by heavy metal accumulation.[993] Microbial activity is inhibited significantly in the heavy metal contaminated soil.[994] Also, the enzymes in soil, which have a major role in organic matter decomposition and nutrient cycling, are considerably reduced by the increase of the

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981 Environment Agency (n 752)
982 ibid
983 C. J. Vorosmarty and others, 'Global threats to human water security and river biodiversity' (2010) 467 Nature 555; Laurence Smith and others, 'Mitigation of diffuse water pollution from agriculture in England and China, and the scope for policy transfer' (2017) 61 Land Use Policy 208
984 'What is diffuse pollution?' (*FWR Sources of Pollution – diffuse pollution*) <http://www.euwfd.com/html/sources-of-pollution---diffuse-pollution.html> accessed 3 July 2019
985 Umar Nazir Bhat and Anisa B. Khan, 'Heavy Metals: An Ambiguous Category of Inorganic Contaminants, Nutrients and Toxins' (2011) 5 Research Journal of Environmental Sciences 682
986 Lina Weissengruber and others, 'Long-term soil accumulation of potentially toxic elements and selected organic pollutants through application of recycled phosphorus fertilizers for organic farming conditions' (2018) 110 Nutrient Cycling in Agroecosystems 427
987 Bhat and Khan (n 985)
988 ibid
989 Iain Green and others, 'Accumulation of Potentially Toxic Elements in Agricultural Soils' in Pozzo B and Jacometti V (eds), *Environmental Loss and Damage in a Comparative Law Perspective: Attribution, Liability, Compensation and Restoration* (Intersentia, Cambridge 2020)
990 Chao Su, LiQin Jiang and WenJun Zhang, 'A review on heavy metal contamination in the soil worldwide: Situation, impact and remediation techniques' (2014) 3 Environmental Skeptics and Critics 24
991 ibid
992 Centre for Ecology & Hydrology, 'Why: do soil microbes matter?' <http://www.ceh.ac.uk/sites/default/files/SoilMicrobes_A4-Leaflet_ForWeb.pdf> accessed 3 June 2020
993 Su, Jiang and Zhang (n 990)
994 ibid

concentration of heavy metals.[995] These PTEs enter soils through several sources, such as depositions from air and water, application of pesticides, fertilisers, sewage sludge, animal manures.[996]

Pollutants, either from anthropocentric sources (e.g., fossil fuels, industrial processes, fertilisers) or natural sources (e.g., natural mercury cycle), are released into the air and carried away by wind patterns.[997] Atmospheric deposition occurs when these pollutants in the air fall on the land or water.[998] Atmospheric deposition is the chief source of copper, nickel, lead and zinc in soils.[999] In England and Wales, zinc was found in soil in the largest amounts from the atmosphere, followed by copper and lead.[1000] Even though this is ubiquitous, atmospheric deposition rates vary depending on proximity to point sources of pollution (e.g., agriculture, heavy industry or major roads).[1001] The current progression in point source pollution due to various pressures significantly increases the amount of pollutants and contribute in PTE contamination in soils and eventually in crops.[1002]

Pesticides are plant protection products that are used to manage pests and diseases in crops, to control growth, to maintain high crop yields and to support production from agricultural land.[1003] They can have detrimental effects on the environment, particularly on terrestrial and aquatic biodiversity.[1004] There is little evidence of long-term harmful effects of the use of typical range of pesticides on the overall activity or population of soil organisms.[1005] However, it is known that high levels of nutrients and pesticides use cause

[995] ibid
[996] F. A. Nicholson and others, 'Quantifying heavy metal inputs to agricultural soils in England and Wales' (2006) 20 Water and Environment Journal 87
[997] United States Environmental Protection Agency Office of Water, 'Air Pollution and Water Quality – Atmospheric Deposition Initiative' <http://itepsrv1.itep.nau.edu/itep_course_downloads/Ecosystems%20_Resources/Air_Pollution_Water_Quality.pdf> accessed 12 September 2019
[998] ibid
[999] Sam Azimi and others, 'Heavy metal determination in atmospheric deposition and other fluxes in Northern France agrosystems' (2004) 157 Water, Air, and Soil Pollution 295; Agata Bartkowiak, Joanna Lemanowicz and Barbara Breza-Boruta, 'Evaluation of the content of Zn, Cu, Ni and Pb as well as the enzymatic activity of forest soils exposed to the effect of road traffic pollution' (2017) 24 Environmental Science and Pollution Research 23893
[1000] F. A. Nicholson and B. J. Chambers, 'Sources and impacts of past, current and future contamination of soil Appendix 1: Heavy Metals. Final Report to DEFRA' (2007) <http://randd.defra.gov.uk/Document.aspx?Document=SP0547_7265_FRA.pdf> accessed 29 March 2019
[1001] ibid
[1002] R. K. Sharma, M. Agrawal and F. M. Marshall, 'Atmospheric deposition of heavy metals (Cu, Zn, Cd and Pb) in Varanasi City, India' (2008) 142 Environ Monit Assess 269; J. W. Dalenberg and W. Van Driel, 'Contribution of atmospheric deposition to heavy-metal concentrations in field crops' (1990) 38 Netherlands Journal of Agricultural Science 369
[1003] Department for Environment, Food and Rural Affairs, Department of Agriculture, Environment and Rural Affairs (Northern Ireland), Welsh Assembly Government The Department for Rural Affairs and Heritage, The Scottish Government Rural and Environment Science and Analytical Services (n 932)
[1004] ibid
[1005] 'Grassland soil biology guide' (*AHDB*) <https://ahdb.org.uk/grassland-soil-biology-guide> accessed 7 June 2019

extreme nutrient and contaminant loads, which contribute to nitrogen and phosphorus losses.[1006] This results in pollution of surface and ground waters.[1007]

Another issue of concern is arsenic found in pesticides, which end up in soil.[1008] Humans are exposed to these through consumption of groundwater containing naturally high levels of inorganic arsenic, or food crops irrigated with water high in arsenic.[1009] Such consumption can lead to several health issues.[1010]

Plant nutrients are vital elements for plant growth.[1011] These are available in the soil (e.g., nitrogen, phosphorus, and potassium), or transferred from air or water (carbon, hydrogen, oxygen).[1012] When existing nutrients cannot support good crop yields, additional nutrients must be added to soil.[1013]

The main sources of nitrogen, which is vital for crop growth,[1014] are mineralisation (the process by which microbes decompose organic nitrogen from manure, SOM and crop residues to ammonium) and fixation (the conversion of atmospheric nitrogen to a plant available form).[1015] When these are insufficient to maximise yields, mineral and organic fertilisers, e.g., manures and slurries from livestock,[1016] compost or biosolids are used.[1017] Most agricultural soils do not have enough naturally occurring nitrogen to meet the needs of a crop throughout the growing season; thus, additional nitrogen applications are required.[1018]

Nutrient management involves using crop nutrients as efficiently as possible to improve productivity while protecting the natural environment.[1019] Applying nutrients in proper quantities and at the right times, optimum crop yields can be achieved; however, applying too little will limit yield and too much application can damage the

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[1006] Bell (n 27)
[1007] ibid
[1008] Science Communication Unit, University of the West of England, 'Science for Environment Policy In-depth Report: Soil Contamination: Impacts on Human Health' (2013) <http://ec.europa.eu/environment/integration/research/newsalert/pdf/IR5_en.pdf> accessed 12 June 2019
[1009] ibid
[1010] ibid
[1011] 'What Is Nutrient Management?' (*Nutrient Management*) <https://www.nutrientmanagement.ca/about/what-is-nutrient-management/> accessed 7 June 2019
[1012] ibid
[1013] ibid
[1014] Department for Environment, Food and Rural Affairs, Department of Agriculture, Environment and Rural Affairs (Northern Ireland), Welsh Assembly Government The Department for Rural Affairs and Heritage, The Scottish Government Rural and Environment Science and Analytical Services (n 932)
[1015] Courtney Johnson and others, 'Nitrogen Basics – The Nitrogen Cycle' (*Cornell University Cooperative* Extension, 2005) <http://cceonondaga.org/resources/nitrogen-basics-the-nitrogen-cycle> accessed 6 June 2019
[1016] Department for Environment, Food and Rural Affairs, Department of Agriculture, Environment and Rural Affairs (Northern Ireland), Welsh Assembly Government The Department for Rural Affairs and Heritage, The Scottish Government Rural and Environment Science and Analytical Services (n 932)
[1017] 'What Is Nutrient Management?' (n 1011)
[1018] Department for Environment, Food and Rural Affairs, Department of Agriculture, Environment and Rural Affairs (Northern Ireland), Welsh Assembly Government The Department for Rural Affairs and Heritage, The Scottish Government Rural and Environment Science and Analytical Services (n 932)
[1019] 'What Is Nutrient Management?' (n 1011)

environment.[1020] For example, nutrients that are not effectively used by crops may leach into ground or surface waters and too much nitrogen or phosphorus can impair water quality.[1021]

Sewage sludge (biosolids) is an alternative to chemical fertilisers. It contains important proportions of nitrogen, phosphorus, trace elements and organic matter (OM).[1022] 80% of treated sewage sludge in the UK is applied to agricultural soils to improve OM and nutrient levels.[1023] However, sewage sludge can also contain potentially harmful substances including pathogens and heavy metals[1024] and materials, such as persistent organic pollutants and pharmaceuticals, which contaminate soil.[1025] These are toxic to bacterial communities and plants as they affect their root production.[1026] Sewage sludge application as a fertiliser is a significant source of microplastics.[1027] These interact with soil organisms, reducing their ability to provide ES.[1028]

Sludge-applied elements are most readily transferred to humans and livestock through direct ingestion adhering to vegetation or lying on the soil surface.[1029] Evidence shows that increased concentrations of cadmium, nickel, copper and zinc applied in liquid sludge are transferred from sludge-treated soil into the leaves and edible parts of crops.[1030] This result can lead to serious human health implications. Therefore, sewage sludge should be applied on agricultural land considering the set limitations and the metal content of the soil.[1031] Controls must be complied with before and after the application to safeguard food safety.[1032]

When chemical fertilisers are too costly or unavailable, organic fertilisers, such as manure and slurry are preferred by farmers to support soil fertility.[1033] In the UK, vast amounts of animal faecal wastes are applied to agricultural land as this is the only

[1020] ibid
[1021] ibid
[1022] Department for Environment, Food and Rural Affairs (n 816)
[1023] Environment Agency (n 752)
[1024] Department for Environment, Food and Rural Affairs (n 816)
[1025] Environment Agency (n 752)
[1026] ibid
[1027] ibid
[1028] ibid
[1029] Rufus Lee Chaney, 'Toxic Element Accumulation in Soils and Crops: Protecting Soil Fertility and Agricultural Food-Chains' in Bnayahu Bar-Yosef, N. J. Barrow and J. Goldshmid (eds), *Inorganic Contaminants in the Vadose Zone* (Springer-Verlag 1989)
[1030] Food and Agriculture Organization of the United Nations, '6. Agricultural use of sewage sludge' <http://www.fao.org/3/t0551e/t0551e08.htm#TopOfPage> accessed 12 June 2019
[1031] Department for Environment, Food and Rural Affairs (n 816)
[1032] ibid
[1033] 'Technologies and crop/soil management systems' <http://www.fao.org/3/y2413e/y2413e0b.htm> accessed 7 June 2019; A. E. Johnston, 'Organic manures and mineral fertilizers' in Dilek Anac and Pierre Martin-Prével (eds) *Improved Crop Quality by Nutrient Management* (Springer 1999)

economically affordable way for disposal of this by-product of farming.[1034] Also, this practice utilises fertiliser value from the essential elements they contain.[1035] So, soil is a disposal site for manure and slurry, and some farms do not have sufficient land to dispose all manure/slurry produced by their stock. Manure, containing nitrogen, phosphorus, potassium and other nutrients, adds OM to soil and improves soil structure, aeration, soil moisture-holding capacity, and water infiltration.[1036] Therefore, it supports soil ES. Manure is important as it releases nitrogen slowly, which reduces leaching (loss of water-soluble plant nutrients from the soil due to rain and irrigation).[1037] As with other fertilisers, unless used responsibly, these can also damage soil.[1038] Poor storage of manure and slurry can cause release of PTEs and harmful chemicals and gases, such as ammonia, which are harmful to the environment.[1039]

5.2.3. Legal Analysis – Agriculture

So far, we have seen that unsustainably intensive agricultural practices are threatening soils. It is important to note that the existing policy approach provides little pressure on farmers to abandon these practices.[1040] Especially, after the UK's implementation of CAP, the economic maximisation objective has amplified and agricultural intensification has become inevitable.[1041] Also, farmers are CAP direct payment receivers (which will be discussed below) and not under pressure of cutting inefficient use of costly fertilisers and pesticides.[1042] Besides, intensified agriculture mostly produces effects that are likely to be seen in a long time as deep soils can be very responsive to high doses of fertilisers.[1043] Indeed, the impacts of poor soil management, such as loss of carbon to air and water, are not as apparent as soil erosion.[1044]

It is clear that agricultural practices need to be regulated appropriately to achieve sustainable intensification where agricultural yields are improved without negative

[1034] F. A. Nicholson and others, 'A study on farm manure applications to agricultural land and an assessment of the risks of pathogen transfer into the food chain' (January 2000) A Report to the Ministry of Agricultural Fisheries and Food
[1035] A. A. Araji, Z. O. Abdo and P. Joyce, 'Efficient use of animal manure on cropland–economic analysis' (2001) 79 Bioresour. Technol. 179
[1036] Wenhui Zhong and others, 'The effects of mineral fertilizer and organic manure on soil microbial community and diversity' (2010) 326 Plant and Soil 511
[1037] ibid
[1038] ibid
[1039] HM Government (n 803)
[1040] Campaign to Protect Rural England (n 791)
[1041] ibid
[1042] ibid
[1043] ibid
[1044] ibid

environmental impacts[1045] and to safeguard the flow of ES from soils. The rest of this section will critically analyse whether the existing legal instruments accommodate this approach and provide sufficient protection for soils.

At the EU level, the Roadmap to a Resource Efficient Europe urges the Member States to set up an inventory of contaminated sites, and a schedule for remedial work by 2015.[1046] DEFRA supported projects with the aim of providing a summary of the approaches taken by several countries to identify and remediate contaminated land.[1047] The UK government majorly supported the objectives laid out in the Roadmap, focusing mostly on business aspects of it, such as smart, sustainable and inclusive growth.[1048] The Roadmap also encourages the Member States to implement the action needed for reducing erosion and increasing SOM content.[1049] However, one can argue that these are vague aims, which lack details and without a functional action plan to back them up, they are quite difficult to achieve. In addition, this document is non-binding, which makes these aims even less realisable.[1050]

Similarly, the 7th Environment Action Programme (EAP) does not set any mandatory requirements; although it highlights the importance of addressing major threats to soils mentioned in this section, i.e., erosion and pollution.[1051] Under the EAP priority objective 1, EU calls for increasing efforts to minimise soil erosion and for an enhanced integration of land use aspects into decision making, supported by the adoption of targets on soil.[1052] The EAP calls for the integration of consideration on water protection and biodiversity conservation into planning decisions relating to land use supporting the objective of 'no net land take' by 2050.[1053]

Regulation of intensified agricultural practices has been scattered through the policy. The summary report 'Best Practice for Managing Soil Organic Matter in

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[1045] Jules Pretty and Zareen Pervez Bharucha, 'Sustainable intensification in agricultural systems' (2014) 114 Annals of Botany 1571

[1046] Commission, 'Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Roadmap to a Resource Efficient Europe' (Communication) COM (2011) 0571 final

[1047] Land Quality Management Ltd, 'International Processes for Identification and Remediation of Contaminated Land – Final' (December 2013) <http://randd.defra.gov.uk/Document.aspx?Document=11863_1023DefraInternational22combined(2).pdf> accessed 19 July 2019

[1048] 'Europe 2020 Strategy: Roadmap to a Resource Efficient Europe Non-Paper by the United Kingdom' (5 April 2011) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69422/resource-efficient-europe.pdf> accessed 19 July 2019

[1049] Commission (n 1046)

[1050] Glæsner, Helming and de Vries (n 43)

[1051] Council Decision 1386/2013/EU of the European Parliament and of the Council of 20 November 2013 on a General Union Environment Action Programme to 2020 'Living well, within the limits of our planet' [2013] OJ L354/171 (hereinafter 'Environment Action Programme')

[1052] ibid

[1053] ibid

Agriculture' highlighted the importance of correct tillage application for maintaining SOM and reducing the risk of erosion.[1054] It is argued that reducing tillage intensity has the potential of moving towards sustainable intensification objectives; hence, it can reduce adverse environmental impacts and improve agricultural outputs.[1055] As mentioned before, SOM loss can be reduced by preventing over-tilling. DEFRA recommends farmers to make an assessment of the risk of operations and management to soil erosion, and to take action to reduce these impacts and mitigate any potential harm.[1056] It also advises on the best times of the year to apply tillage, manure and fertilisers.[1057] Similarly, DEFRA's Code of Practice,[1058] the Environment Agency's strategy document[1059] and the England Catchment Sensitive Farming Delivery Initiative[1060] also provide advice on soil management. However, there is no direct legislation that regulates or bans intensified tillage or ploughing.

The 25 Year Environment Plan generally recognises the use of agricultural fertilisers and pesticides as a pressure on waterbodies, rather than the soil itself.[1061] It adopts the action for "ensuring that the regulation of pesticides continues to develop with scientific knowledge and is robust and fit for purpose, so as to protect people and the environment".[1062] It reinforces implementing policies that encourage and support sustainable crop protection with the minimum use of pesticides.[1063] It highlights the need for a better air and water protection through an efficient use of fertilisers.[1064] Similarly, the Plan emphasises the need for a robust regulation for the storage and spreading of manure and slurry that limits inputs.[1065] It also advocates for taking action to decrease the risk of harm from flooding and coastal erosion, including greater use of natural flood management solutions.[1066] This point is interesting as only coastal erosion has a focus in the document, and where soil erosion is mentioned, majorly its effects on waterbodies are

[1054] A. Bhogal and others, 'Best Practice for Managing Soil Organic Matter in Agriculture – Manual of Methods for Lowland Agriculture' (July 2009) <http://randd.defra.gov.uk/Document.aspx?Document=SP08016_8567_FRP.pdf> accessed 13 September 2019
[1055] Townsend, Ramsden and Wilson (n 965)
[1056] Department for Environment, Food and Rural Affairs, 'The guide to cross compliance in England 2019' <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/764890/Cross_Compliance_2019_rules_v1.0.pdf> accessed 13 September 2019
[1057] ibid
[1058] Department for Environment, Food and Rural Affairs (n 816)
[1059] Environment Agency, 'Soil: A Precious Resource - Our strategy for protecting, managing and restoring soil' (2007) <https://static1.squarespace.com/static/58cff61c414fb598d9e947ca/t/5abb6945758d462671b79208/1522231625807/EA+2007+Soilis-+a+Precious+resouce.pdf> accessed 13 September 2019
[1060] Department for Environment, Food and Rural Affairs, Environment Agency and Natural England (n 872)
[1061] HM Government (n 803)
[1062] ibid
[1063] ibid
[1064] ibid
[1065] ibid
[1066] ibid

of concern. Soil health also has a particular mention in the Plan. It encourages making appropriate tillage or rotation choices that can improve soil health, maintain good soil structure and increase crop yields, while minimising the risk of environmental damage.[1067] It aims to ensure healthier soils by addressing erosion, compaction and SOM loss.[1068] There are clearly several aspects that are related to threats from agricultural practices. However, considering the fact that the Plan is not a legally binding instrument, similar to the documents mentioned before, it is arguable how successful these indirect and vague measures can be for soil protection.

The rest of this chapter will analyse the effectiveness of legal instruments that have been shaping soil protection in the UK.

5.2.3.1. Agriculture Act

During the Second World War, there was a significant increase in the prosperity of agriculture in the country.[1069] The UK government committed to permanent cultivation of land and the financial stability of farms and agriculture.[1070] The government's main agenda was to maintain high levels of agricultural production through a system of guaranteed prices negotiated annually by the Ministry of Agriculture and the National Farmers' Union.[1071] The government subsidised shortfalls between food market prices and the income requirements of farmers.[1072] This post-war policy was shaped by Agriculture Act 1947.[1073]

The objectives of this Act were to provide price stability, lower food imports,[1074] increase agricultural protection and encourage farming through securing farmer incomes, improving farmer security and implementing good farming practices.[1075] Data provided by DEFRA show that this productionist approach achieved its objective as there was a noteworthy increase in yields from the late-1940s onwards.[1076]

[1067] ibid
[1068] ibid
[1069] 'Farming and the Agriculture Acts' (*The National Archives*) <http://www.nationalarchives.gov.uk/cabinetpapers/themes/farming-agriculture-acts.htm> accessed 10 August 2019
[1070] ibid
[1071] ibid
[1072] ibid
[1073] ibid
[1074] ibid
[1075] 'We are to get a new Agriculture Act - so let's have a look at the old one - the 1947 Agriculture Act' (*Sustain*, 27 July 2017) <https://www.sustainweb.org/news/jul17_1947_agriculture_act_and_amends/> 13 August 2019
[1076] Department for Environment, Food and Rural Affairs, 'UK cereal yields summary' (31 May 2019) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/805508/structure-june-ukcerealoilseed-31may19.xls> accessed 13 September 2019

Initially, the Act was introduced to increase agricultural output by 60% over pre-war levels.[1077] In 1953, world cereal prices dropped, and minimum guaranteed prices were replaced by deficiency payments.[1078] These payments comprise of retrospective bonus payments from the government for each unit of output sold when farmers sold their output at the best market price they could obtain.[1079] The increased use of deficiency payments was embodied in law in the 1950s.[1080] The Agriculture Act 1957 aimed to ensure that guaranteed prices did not drop below a certain level.[1081] This stability in prices increased farm incomes and cereal prices.[1082] Besides, due to more intensive agricultural practices, such as mechanisation and application of inorganic herbicides, fertilisers and pesticides,[1083] crop yields improved and labour use and costs reduced.[1084]

From a soil perspective, as opposed to the abovementioned efforts, there was no aim or objectives that provided protection for soils or the environment. As the aim of maximising production has intensified agricultural practices, outputs were raised in the expense of environmental damage.[1085] However, these environmental impacts of intensive agriculture were excluded from the primary decision making arena for a long time.[1086]

Especially after the Thatcher era, the commitment to the productionist policy has been challenged by the emergence of new agendas, such as international trade, food safety and quality, conservation and the environment.[1087] However, the most lasting effect of this productionist paradigm is argued to be the mentality, which was difficult to change.[1088] Today, the main objectives are switched into obtaining larger yields for the growing population while reducing the adverse impact of agricultural activities on the environment. Whether the existing policies are effective to achieve this aim is another question.

In 1980s, following the growing public and political awareness of the impact of agriculture on the environment, the Agricultural Act 1986 introduced the

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1077 J. K. Bowers, 'British Agricultural Policy since the Second World War' (1985) 33 The Agricultural History Review 66
1078 'Agriculture in Post-war Britain' <http://www.ecifm.rdg.ac.uk/postwarag.htm> accessed 13 September 2019
1079 Peter Self and Herbert J. Storing, *The State and the Farmer* (George Allen & Unwin 1962)
1080 Grant (n 882)
1081 'Agriculture in Post-war Britain' (n 1078)
1082 ibid
1083 David Jenkins (ed), *Agriculture and the Environment* (Natural Environment Research Council 1984) 3
1084 'Agriculture in Post-war Britain' (n 1078)
1085 Grant (n 882)
1086 ibid
1087 ibid
1088 ibid

Environmentally Sensitive Areas scheme.[1089] This scheme is the first large scale agri-environmental programme that paid farmers for conserving natural features and producing non-farm environmental goods.[1090] This programme is seen as a new approach to policy development and delivery within agriculture.[1091] The Environmentally Sensitive Areas scheme laid the foundation for later EU-wide agri-environmental programmes, which will be discussed below.[1092]

The Act has seen multiple reforms since 1947.[1093] Even though the Agriculture Act 1986 considered the importance of the conservation and enhancement of the natural beauty and amenity of the countryside,[1094] there is no specific protection provided for soils from the potential impact of intensive agricultural practices. Indeed, the Act does not contain any soil specific targets or objectives. It can be argued that, reflecting the government's priorities, the Agriculture Act did not focus on sustaining natural resources and protecting soils, although it was a highly relevant instrument.

The latest Act also fails to give explicit soil or soil ES references as the Act predates the concept (Table 5.2.). Its focus is on maximising food production, thus implicitly, it should contribute to this provisioning soil ES. It also mentions preventing damage to crops and animals on a land,[1095] which can be interpreted as a reference to primary production and habitat. In addition, there is a requirement to strike a balance between "the promotion and maintenance of a stable and efficient agricultural industry, the economic and social interests of rural areas, the conservation and enhancement of the natural beauty and amenity of the countryside (including its flora and fauna and geological and physiographical features) and of any features of archaeological interest there and the promotion of the enjoyment of the countryside by the public."[1096] It can be argued that these constitute an implicit reference to supporting soil ES, recreation, cognitive and heritage. In sum, although these aspects that could potentially contribute to soil protection, this Act can be seen as a somewhat powerless piece of legislation from a soil conservation point of view as it has no specific action plan for soil protection and eventually has failed to protect soils.

[1089] Richard Byrne, 'The Common Agricultural Policy is dead: long live the BAP' (*The London School of Economic and Political Science*, 21 March 2018) <https://blogs.lse.ac.uk/brexit/2018/03/21/the-common-agricultural-policy-is-dead-long-live-the-bap/> accessed 17 June 2019
[1090] ibid
[1091] ibid
[1092] ibid
[1093] Agriculture Act 1957, 1958, 1967, 1970, 1986, 1993
[1094] Agriculture Act 1986, s 1(1)(b)
[1095] Agriculture Act 1947, s 98
[1096] Agriculture Act 1986, s 17(1)

Table 5.2. The analysis of soil protection legislation.

This table lists the legislative instruments related to soils and shows whether they have soil specific targets or objectives, soil focused provisions and content and references to soil threats in an explicit or implicit manner. This table also shows the direct (D) or indirect (I) relevance of these instruments to soil protection and potential contribution to soil ES provision. It also contains an overall analysis of the level of protection given to soil: very weak (VW), weak (W), modest (M), strong (S), very strong (VS).

	Legislation reference	**Related pressure**	**Soil specific targets or objectives**	**Relevance to soil protection**	**Soil focused provisions and content**	**Soil threats explicitly mentioned**	**Soil threats implicitly mentioned**	**Direct reference to ecosystem services**	**Level of protection given to soil**
Agriculture Act	1947 – 1986	Agriculture	None	I	None	None	None	None	VW
Direct Payments Regulation	Regulation 1307/2013 CAP Pillar I	Agriculture	None	D	**Recital 42 and 45** – improvement of soil quality **Art 24 (6)** – poor soil quality as a natural constraint **Art 43** – payment for agricultural practices beneficial for soils **Art 45 (1)** – importance of protecting permanent grasslands on carbon-rich soils **Annex IV** – practices equivalent to EFAs which can be beneficial for soils	Sealing	Erosion, SOM loss, compaction, diffuse pollution, desertification	Soil biodiversity (Preamble)	W
Horizontal Regulation	Regulation 1306/2013 CAP Pillar I	Agriculture	**GAEC 4:** minimum soil cover **GAEC 5:** minimum land management reflecting site specific conditions to limit erosion, **GAEC 6:** maintenance of SOM level through appropriate practices	D	**Annex II** – Standards for GAEC (GAEC 4 – minimum soil cover, GAEC 5 – minimum land management reflecting site specific conditions to limit erosion, GAEC 6 – maintenance of SOM level through appropriate practices, GAEC 7 – retention of landscape features)	Erosion, SOM loss	Compaction, pollution	Food production (Art 110 (2) (a)), refugia (Preamble)	M
Rural Development Regulation	Regulation 1305/2013 CAP Pillar II	Agriculture	**Priority 4:** restoring, preserving and enhancing ecosystems related to agriculture	D	**Art 5 (4)** – restoring, preserving and enhancing soil ecosystems, preventing erosion, improving soil management	Erosion	Compaction, soil pollution, desertification, SOM loss, salinisation	Carbon sequestration (Art 5 (5) (e)), soil biodiversity	S

			and forestry **Priority 5:** promoting resource efficiency and supporting the shift towards a low carbon and climate resilient economy in the agriculture and food sectors and the forestry sector		**Art 53** – significance of soil functionality			(Arts 5 (4) (a)), cultural and natural heritage (Art 20 (1) (f)), ecosystem services (Arts 25 (2), 53 (3) (a) (iii)), food production (Art 5 (1) (b)), biomass (Art 35 (2) (h)), refugia (Art 17 (1) (d))	
Animal Feed Directive	Directive 2002/32	Agriculture	None	I	**Recital 6** – animal feed may contain undesirable substances which can endanger the environment **Annex I –** maximum levels of undesirable substances	None	Soil pollution	None	VW
Organics Regulation	Regulation 834/2007	Agriculture	**Art 3** – establishing a sustainable management system for agriculture that sustains and enhances the health of soil and makes responsible use of natural resources, such as soil.	D	**Recital 12 and 13** – maintaining and enhancing soil fertility, preventing erosion, limiting fertiliser use **Recital 15** – preventing soil pollution **Art 3** – soil related objectives **Art 5 (a)** – maintenance and enhancement of soil life and fertility, stability and biodiversity, combating compaction and erosion **Art 12 (1) (a)** – supporting use of tillage and cultivation practices that maintain or increase SOM, enhance soil stability and biodiversity, and prevent compaction and erosion) **Art 14** – limiting livestock to minimise overgrazing, poaching of soil, erosion, or pollution	Erosion, pollution, compaction	SOM loss	Food production (Art 3 (c)), soil biodiversity (Arts 5(a), 12 (1) (a))	S

Water Framework Directive	Directive 2000/60	Agriculture	None	I	None	None	Erosion, soil pollution, salinisation, SOM loss, sealing	Water storage (Art 4 (3)), water quality regulation (Preamble), water supply regulation (Preamble, Art (1) (e))	W
Diffuse Pollution Regulations	SI 2018/151	Agriculture	None	I	None	None	Erosion, soil pollution, compaction	None	M
Groundwater Directive	Directive 2006/118	Agriculture	None	I	None	None	Soil pollution	None	VW
Nitrates Directive	Directive 91/676	Agriculture	None	D	**Art 4** – Member States shall establish codes of good agricultural practice for farmers which should cover items in Annex IIA **Annex II** – objective of reducing nitrate pollution and provisions on land application of fertilisers	None	Erosion, soil pollution, compaction	Water storage, water supply regulation, water quality regulation (Preamble)	S
Sewage Sludge Directive	Directive 86/278	Agriculture	**Preamble** – establishing certain measures in connection with soil protection and avoiding the use of sewage sludge that impairs the quality of soil. **Art 1** – regulating the use of sewage sludge in agriculture in a way that prevents harmful effects on soil	D	**Preamble** – soil related objectives **Art 1** – purpose of the Directive **Art 5 (1)** – prohibiting the use of sludge where heavy metal concentration in soil exceeds limit values in Annex IA **Art 7** – prohibiting the use of sludge on soil in which fruit and vegetable crops are growing **Art 8** – sludge use must not impair soil quality **Art 9** – requirement for soil and sludge analysis	Soil pollution	Erosion, SOM loss	None	VS
Pesticides Directive	2009/128	Agriculture	None	I	None	None	Soil pollution	Recreation (Art 12 (a))	W
Part IIA of the Environmental	1990	Industry and waste	Addressing the legacy of land which is	D	**S 78A (2)** – statutory definition of contaminated land	Soil pollution	None	None	W

Protection Act			already chemically contaminated		**S 78B** – requirement for identification of contaminated land **S 78E** – requirement for remediation of contaminated land				
Environmental Liability Directive	Directive 2004/35	Industry and waste	None	D	**Art 2 (1) (c)** – Land damage is a type of environmental damage. **Art 3** – the Directive applies to environmental damage or imminent threat of such damage. **Annex II** – removal and control of contaminants so that contaminated land does not pose any significant risk of adversely affecting on human health	Soil pollution	None	None	M
Industrial Emissions Directive	Directive 2010/75	Industry and waste	**Art 1** – direct aim of preventing or reducing industrial pollution on land	D	**Art 3 (21)** – definition of soil **Art 14 (1) (b)** – appropriate measures to ensure soil protection **Art 14 (1) (e)** – monitoring of measures to prevent emissions to soil **Art 22** – consideration of the possibility of soil contamination and the state of soil **Art 46** – preventing release of polluting substances into soil from waste incineration plant sites **Art 52** – precautions in delivery and reception of waste to prevent or limit soil pollution	Soil pollution	SOM loss	None	S
Waste Framework Directive	Directive 2008/98	Industry and waste	None	D	**Art 13** – requirement to take measures to ensure that waste management does not pose risk to soil	Soil pollution	SOM loss	None	W
Landfill Directive	Directive 1999/31	Industry and waste	**Art 1** – providing for measures, procedures and guidance to prevent or reduce negative effects on soil from landfilling of waste, during the whole lifecycle of the landfill	D	**Art 1** – soil related aim **Annex I (3)** – protection of soil	Soil pollution	Sealing	Platform (Annex I), recreation (Annex I), heritage (Annex I)	M
Mining Waste Directive	Directive 2006/21	Industry and waste	**Art 1** – providing measures,	D	**Art 1** – soil related aim	Erosion, soil	None	Water quality regulati	S

			procedures and guidance to prevent or reduce adverse effects on soil		**Art 4** – requirement for necessary measures to ensure that extractive waste is managed without risk to soil **Art 5 (3)** – waste management plan should contain measures that prevent soil pollution **Art 10 (1) (2)** – preventing soil pollution when extractive waste is being out back in excavation voids **Art 11 (2)** – locating waste facilities considering soil pollution and erosion and constructing waste facilities considering soil pollution **Art 13** – necessary measures for preventing or minimising soil contamination by waste	pollution		on (Preamble)	
Environmental Impact Assessment Directive	Directive 2014/52	Development	None	D	**Art 3 (1) –** EIA should identify, describe and assess direct and indirect significant effects of a project on land and soil.	Erosion, soil pollution, compaction, sealing, SOM loss	None	None	S
Strategic Environmental Assessment Directive	Directive 2001/42	Development	None	D	**Annex I** – The information to be provided under Art 5(1), where an environmental assessment is required, includes the likely significant effects on soil of implementing the plan or programme.	None	Compaction, erosion, SOM loss, sealing, soil pollution, desertification, salinisation	None	M

5.2.3.2. Common Agricultural Policy

5.2.3.2.1. Background

CAP, launched in 1962, is a partnership between agriculture and society, and between the EU and its farmers.[1097] It aims to build a cost-effective system where farmers work in a sustainable and environment-friendly manner and maintain the healthy status of soils and biodiversity.[1098]

[1097] 'The common agricultural policy at a glance' (*European Commission*) <https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/cap-glance_en> accessed 12 June 2019

[1098] ibid

After Britain entered the EEC, the system of price support altered from deficiency payments to protection and intervention payments.[1099] CAP has been the most significant influence on the UK agriculture policy since 1973.[1100] It has been a key source of funding for and approaches to sustainability in the agriculture and rural development sectors.[1101]

It can be argued that CAP has achieved its main objective of ensuring farm income and food security.[1102] Since the 1990s, the policy has gone through several reforms.[1103] Its initial objectives, such as supporting food production in post-war Europe, are no longer relevant.[1104] CAP does not reflect the need for robust environmental protection and the current public demand for food quality instead of affordable food.[1105] Arguably, these conflicting objectives and instruments weaken the policy design and its implementation.[1106]

The rest of this section will give a brief background on how the policy has developed and outline the rules that shaped the policy. However, the legal analysis will focus on the most soil-relevant aspects: Greening direct payments for agricultural practices beneficial for the climate and the environment (Direct Payments Regulation)[1107] and cross-compliance rules and GAEC standards for soils (Horizontal Regulation)[1108] under Pillar I; and rural development support under Pillar II (Rural Development Regulation).[1109]

1099 'Agriculture in Post-war Britain' (n 1078)
1100 Nature Friendly Farming Network (n 802)
1101 Stephen Whitfield and Aron Marshall, 'Defining and Delivering 'Sustainable' Agriculture in the UK after Brexit: Interdisciplinary Lessons from Experiences of Agricultural Reform (2017) 15 International Journal of Agricultural Sustainability 501
1102 Samuel White, 'EU agricultural policy incoherent and outdated – report' (*EURACTIV*, 4 December 2017) <https://www.euractiv.com/section/agriculture-food/news/eu-agricultural-policy-incoherent-and-outdated-report/> accessed 18 June 2019
1103 European Commission, 'CAP Explained – Direct Payments for Farmers 2015-2020' (May 2017) <https://ec.europa.eu/agriculture/sites/agriculture/files/direct-support/direct-payments/docs/direct-payments-schemes_en.pdf> accessed 19 June 2019
1104 White (n 1102)
1105 ibid
1106 ibid
1107 Regulation (EU) No 1307/2013 of the European Parliament and of the Council of 17 December 2013 establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy and repealing Council Regulation (EC) No 637/2008 and Council Regulation (EC) No 73/2009 [2013] OJ L 347/608 (hereinafter 'Direct Payments Regulation')
1108 Regulation (EU) No 1306/2013 of the European Parliament and of the Council of 17 December 2013 on the financing, management and monitoring of the common agricultural policy and repealing Council Regulations (EEC) No 352/78, (EC) No 165/94, (EC) No 2799/98, (EC) No 814/2000, (EC) No 1290/2005 and (EC) No 485/2008 [2013] OJ L 347/549 (hereinafter 'Horizontal Regulation')
1109 Regulation (EU) No 1305/2013 of the European Parliament and of the Council of 17 December 2013 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD) and repealing Council Regulation (EC) No 1698/2005 [2013] OJ L 347/487 (hereinafter 'Rural Development Regulation')

5.2.3.2.2. Payments and Other Measures

CAP introduced three types of payments: Direct payments, market management measures and rural development schemes.[1110]

Income support through direct payments aims to ensure income stability, to reward farmers for choosing environment-friendly farming options and to deliver public goods, such as taking care of the countryside.[1111] Direct payments under 'Pillar I' (€3.1 billion in the UK in 2016) include the Basic Payment Scheme (BPS), a greening payment, which is 30% of the direct payments total, and a Young Farmers Scheme.[1112]

Rules for greening direct payments for agricultural practices beneficial for the climate and the environment under Pillar 1 of the CAP are found in Direct Payments Regulation[1113] in conjunction with Delegated Regulation (EU) No 639/2014[1114] on direct payments under the CAP and Implementing Regulation (EU) No 641/2014[1115] on direct payments under the CAP.

The objective of the greening direct payment is enhancing the policy's environmental performance through payments for farmers who apply agricultural practices beneficial for the environment and climate. These are intended to strengthen CAP for delivering its environmental objectives and to ensure the long-term sustainability of EU agriculture.[1116] Pillar 1 greening requirements can be viewed under three groups, namely crop diversification ("the farmer must cultivate at least two different crops if he has more than 10 hectares of arable land; if he has more than 30 hectares, he must cultivate at least three crops; the main crop may cover no more than 75% of the arable land, and the two main crops no more than 95%");[1117] maintaining an Ecological Focus Areas (EFA) "of at least 5% of the arable area of the holding on farms with more than 15 hectares of arable land (excluding permanent grassland and permanent crops): edges of fields, hedges, trees, fallow land, landscape features, biotopes, buffer strips, afforested

1110 'The common agricultural policy at a glance' (n 1097)
1111 ibid
1112 Department for Environment, Food and Rural Affairs, *Health and Harmony: the future for food, farming and the environment in a Green Brexit* (Cm 9577, 2018)
1113 Direct Payments Regulation (n 1107)
1114 Commission Delegated Regulation (EU) No 639/2014 of 11 March 2014 supplementing Regulation (EU) No 1307/2013 of the European Parliament and of the Council establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy and amending Annex X to that Regulation [2014] OJ L 181
1115 Commission Implementing Regulation (EU) No 641/2014 of 16 June 2014 laying down rules for the application of Regulation (EU) No 1307/2013 of the European Parliament and of the Council establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy [2014] OJ L 181
1116 European Commission, 'Evaluation of the CAP Greening Measures' <https://ec.europa.eu/agriculture/sites/agriculture/files/leaflet_en.pdf> accessed 16 September 2019
1117 European Parliament, 'First pillar of the common agricultural policy (CAP): II – Direct payments to farmers' (*Fact Sheets on the European Union*) <https://www.europarl.europa.eu/factsheets/en/sheet/109/first-pillar-of-the-common-agricultural-policy-cap-ii-direct-payments-to-farmers> accessed 9 July 2020

areas or nitrogen-fixing crops";[1118] and the maintenance of permanent grassland, including the designation and protection of environmentally sensitive permanent grassland to meet the objectives of the Birds and Habitats Directives through not converting or ploughing the grassland.[1119] Permanent grassland is grassland that has not been included in the crop rotation of the holding for at least five years.[1120] The Member States must make sure that the ratio of permanent grassland to the total agricultural area is not under 5%.[1121] This approach has a potential for soil protection; however, the area of farms covered apart from grassland is small.[1122]

Considering soil protection, the most beneficial requirements of these are EFAs is the designation of permanent grasslands on carbon rich soils, which addresses issues in addressing related to erosion and soil carbon.[1123] Arguably, some EFAs allow the Member States to pick whether farmers are allowed to use fertilisers, which may hinder the expected soil benefits.[1124] The effectiveness of EFAs in relation to soil protection depends on which EFA type the Member States choose to include in their list and the definitions of them.[1125] Issues about the eligibility for payments have resulted in the removal of scrub and areas of gorse from a large number of farms in the UK and led to adverse environmental impacts. It can be argued that a more inclusive approach in EFAs would be beneficial.[1126]

Designation of permanent grassland can potentially reduce SOM loss in addition to erosion risk as mentioned earlier.[1127] An issue about this can be seen as that these soils can still be cultivated under the European rules, as long as the 5% ratio is achieved.[1128]

Crop diversification can make an important contribution to controlling disease, enhancing biodiversity and the provision of ES and building soil fertility.[1129] The objective of crop diversification requirement is improving soil quality;[1130] however, this measure is only effective in theory. Because, in practice, soil-related benefits of this requirement can only become a reality depending on the individual farmer's

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1118 ibid
1119 Frelih-Larsen and others (n 40)
1120 European Parliament (n 1117)
1121 ibid
1122 Campaign to Protect Rural England (n 791)
1123 Frelih-Larsen and others (n 40)
1124 ibid
1125 ibid
1126 House of Commons Environment, Food and Rural Affairs Committee, 'Greening the Common Agricultural Policy – Written Evidence' <https://www.parliament.uk/documents/commons-committees/environment-food-rural-affairs/GCAPConsolidatedwrittenevidence.pdf> accessed 19 June 2019
1127 Frelih-Larsen and others (n 40)
1128 ibid
1129 House of Commons Environment, Food and Rural Affairs Committee (n 1126)
1130 Direct Payments Regulation (n 1107), recital 41

implementation.[1131] Also, crop diversification does not stop intensive agricultural practices, such as ploughing, pesticide and fertiliser use.

In sum, the strengths of greening requirements in terms of soil protection can be seen as indirectly addressing a number of soil threats, i.e., erosion and loss of SOM. These requirements are also obligatory for all farmers who are eligible.[1132] Thus, these measures can have impact as EFAs can be applied to a large number of arable farms.[1133] Additionally, the policy provides the Member States with the flexibility of introducing equivalent agri-environment measures, which may include more specific soil protection measures or requirements.[1134] Finally, the policy serves an opportunity for the Member States to protect environmentally sensitive permanent grasslands outside designated protection areas, such as Natura 2000.[1135]

There are also some weaknesses that may hinder the soil benefits of these requirements. Firstly, crop diversification does not include crop rotation, which is beneficial for keeping the nutrient levels high in soil.[1136] The lack of crop rotation may risk exhausting the soil in time whilst increasing soil erosion.[1137] This situation can lead to poor plant health, which would require more use of pesticides.[1138] Besides, there are a few overlaps within the policy, namely the addition of EFA option for landscape and terraces that were already protected under GAEC 7 (discussed below), and the addition of agroforestry and forested areas that were already recognised under the rural development funding (discussed below).[1139] Overall, the efforts for greening the payments were found somewhat ineffective as just £0.64 billion – 20% of the total – is spent on payments for environmentally friendly farming.[1140] The European Court of Auditors[1141] concluded that the mechanism is not likely to significantly enhance CAP's

[1131] Frelih-Larsen and others (n 40)
[1132] ibid
[1133] ibid
[1134] ibid
[1135] ibid
[1136] Johannes Hufnagel, Moritz Reckling and Frank Ewert, 'Diverse approaches to crop diversification in agricultural research. A review' (2020) 40 Agronomy for Sustainable Development 14
[1137] House of Commons Environment, Food and Rural Affairs Committee (n 1126)
[1138] ibid
[1139] Frelih-Larsen and others (n 40)
[1140] HM Government (n 803)
[1141] European Court of Auditors, 'Future of the CAP' (March 2018) Briefing Paper <https://www.eca.europa.eu/Lists/ECADocuments/Briefing_paper_CAP/Briefing_paper_CAP_EN.pdf> accessed 21 June 2019

environmental impacts.[1142] The objective of these measures was found unclear and lacking specific targets for the measure's contribution to the environment and climate.[1143]

BPS, another direct payment type under Pillar I, which is focused on enhancing farm income rather than environmental protection, is linked to farmed hectares, not to the quantities produced to avoid unnecessary food production.[1144] Indeed, £3.2bn is spent in the UK under the CAP (£2.59bn of this is spent under BPS) and this payment is determined according to the amount of land they own.[1145]

Under this scheme, small farmers are not supported sufficiently, as payments under the Young Farmers Scheme make up a very small portion of total payments.[1146] Indeed, small farmers receive inadequate support[1147] and bigger businesses and landowners receive greater subsidies.[1148] Thus, it is clear that the distribution of these payments is inefficient and poorly justified.[1149] Also, payments under BPS are received by farmers according to the amount of land they own, not for the outcomes they accomplish.[1150] Indeed, BPS is focused on those who already have noteworthy private wealth, without improving environmental outcomes.[1151] It introduces distortionary incentives that hinder a productive and competitive agricultural sector that delivers positive environmental outcomes.[1152] Besides, direct payments support farm incomes, but create dependencies on subsidies and influence production decisions.[1153] Farmers started working towards production efficiency to stay competitive, following the introduction of an income support subsidy system and the increased globalisation of agricultural markets.[1154] More cost-efficient agriculture required changes in agricultural management, such as agricultural intensification and land use changes.[1155] Therefore, CAP indirectly supports these changes, which can potentially lead to additional environmental problems, such as soil pollution.[1156] Direct payments encourage using intensive methods, which

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[1142] Department for Environment, Food and Rural Affairs, 'Moving away from Direct Payments – Agriculture Bill: Analysis of the impacts of removing Direct Payments' (September 2018) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/740669/agri-bill-evidence-slide-pack-direct-payments.pdf> accessed 20 June 2019
[1143] European Court of Auditors (n 1141)
[1144] 'Income support explained' (*European Commission*) <https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/income-support/income-support-explained_en> accessed 12 June 2019
[1145] HM Government (n 803)
[1146] Department for Environment, Food and Rural Affairs (n 1142)
[1147] Guy Pe'er and others, 'Is the CAP Fit for purpose? An evidence-based fitness-check assessment' (November 2017) <http://extranet.greens-efa-service.eu/public/media/file/1/5401> accessed 18 June 2019
[1148] White (n 1102)
[1149] Pe'er and others (n 1147)
[1150] HM Government (n 803)
[1151] ibid
[1152] Department for Environment, Food and Rural Affairs (n 1142)
[1153] White (n 1102)
[1154] Van Zanten and others (n 940)
[1155] ibid
[1156] Pe'er and others (n 1147)

would eventually cancel out the benefits that the pro-environment measures of CAP aim to achieve.[1157] Thus, it can be argued that CAP provided little incentive for sustainable farming.[1158]

There has been little pressure, incentive, or willingness to move away from unsustainable farming.[1159] The UK implemented CAP in a high production focused manner until the early 2000s and it is deeply embedded in the national policy.[1160] Furthermore, as mentioned, farmers who receive direct payments that can underwrite some costs can use costly resources, e.g., fertilisers and pesticides.[1161] This point supports that CAP encourages agricultural intensification, not abandoning it.

To claim payments under BPS, certain animal and public health, welfare and environmental standards must be met.[1162] These requirements are known as CC.[1163] CC is described as the interplay between the respect for certain rules and the support provided to farmers.[1164] These rules reflect the aspiration to respect the environment, plant health, and animal health and welfare, contributing to sustainable agriculture.[1165] Payments for farmers who do not comply with these requirements can be reduced or stopped entirely.[1166] The rules for CC scheme are introduced in European Parliament and Council Regulation (EU) No 1306/2013 (Articles 93, 94 and Annex II), Commission Delegated Regulation (EU) No 640/2014 and Commission Implementing Regulation (EU) No 809/2014.

CC contributes to halting soil degradation, specifically soil erosion.[1167] It is acknowledged that CC has a significant role in the protection and improvement of soils.[1168] However, as mentioned earlier, these specific instruments are limited in reversing the larger-scale impacts of other CAP instruments, which support agricultural intensification and environmental degradation.[1169] This result is due to the conflicting objectives found in CAP.

1157 White (n 1102)
1158 Nature Friendly Farming Network (n 802)
1159 Campaign to Protect Rural England (n 791)
1160 ibid
1161 ibid
1162 Department for Environment, Food and Rural Affairs (n 1142)
1163 ibid
1164 'Cross-compliance' (*European Commission*) <https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/income-support/cross-compliance_en> accessed 12 June 2019
1165 'Income support explained' (n 1144)
1166 'ibid
1167 Pe'er and others (n 1147)
1168 Geertrui Louwagie and others, 'The Potential of European Union Policies to Address Soil Degradation in Agriculture' (2011) 22 Land Degrad. Develop. 5
1169 Pe'er and others (n 1147)

CC introduces some conditions that farmers must comply with for receiving Single Farm Payments.[1170] The two sets of requirements that farmers are expected to comply with are Statutory Management Requirements (SMRs) and GAECs.[1171] While SMRs apply to all farmers, whether they receive support, GAECs apply only to farmers who receive support under the CAP regime.[1172] It is argued that the partial application of GAECs decreases the policy's effectiveness.[1173]

SMRs are statutory rules on public, animal and plant health, animal welfare and the environment.[1174] SMRs require farmers to comply with various items of the existing legislation.[1175] SMRs include the Nitrates Directive, Groundwater Directive, Sewage Sludge Directive, Birds and Habitats Directives.[1176] The effectiveness of SMR enforcement depend on two elements:[1177] First, the level of effectiveness of these specific SMRs for reducing soil degradation processes is highly significant.[1178] Also, it depends on how the obligation set out in the specific SMR is implemented at farm-level and how satisfactory the farmers' application of them is.[1179] At the EU level, the degree of compliance with the Birds and Habitats Directives, the protection of groundwater and compliance with the Sewage Sludge Directive are generally high.[1180] In some Member States, in contrast, the rate of compliance with the Nitrates Directive is poor, e.g., in the UK, the second most common breach was found to be the heavy usage of manure in nitrate vulnerable zones.[1181] Integration with other policies, such as the Nitrates Directive, which regulates the use of nitrates and pesticides through intensive agriculture, have shown some positive impact.[1182] However, considering the ongoing issues related to agricultural soil conservation, further action is needed, such as sustainable pesticide use.[1183]

[1170] Nigel Boatman and others, 'A review of environmental benefits supplied by agri-environment schemes' (15 August 2008) <http://eprints.glos.ac.uk/3605/1/A931063.pdf> accessed 25 June 2019
[1171] 'Cross-compliance' (n 1164)
[1172] ibid
[1173] Paleari (n 49)
[1174] 'Cross-compliance' (n 1164)
[1175] Martin Farmer and Vicki Swales, 'The Development and Implementation of Cross Compliance in the EU 15: An Analysis' (*Institute for European Environmental Policy*, December 2004) <http://minisites.ieep.eu/assets/200/RSPBcrosscompliance.pdf> accessed 21 June 2019
[1176] 'Cross-compliance' (n 1164)
[1177] Louwagie and others (n 1168)
[1178] ibid
[1179] ibid
[1180] ibid
[1181] ibid
[1182] Pe'er and others (n 1147)
[1183] ibid

There are SMRs indirectly contributing to the objectives of the GAECs.[1184] These aim to ensure that all agricultural areas (including land that is no longer used for production purposes) is maintained in a good agricultural and environmental condition. GAECs require duties, such as undertaking a soil protection review (GAEC 1); post-harvest management of uncropped land to prevent run-off and soil erosion (GAEC 2); and preventing waterlogged soil, maintaining soil structure and prevention of compaction (GAEC 3).[1185] These support agri-environment scheme measures (discussed below) and help to reduce erosion risk and movement of pollutants to water and to prevent pollution at source.[1186] Moreover, GAEC 4 aims to achieve a minimum soil cover, which would reduce soil erosion risk.[1187] However, it permits maize stubbles, which provide poor soil cover against water flowing overland.[1188] GAEC 5 aims to minimise soil erosion through minimum land management that reflects site specific conditions to limit erosion.[1189] GAEC 6 focuses on preserving SOM, yet merely tackles the burning of crop residues, grass or heather.[1190]

GAEC 4, 5, 6, 7, which are CC standards for soils and landscape, show some weaknesses. First of all, there is no requirements for the Member States to implement these standards and greening practices in a holistic approach that aims to address soil protection issues.[1191] Besides, there is a lack of clarity in the provisions related to the minimum appropriate practices for soil cover (GAEC 4) and land management to limit erosion (GAEC 5).[1192] Additionally, GAEC 6 indicates merely a ban on burning arable stubble, which means that whether to introduce additional practices depends on the Member States' choice.[1193]

GAECs address a number of soil threats in a direct and indirect manner (Table 5.2.). Although there is no distinction between water and wind erosion in the Regulation 1306/2013, as mentioned before, GAEC 4 standards for soil cover have the potential reducing both types of erosion.[1194] This measure implicitly contributes to the risk of SOM loss. As discussed above, GAEC 5 standards are specifically set out to limit both types of

1184 R. Jongeneel and others, 'Compliance with mandatory standards in agriculture A comparative approach of the EU vis-à-vis the United States, Canada and New Zealand' (2007) The Agricultural Economics Research Institute Project code 20528 - Report 6.07.21 <https://library.wur.nl/WebQuery/wurpubs/fulltext/42429> accessed 21 June 2019
1185 Boatman and others (n 1170)
1186 ibid
1187 Campaign to Protect Rural England (n 791)
1188 ibid
1189 ibid
1190 ibid
1191 Frelih-Larsen and others (n 40)
1192 ibid
1193 ibid
1194 ibid

erosion. Arguably, these land management standards can be defined in a manner that would reduce compaction risk.[1195] GAEC 6 standards are specifically to maintain SOM.[1196] GAEC 7 is rather related to retention of landscape features and may reduce the risk of soil erosion by disrupting the flow of wind and water; however, does not directly contribute to soil threats.[1197]

Evaluating soil protection, SMRs and GAECs require landowners to identify and record existing and potential problems regarding soil and assess degradation and present land use information; carry out measures to prevent or reduce the impact of these problems.[1198] Additionally, in defining the standards for each GAEC, the Member States must consider the characteristics of the concerned area, which include soil conditions.[1199] Therefore, these measures can, in theory, be beneficial for protecting soils.[1200]

On the other hand, GAEC standards have weaknesses. Out of four relevant GAEC standards, the EU defined minimum requirements merely for GAEC 6 (the minimum requirement for maintenance of SOM is a ban on burning arable stubbles).[1201]

The literature suggests that GAECs have positive effects on soil properties and indirectly on soil biodiversity at European and national levels.[1202] Furthermore, it was found that compliance with GAECs in the UK has shown positive impact on the battle against soil degradation.[1203] For example, CAP has some positive effects on erosion trends through GAEC.[1204] GAEC directly addresses soil related problems and degrading farming practices.[1205] However, it is argued that the overall trend seems negative[1206] as GAECs are not being delivered in practice by some Member States and the greening measures discussed above provide a more effective tool for basic level environmental management.[1207] It is argued that CC measures lack the scope and enforcement to protect soils specifically in an effective manner.[1208] One can argue that more needs to be achieved to protect and enhance the productive potential and to safeguard soils.[1209] The analysis of the effectiveness of CC measures are further discussed in the CAP analysis section.

1195 ibid
1196 ibid
1197 ibid
1198 Stankovics, Tóth and Tóth (n 804)
1199 Frelih-Larsen and others (n 40)
1200 Paleari (n 49)
1201 Frelih-Larsen and others (n 40)
1202 Panagos and others (n 600); Pasquale Borrelli and others, 'Towards a Pan-European Assessment of Land Susceptibility to Wind Erosion' (2016) 27 Land Degrad. Develop. 1093; Posthumus and others (n 936)
1203 Posthumus and others (n 936)
1204 Pe'er and others (n 1147)
1205 Louwagie and others (n 1168)
1206 Pe'er and others (n 1147)
1207 House of Commons Environment, Food and Rural Affairs Committee (n 1126)
1208 Campaign to Protect Rural England (n 791)
1209 House of Commons Environment, Food and Rural Affairs Committee (n 1126)

The second scheme under Pillar I sets market management measures that are introduced to deal with difficult market situations, such as a sudden drop in demand or a fall in prices as a result of a temporary oversupply on the market.[1210] A common organisation of the markets in agricultural products is set in Regulation (EU) 1308/2013.[1211] These measures provide price support for producers by combining with import tariffs in order to keep agricultural prices higher than expected.[1212] They also aim to encourage producer collaboration and to provide measures to manage crises.[1213]

Rural development schemes under Pillar II (€0.8 billion in 2016)[1214] were introduced to address the specific issues of rural areas.[1215] These schemes include Agri-Environmental Measures (AEMs).[1216] The aspects of the support for rural development are regulated in Regulation (EU) 1305/2013.[1217] Only 20% of the total is spent on environmental stewardship programmes under Pillar II.[1218]

CAP acknowledged the role of farmers in protecting the natural environment[1219] through the 1992 reform that led to the introduction of AEMs.[1220] These are voluntary economic instruments for farmers to claim payments if they wish to take extra measures for protecting the environment by going beyond the current basic requirements (either mandatory or those allowing them to qualify for a basic subsidy under CAP, e.g., GAECs or greening practices).[1221]

Each AEM has a specific objective, such as protecting soil, biodiversity, air quality and water.[1222] These measures can include organic farming, integrated production, reducing inputs of fertilisers and pesticides, crop rotation, enhancing habitats for wildlife, introducing buffer strips, managing livestock to provide the right grazing pressure on grassland species and avoiding the risk of soil erosion, and conserving genetic resources

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[1210] 'The common agricultural policy at a glance' (n 1097)
[1211] Regulation (EU) No 1308/2013 of the European Parliament and of the Council of 17 December 2013 establishing a common organisation of the markets in agricultural products and repealing Council Regulations (EEC) No 922/72, (EEC) No 234/79, (EC) No 1037/2001 and (EC) No 1234/2007 [2013] OJ L 347/671
[1212] Department for Environment, Food and Rural Affairs (n 1112)
[1213] ibid
[1214] ibid
[1215] 'The common agricultural policy at a glance' (n 1097)
[1216] Department for Environment, Food and Rural Affairs (n 1112)
[1217] Rural Development Regulation (n 1109)
[1218] HM Government (n 803)
[1219] Rob J. F. Burton, Carmen Kuczera and Gerald Schwarz, 'Exploring Farmers' Cultural Resistance to Voluntary Agri-environmental Schemes' (2008) 48 Journal of the European Society for Rural Sociology 16
[1220] Council Regulation (EEC) No 2078/92 of 30 June 1992 on agricultural production methods compatible with the requirements of the protection of the environment and the maintenance of the countryside [1992] OJ L 215
[1221] 'Science for Environment Policy – Thematic Issue: Agri-environment schemes: impacts on the agricultural environment' (June 2017, Issue 57) <http://ec.europa.eu/environment/integration/research/newsalert/pdf/AES_impacts_on_agricultural_environment_57si_en.pdf> accessed 18 June 2019
[1222] ibid

in agriculture and local species and in animal breeds threatened by genetic erosion.[1223] The drawback is that there is no legal requirement for Member States to implement these AEMs, reflecting a similar problem to the criticism of the abovementioned GAECs and greening practices.[1224]

Since the reform, these measures have formed an essential aspect of the policy for conserving and enhancing the environment.[1225] It is argued that CAP contributes to preventing and mitigating soil degradation, especially through AEMs, which offer opportunities for enhancing soil biodiversity and SOM levels or reducing soil threats.[1226] The effectiveness of the current measures is open for debate as these commonly function at farm level[1227] and a spatial incompatibility occurs between management levels and targeted ecological processes.[1228] Also, these measures have the potential to protect soils; however, their effectiveness could be enhanced through an increased level of participation.[1229]

Under this rural development scheme, the Member States are required to prepare, implement and monitor their national or regional rural development programmes.[1230] The Regulation sets outs the EU's priorities, in which there are soil focused aspects. These priorities include preventing soil erosion and improving soil management[1231] and fostering carbon conservation and carbon sequestration in agriculture and forestry.[1232] As a reflection of the subsidiarity principle, this scheme offers great flexibility for the Member States to design and target sub-measures to suit their unique circumstances and needs, such as making soil protection a priority.[1233] This level of flexibility can be a weakness of the scheme because it may hinder environmental protection as the Member States may overlook the need to address certain issues.

Most of the measures found in the Regulation are found relevant to soil protection[1234] as these measures have the potential to address most soil threats implicitly and erosion in an explicit manner.[1235] Amongst these, only agri-environment-climate

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[1223] ibid
[1224] Frelih-Larsen and others (n 40)
[1225] Burton, Kuczera and Schwarz (n 1219)
[1226] 'Agriculture and soil protection' (*European Commission*) <https://ec.europa.eu/agriculture/envir/soil_en> accessed 17 June 2019
[1227] Katrin Prager, Mark Reed and Alister Scott, 'Encouraging collaboration for the provision of ecosystem services at a landscape scale—Rethinking agri-environmental payments' (2012) 29 Land Use Policy 244
[1228] Van Zanten and others (n 940)
[1229] 'Science for Environment Policy – Thematic Issue: Agri-environment schemes: impacts on the agricultural environment' (n 1221)
[1230] Rural Development Regulation (n 1109), recital 7
[1231] ibid, art 5(4)(c)
[1232] ibid, art 5(5)(e)
[1233] Frelih-Larsen and others (n 40)
[1234] Rural Development Regulation (n 1109), arts 14, 15, 17, 18, 19, 20, 21, 28, 29, 30, 31, 34, 35
[1235] Frelih-Larsen and others (n 40)

measures are compulsory for the Member States.[1236] These measures offer farmer and land managers multi-annual contracts for environmentally friendly agricultural practices.[1237] While calculating the payments, CC requirements and greening options are considered, and double funding is prevented.[1238]

The scheme has many strengths as well as weaknesses. The flexibility provided for the Member States can be seen as both a strength and weakness. Furthermore, there are EU level priorities with direct relevance to soil threats and functions.[1239] These are optional and if chosen by the Member States, the rural development programme must set targets for land under contract to address these focus areas.[1240] If these two measures are not chosen by the Member States, all priorities must contribute to cross-cutting objectives of the environment and climate change mitigation and adaptation, and at least 30% of the total contribution to the rural development programme shall be reserved for measures under the articles.[1241] These are clear measures relevant to soil protection.[1242]

The scheme was found to be an ineffective one for several reasons. Rural development programmes, unlike Pillar 1 direct payments, are co-financed by the Member States' national governments.[1243] This means that States can choose to move CAP funding from this programme to direct payments. Even though the Member States have an obligation to address the specific problems they identified, there is no requirement for them to focus on articles 5(4)(c) and 5(5)(e), which are direct aspects of soil protection.[1244] Additionally, it is argued that the amount of budget allocated for land management is not enough to deliver the objectives and key priorities, especially restoring, preserving and enhancing ecosystems.[1245] Although greening measures supported by rural development measures have a potential for an extensive restoration of natural environments, the uncertainties in the relationship between the greening measures and agri-environmental schemes (discussed below) create doubt as to the effectiveness of this policy.[1246]

[1236] Development Regulation (n 1109), art 28(1)
[1237] ibid, art 28
[1238] Frelih-Larsen and others (n 40)
[1239] Rural Development Regulation (n 1109), arts 5(4)(c) and 5(5)(e)
[1240] ibid, art 8
[1241] ibid, art 59(6)
[1242] ibid, arts 17, 21, 28, 29, 30, 31, 32, 34
[1243] Frelih-Larsen and others (n 40)
[1244] ibid
[1245] House of Commons Environment, Food and Rural Affairs Committee (n 1126)
[1246] ibid

5.2.3.2.3. Common Agricultural Policy Analysis

Overall, CAP's performance indicates that sustainability has not been achieved and is unlikely to be accomplished under existing circumstances.[1247] The policy is seen as ineffective in achieving its objectives[1248] as it spends £44 billion[1249] for no significant positive outcomes in terms of soil protection.

The EU stated that CAP measures, such as CC, greening measures, rural development programmes, had positive impacts on soils.[1250] It is evidenced that between 2000 and 2010, the rate of soil erosion decreased by 9% in total and by 20% in arable land.[1251] However, CAP is generally found to be unsuccessful in preventing other ongoing environmental problems, such as the decline of biodiversity and ES in Europe.[1252] Payments are made only for lands in agricultural condition; thus, the system led people to clear wildlife habitats to generate such fields.[1253]

As mentioned before, the flexibility in the choices of the Member States for the implementation of GAEC standards and Pillar 1 greening requirements stemming from the subsidiarity principle comes across as another weakness of the policy.[1254] Because, there are no legal requirements for the states to include specific targets for soils in these measures.[1255] This situation is similar in rural development schemes under Pillar II. Although, the EU rules have a requirement for these measures to identify the specific area's needs and to link the needs to targets and measures, it is in the Member States' discretion whether to include additional measures.[1256] Although the Commission checks the implementation of the Member States of the CAP Regulations and there are penalties where there is non-compliance, the lack of legal requirement for the Member States to introduce a coherent package for the use of GAEC, greening requirements and rural development schemes comes across as a striking limitation of the policy.[1257]

The reflection of the subsidiarity principle in CAP can also be seen as a strength as it enables the Member States to take action with a certain level of flexibility to make

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[1247] Pe'er and others (n 1147)
[1248] George Monbiot, 'The one good thing about Brexit? Leaving the EU's disgraceful farming system' (*The Guardian*, 10 October 2018) <https://www.theguardian.com/commentisfree/2018/oct/10/brexit-leaving-eu-farming-agriculture> accessed 17 June 2019
[1249] European Commission, 'CAP expenditure in the total EU expenditure' (April 2018) <https://ec.europa.eu/agriculture/sites/agriculture/files/cap-post-2013/graphs/graph1_en.pdf> accessed 17 June 2019
[1250] 'Preserving our soil to protect our food' (*European Commission*, 5 December 2018) <https://ec.europa.eu/info/news/preserving-our-soil-protect-our-food-2018-dec-05_en> accessed 17 June 2019
[1251] ibid
[1252] Pe'er and others (n 1147)
[1253] Monbiot (n 1248)
[1254] Frelih-Larsen and others (n 40)
[1255] ibid
[1256] ibid
[1257] ibid

the best use of policy instruments to achieve soil protection benefits.[1258] Although agricultural policy has impacts on many supranational issues, such as food security (as agricultural products move freely within the EU), biodiversity and natural resource conservation (excluding specific habitats that are a local issue), and tackling climate change,[1259] national level policies have the potential to address national or regional priority needs.[1260] Indeed, addressing various soil, water and air pollution problems would be better managed by the Member States.[1261] However, as seen in the UK example, this opportunity is not always used.

The weak implementation of CAP causes conflicts among other environmental policies, such as nature and biodiversity conservation, e.g., CBD, Habitats and Birds Directives.[1262] Also, CAP's complex administrative requirements weaken its effectiveness, especially through the difficulty in accessing funding, which leads farmers to making less environmentally friendly choices.[1263] Indeed, the bureaucratic structure of CAP has limited the efforts to protect the environment.[1264] Furthermore, it is argued that CAP has regulatory burdens and fails to reward some public goods sufficiently, such as improving soil health and water quality.[1265]

This argument can be supported by the overall performance of CAP as regard to ES protection. In addition to its explicit reference to biodiversity (Table 5.2.), greening direct payments can indirectly contribute to carbon sequestration, water storage, water quality regulation, water supply regulation, gene pool and genetic resources and nutrient cycling through measures related to buffer strips, landscape features, afforested areas, short rotation coppice.[1266] Also, agroforestry and afforested areas can contribute to carbon sequestration as well as biomass production.[1267] Environmentally sensitive permanent grassland requirements can contribute to carbon sequestration, but additionally to ecological and archaeological heritage.[1268]

1258 ibid
1259 'Objectives of the Common Agricultural Policy' (*www.parliament.uk*, 15 April 2011) <https://publications.parliament.uk/pa/cm201011/cmselect/cmenvfru/671/67105.htm#note36> accessed 25 September 2020
1260 Frelih-Larsen and others (n 40)
1261 'The Common Agricultural Policy and the challenge of subsidiarity' (*Fondation Robert Schuman*, 18 February 2019) <https://www.robert-schuman.eu/en/european-issues/0503-the-common-agricultural-policy-and-the-challenge-of-subsidiarity> accessed 25 September 2020
1262 Pe'er and others (n 1147)
1263 White (n 1102)
1264 Department for Environment, Food and Rural Affairs (n 1112)
1265 ibid
1266 Frelih-Larsen and others (n 40)
1267 ibid
1268 ibid

CAP's CC measures also indirectly contributed to the protection of a number of ES. Arguably, carbon sequestration is addressed through GAEC 6 standards that are focused on maintaining SOM. Also, GAEC 4 standards for soil cover could contribute to maintaining SOM, although this outcome depends on how soil cover is managed.[1269] These two standards are expected to indirectly reduce the loss of soil biodiversity. GAEC 7 standards, which are focused on landscape features, may contribute to recreation, cognitive and heritage services. Overall, all soil related GAEC standards have a particular focus on protecting agricultural soils. Thus, they contribute to platform service, which is supporting structure for human occupation.[1270]

Pillar II of the CAP, rural development programmes support several ES implicitly through its measures, in addition to the direct reference to a few ES, as seen in Table 5.2. Especially, M1 (knowledge transfer and information actions), M2 (advisory services, farm management and farm relief services), M4 (investments in physical assets), M6 (farm and business and development), M16 (cooperation) were found beneficial for ES, such as platform, nutrient cycle, water quality regulation and water supply regulation.[1271] As the Regulation has priorities, such as preventing soil erosion and improving soil management,[1272] it can be argued that it implicitly supports erosion control and sediment retention service.

In the UK, CAP provides support for farmers in an amount around £4bn annually.[1273] Its support makes up nearly 80% of a British farmer's income.[1274] These funds are pledged by the UK government to remain the same until the current Parliament comes to an end (maximum until 2024).[1275] It is unlikely for the government to introduce any new system of farm support until after 2024.[1276]

Under the 25 Year Environment Plan, all farmers will be supported and paid for public benefits[1277] (e.g., environmental enhancement), replacing the current direct payments to farmers in England from 2024.[1278] The problem is whether the government

[1269] ibid
[1270] ibid
[1271] ibid
[1272] Rural Development Regulation (n 1109), art 5(4)(c)
[1273] 'Brexit: UK agriculture policy' (*www.parliament.uk*, 11 September 2018) <https://researchbriefings.parliament.uk/ResearchBriefing/Summary/CBP-8218> accessed 17 June 2019
[1274] ibid
[1275] ibid
[1276] ibid
[1277] Helm (n 802)
[1278] 'Brexit: UK agriculture policy' (n 1273)

will deliver this public interest rather than economic ones.[1279] The Agriculture Act 2020 will set out a framework for post-Brexit measures for farmers.[1280]

Specifically, for the UK environment, overall, CAP is seen as an environmentally harmful policy.[1281] Following Brexit, the rules governing UK agriculture are outside CAP.[1282] Hence, the UK government and devolved legislatures will have the chance of reconsidering farm subsidies and agriculture businesses.[1283] The UK will have the opportunity to avoid further environmental harm, farmers will be able to avoid tyranny of land capitalisation and young farmers will have a chance to enter the market.[1284]

5.2.3.2.4. Agri-Environmental Schemes

Since 1992, CAP reforms have had the objective of mitigating environmental pressures.[1285] Several instruments and tools have been developed for farmers to reduce the adverse impacts of agriculture.[1286] Agri-Environmental Schemes (AES) is one of these policy tools. As a result of agricultural intensification causing rapid loss of wildlife and degradation of landscape, an initiative named the Environmentally Sensitive Areas was designed for biodiversity conservation and protection of highly important areas.[1287] AES in the UK began in 1987 with the launch of the Environmentally Sensitive Areas.

The Environmentally Sensitive Areas were supplemented by other schemes, which enable whole- and part-farm agreements and new range of management options.[1288] One of these schemes was the Countryside Stewardship Scheme (CSS),[1289] which was launched in 1991 to cover the areas outside of Environmentally Sensitive Areas.[1290] CSS was closely followed by Tir Cymen in Wales in 1992,[1291] which was replaced by Tir Gofal in 1999.[1292]

The original form of CSS expired in 2014. However, it was relaunched for the England Rural Development Programme 2014-2020 with £3.1bn of government subsidy

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[1279] Helm (n 802)
[1280] 'Brexit: UK agriculture policy' (n 1273)
[1281] Helm (n 802)
[1282] 'Brexit: UK agriculture policy' (n 1273)
[1283] ibid
[1284] Helm (n 802)
[1285] European Commission, 'Agri-environmental schemes: impacts on the agricultural environment' (*Reinforcing CAP*, 27 June 2017) <https://www.recap-h2020.eu/agri-environmental-schemes-impacts-on-agricultural-environment/> accessed 23 June 2019
[1286] ibid
[1287] Boatman and others (n 1170)
[1288] ibid
[1289] ibid
[1290] Natural England, 'Agri-environment schemes in England 2009 – A review of results and effectiveness' (2009) <http://publications.naturalengland.org.uk/publication/46002> accessed 25 June 2019
[1291] Boatman and others (n 1170)
[1292] Land in Care Scheme (Tir Gofal) (Wales) Regulations 1999, SI 1999/1176

for agriculture and forestry, replacing the previous Environmental Stewardship Scheme (ESS).[1293] This new CSS will pay individual land managers to undertake environmental activities across their land.[1294] CSS has a bad reputation in agricultural sector as it has shown a poor performance related to payments, inspections and setting up agreements.[1295] Payments were late and rates were unattractive.[1296] Also, farmers who received an inspection had to wait for their reports for a year, in addition to the excess evidence requirements.[1297] These issues led to an under delivery of positive environmental outcomes.[1298] The current CSS is targeted mainly towards improving biodiversity and water quality,[1299] which can provide indirect protection for soils.

ESS replaced CSS and the Environmentally Sensitive Areas in England in 2005.[1300] Pillar II of CAP (rural development scheme) funds ESS,[1301] which requires farmers in England to comply with either the general CC conditions or particular conditions under AES.[1302] This scheme seeks a more holistic approach to farmland biodiversity.[1303] Under this scheme, an agreement is made with the Secretary of State for providing a grant for those who comply with the conditions of the agreement.[1304] The agreement requires the beneficiary to undertake specific activities to enhance environmental protection.[1305] Indeed, ESS has a number of objectives, including protecting and enhancing habitats and species, landscape character and quality, the historic environment, soils and natural resources, supporting the adaptation of the natural environment to climate change, contributing climate change mitigation, reducing flood risk and conserving genetic resources, and providing opportunities for people to visit and learn about the countryside.[1306] It has been demonstrated that ESS has delivered solutions to specific issues, e.g., slowing down the decline in a number of species, contributing to

[1293] 'Countryside Stewardship Scheme Agreements (England)' (*Natural England Open Data*) <https://naturalengland-defra.opendata.arcgis.com/datasets/dd63fbfeda8e48878eb19db84883147b_0> accessed 25 June 2019
[1294] 'Improvement Plan for Countryside Stewardship' (*CLA*) <https://www.cla.org.uk/sites/default/files/FINAL_CLA%20_CS_improvement%20plan2018.pdf> accessed 26 June 2019
[1295] ibid
[1296] ibid
[1297] ibid
[1298] ibid
[1299] Campaign to Protect Rural England (n 791)
[1300] Christopher Rodgers, *The Law of Nature Conservation* (illustrated edn, OUP 2013) 136
[1301] Natural England (n 1290)
[1302] Brian Jack, *Agriculture and EU Environmental Law* (Routledge 2016)
[1303] Rodgers (n 1300) 136
[1304] ibid 136
[1305] ibid 136
[1306] Natural England (n 1290)

the management of archaeological features, enhancing landscape character and reducing GHG emissions from land management.[1307]

The main AES in Wales since 1999 is Tir Gofal.[1308] This scheme pays farmers and other land managers to manage agricultural land in an environmentally friendly manner.[1309] The key objectives are to protect and enhance habitats of importance to wildlife, protect the historic environment, protect and restore rural landscapes, and promote public access to the countryside.[1310] The scheme has a specific focus for the protection of soils through several measures, such as submission of soil management plans for farms, less intensive use of grassland and arable production which would result in achieving more vegetative cover, less soil erosion (associated with improved landscape, biodiversity and water quality) and less pollution, buffer zones around watercourses, which limits soil erosion, controls on the use of plant protection substances, farmyard manure and chemical fertiliser, which would reduce soil pollution.[1311] It can be argued that Tir Gofal has a clear potential to benefit the rural environment and soils although it costs more to run than was initially envisaged and less responsive to local needs and priorities than expected.[1312]

Overall, the objective of protecting natural resources, such as soil and water, became relevant for AES in the last two decades.[1313] This objective is a significant one as measures beyond good practice are necessary to protect such sensitive resources.[1314] Regarding soils, AES are designed to reduce the risk of soil erosion and pollution.[1315] Indeed, soil protection is one of the primary objectives of this scheme.[1316] Maintaining grass cover and limiting nitrogen fertilisers and organic manure inputs (to prevent erosion or run-off from intensively managed grassland) and land use changes are seen as significant management options.[1317] These management options also have a number of positive impacts on soil ES. To mitigate flood risk, maximising water infiltration capacity of soils is essential.[1318] This objective can be achieved by reducing soil compaction and eventually maximising water infiltration, leading to reduced risk of erosion.[1319] In

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1307 ibid
1308 Land in Care Scheme (Tir Gofal) (Wales) Regulations (n 1292)
1309 Wales Audit Office, 'Tir Gofal' (15 November 2007) <https://senedd.wales/Laid%20Documents/AGR-LD6870%20-%20Tir%20Gofal-15112007-65632/agr-ld6870-e-English.pdf> accessed 30 June 2020
1310 ibid
1311 ibid
1312 ibid
1313 Boatman and others (n 1170)
1314 ibid
1315 Natural England (n 1290)
1316 ibid
1317 ibid
1318 ibid
1319 ibid

addition, it is found that the current AES underpin some soil ES, such as erosion regulation, soil quality, food and raw material production as well as some cultural services, such as heritage or recreation.[1320] Thus, AES have the potential to integrate the delivery of a range of soil ES.[1321] Indeed, the scheme has future perceptions of achieving to maximise the provision of soil ES.[1322] It reflects that there is a need for future work for optimising the delivery of both market and non-market ES considering the competing land uses and future food security.[1323] The scheme has the objective of placing ES in the centre of farm management decisions.[1324] However, it is stated that farmers and land managers are not getting paid for these public goods.[1325] The scheme recognises that the same piece of land can provide multiple services and the scheme should be improved enough to reflect this.[1326] Indeed, options such as payments for ES, embracing cultural and regulating services, and understating the relationship among different types of ES could be beneficial in this sense.[1327] There is observable evidence of the positive impact of AES on soil ES.[1328] AES also have been found beneficial for soil protection and reducing water pollution, such as for limiting the inputs of nitrogen fertiliser to a certain level in grasslands is found to reduce nitrate leaching,[1329] which occurs when nitrate leaves soil in drainage water and enters groundwater and other fresh waterbodies.[1330] However, it is important to consider that these agreements target merely 1.6 million hectares in England and 0.5 million hectares in Wales.[1331] Consequently, these schemes do not constitute a sufficient measure by themselves; however, they can function more effectively as part of a bundle of different measures, such as regulation and CC.[1332]

[1320] Boatman and others (n 1170)
[1321] Natural England (n 1290)
[1322] ibid
[1323] ibid
[1324] ibid
[1325] ibid
[1326] ibid
[1327] ibid
[1328] Boatman and others (n 1170)
[1329] Natural England (n 1290)
[1330] 'Nitrate Leaching' (*Resilient Cropping*) <https://www.far.org.nz/assets/files/uploads/Nitrogen_leaching.pdf> accessed 25 June 2019
[1331] JNCC, 'B1a. Area of land in agri-environment schemes' (5 September 2019) <https://jncc.gov.uk/our-work/ukbi-b1a-agri-environment-schemes/> accessed 2 October 2020
[1332] J. R. Franks and others, 'Options for landscape scale collaboration under the UK's Environmental Stewardship Scheme' (*Centre for Rural* Economy, April 2011) <https://www.ncl.ac.uk/media/wwwnclacuk/centreforruraleconomy/files/stewardship-scheme.pdf> accessed 25 June 2019

5.2.3.3. Animal Feed Directive

The Animal Feed Directive[1333] deals with undesirable substances in products intended for animal feed.[1334] Undesirable substance comprises of any substance or product, with the exception of pathogenic agents, which is present in and on the product intended for animal feed and which presents a potential danger to animal or human health or to the environment or could adversely affect livestock production.[1335]

The general aim of the Directive is to set out rules regulating feeding stuffs to ensure agricultural productivity and sustainability.[1336] The Directive provides a list of undesirable substances and limits values for the presence of these substances in animal feed.[1337]

From a soil point of view, these are measures that set limits also for heavy metals, such as arsenic, lead, mercury, cadmium,[1338] which can be highly toxic for soils. These elements risk soil and water quality, nutrient cycling, soil fertility,[1339] soil health[1340] and increase pesticide toxicity.[1341] Thus, it can be argued that manure damages soil if not managed responsibly and heavy metals in food end up in the manure. In addition to the levels in animal feed found in this Directive, the concentration levels for these PTEs in food are regulated.[1342] However, this Directive is not directly regulating manure, in fact direct legislation for manure and soil concentrations is lacking. There are voluntary soil concentrations of zinc and copper providing warnings when using manure, while mandatory limits are only a recommendation for organic fertilisers.[1343]

The Animal Feed Directive, considering the increasing need for protecting soil health, provides protection for soils from these abovementioned elements. However, this protection is indirect, and controls input of the most toxic metals, but not essential metals,

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1333 Commission Directive (EC) 2002/32/EC of the European Parliament and of the Council of 7 May 2002 on undesirable substances in animal feed [2002] OJ L 140/10 (hereinafter 'Animal Feed Directive')
1334 ibid, art 1(1)
1335 ibid, art 2(l)
1336 ibid, preamble
1337 ibid, annex I
1338 ibid, annex I
1339 W. Tian and others, 'Short-term changes in total heavy metal concentration and bacterial community composition after replicated and heavy application of pig manure-based compost in an organic vegetable production system' (2015) 51 Biology and Fertility of Soils 593
1340 ibid
1341 Y. X. Chen and others, 'Behavior of Cu and Zn under combined pollution of 2, 4-dichlorophenol in the planted soil' (2004) 261 Plant and Soil 127; B. Sharma and others, 'Synergistic effects of heavy metals and pesticides in living systems' (2017) 5 Frontiers in Chemistry 70
1342 Commission Regulation (EC) 1334/2003 of 25 July 2003 amending the conditions for authorisation of a number of additives in feeding stuffs belonging to the group of trace elements [2003] OJ L 187/11; Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs [2006] OJ L 364/5; Commission Regulation (EC) 629/2008 of 2 July 2008 amending Regulation (EC) No 1881/2006 setting maximum levels for certain contaminants in foodstuffs [2008] OJ L 173/6
1343 A. Cundill and others, 'Review of the application of organic materials to land' (*Natural Scotland and SEPA,* 2012) <https://www.sepa.org.uk/media/163500/review_application_-organic_materials_to_land_2011_12.pdf> accessed 26 March 2019

such as copper and zinc, which are damaging soil. Indeed, the Directive does not have soil specific targets or objectives (Table 5.2.).

It must be noted that this legislative instrument is indirectly relevant to the soil. Once an animal is fed, eventually animal waste is disposed in manures and slurries into the soil. The important point here is that limiting arsenic, lead, mercury, cadmium at the Directive's levels may limit toxicity to mammals to low levels. However, same levels can be extremely toxic to soil microbes. Therefore, the Directive does not offer protection for soils and soil biodiversity from these elements.

This Directive deals with the undesirable substances in animal feed, which present a potential danger to animal health or could adversely affect livestock production.[1344] As these substances in animal feed can enter into soils, the scope and objective in the Directive can indirectly contribute to soil biodiversity and refugia from an ES protection; however, there are no direct and explicit references to soil ES in the Directive (Table 5.2.). Overall, this Directive merely provides very weak protection for soils.

5.2.3.4. Organics Regulation

The Organics Regulation[1345] sets the legal framework for organic products and organic farming, and contains rules for production, labelling, controls and trade with non-EU countries.[1346] It aims for the basis for the sustainable development of organic production while ensuring the effective functioning of the internal market, guaranteeing fair competition, ensuring consumer confidence and protecting consumer interests.[1347]

In the Regulation, soil has a specific focus, which can be seen in a number of soil related objectives, such as achieving sustainable agriculture by establishing respect for natural systems and soil health,[1348] and responsible use of soil and other aspects of the environment (Table 5.2.).[1349] It also supports the maintenance and enhancement of soil life and natural soil fertility, soil stability and soil biodiversity preventing and combating soil compaction and soil erosion, and the nourishing of plants primarily through the soil ecosystem.[1350]

[1344] Animal Feed Directive (n 1333), art 2(l)
[1345] Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91 [2007] OJ L 189 (hereinafter 'Organics Regulation')
[1346] 'Production and labelling of organic products' (*EUR-Lex*, 24 September 2018) <https://eur-lex.europa.eu/legal-content/EN/LSU/?uri=celex:32007R0834> accessed 20 September 2019
[1347] Organics Regulation (n 1345), art 1
[1348] ibid, art 3(a)(i)
[1349] ibid, art 3(a)(iii)
[1350] ibid, art 5(a)

Additionally, the Regulation has a direct manner in addressing a number of soil threats (Table 5.2.). It established that organic plant production should enhance soil fertility and prevent soil erosion.[1351] Tillage and cultivation practices that do not decrease SOM, do not cause compaction and erosion and that enhance soil biodiversity should be used.[1352] Application of livestock manure or organic material and multiannual crop rotation should maintain and enhance soil fertility.[1353] In addition, the use of fertilisers in organic plant production should be the last resort.[1354] Genetically Modified Organisms (GMO) should not be used as food, feed, fertilisers or soil conditioners.[1355] To minimise erosion, pollution, poaching and overgrazing, livestock numbers should be limited.[1356] Also, agricultural management decisions should consider the objective of avoiding environmental pollution of natural resources, such as soil and water.[1357] Moreover, organic farming and plant production shall prevent and combat soil compaction.[1358] Finally, the Regulation indirectly addresses SOM loss through requiring organic plant production to use tillage and cultivation practices that maintain or increase SOM.[1359]

From a soil ES perspective, it is clear that the Regulation contains several direct references to soil biodiversity (Table 5.2.). In an indirect manner, considering the objectives of the Regulation,[1360] it is expected to contribute to some soil ES, namely primary production, nutrient cycling, water storage, water quality and supply regulation. As it directly addresses the threat of soil erosion,[1361] it can also indirectly contribute to the ES of erosion control and sediment retention.

Although the abovementioned aspects of the Regulation seem promising from a soil protection point of view, it is important to note that the principles found in this instrument only applies to organic farming.[1362] Thus, the Regulation has a potential of protecting soils in organic farms. In 2017, the organic farming areas made up 7% of total agricultural area in EU,[1363] and 2.9% in the UK.[1364] Considering this and the points

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[1351] ibid, (12)
[1352] ibid, art 12(1)(a)
[1353] ibid, art 12(1)(b)
[1354] ibid, (12)
[1355] ibid, art 9
[1356] ibid, art 14(1)(b) (iv)
[1357] ibid, (15)
[1358] ibid, arts 5(a), 12(1)(a)
[1359] ibid, art 12(1)(a)
[1360] ibid, art 3
[1361] ibid, art 5 (a)
[1362] Paleari (n 49)
[1363] 'Organic farming statistics' (*Eurostat Statistics Explained*, January 2019) <https://ec.europa.eu/eurostat/statistics-explained/index.php/Organic_farming_statistics#targetText=The%20total%20area%20under%20organic,the%20European%20Union%20(EU).> accessed 9 June 2019
[1364] Department for Environment, Food and Rural Affairs, 'Organic farming statistics 2017' (17 May 2018) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/758533/organics-statsnotice-23nov18.pdf> accessed 9 June 2019

discussed above, the Regulation arguably offers strong protection for only a very small portion of agricultural soils (Table 5.2.).

5.2.3.5. Water Framework Directive

As a part of the EU initiatives to ensure clean water, the Urban Waste Water Treatment Directive and the Nitrates Directive alongside the Drinking Water Directive and the Directive for Integrated Pollution and Prevention Control were adopted.[1365] The EU then needed a single piece of legislation that would address issues related to water,[1366] which led to the adoption of the Water Framework Directive (WFD).[1367]

The key objectives of this Directive are providing protection and achieving good status for all waters (inland surface waters, estuaries, coastal waters and groundwater), and water management based on river basins.[1368] As a framework Directive, WFD is implemented in the national law through a vast number of provisions found in over a hundred legislative instruments (main implementation instruments can be found in Table 5.3.). Thus, its effect is extensive in the UK environmental law.

Although it is an ambitious and comprehensive legal instrument for water protection, the Directive does not have any soil specific targets or objectives (Table 5.2.). On the other hand, WFD requires the introduction of measures, such as a decrease in the release of nutrients, the proper handling of pesticides and the prevention of soil erosion through erosion-minimising soil cultivation; thus, it does contribute to soil protection.[1369] Indeed, it has explicit references and links to a number of soil related threats (Table 5.2.). The Directive addresses the identification of point-source pollution originating from the soil, specifically from urban and industrial sites and regional pollution from agricultural land.[1370] Moreover, WFD is a key legal instrument to control diffuse pollution in water, including routes to water.[1371] It classifies sediments in water as a pollutant, which should be controlled where they have impact on water status.[1372] This helps to reduce erosion risk as a considerable amount of PTEs are mobilised though erosion and ends up in

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[1365] European Commission, 'Introduction to the EU Water Framework Directive' (*Environment*, 7 August 2019) <https://ec.europa.eu/environment/water/water-framework/info/intro_en.htm> accessed 24 September 2019
[1366] ibid
[1367] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy [2000] OJ L327 (hereinafter 'Water Framework Directive')
[1368] European Commission (n 1365)
[1369] R. Andreas Kraemer and others, 'EU Soil Protection Policy: Current Status and the Way Forward' <https://www.ecologic.eu/sites/default/files/publication/2015/1965_soil_protection_background_paper.pdf> accessed 2 October 2019
[1370] Water Framework Directive (n 1367), annex II
[1371] Frelih-Larsen and others (n 40)
[1372] ibid

waterbodies.[1373] Over 70% of the sediment load in rivers comes from agricultural land in the UK.[1374] When large amounts of eroded soil enter the water systems generates detrimental effects on water biodiversity.[1375] Eventually, soil degradation related to pollution, diffuse pollution and erosion creates a pressure for water quality.[1376] As many water-threats, such as nutrients and pesticides, end up in waterbodies through soil use, such as agricultural and urban, WFD measures that protect water have potentially positive and indirect impacts on soil protection.[1377] Finally, it can be argued that there are opportunities for the Directive to extend its coverage for addressing some soil threats through implicit links. For example, it could reduce the impacts of soil sealing, where sealed soil affects inputs of pollutants to waterbodies and impact their status.[1378]

WFD is the main legal instrument addressing nutrient and water movements in so far that they affect status of waterbodies, so it directly contributes to water-related soil ES (Table 5.2.). The Directive also implicitly covers soil ES, namely carbon sequestration and platform for human activities through achieving better soil quality by meeting the objectives.[1379] Also, by controlling diffuse pollution in water, support for biomass production and soil biodiversity can be expected.[1380] Furthermore, in article 14, the Directive offers the Member States a good opportunity to address diffuse pollution from agriculture by setting up and adopting measures through meaningful participation and cooperation between different stakeholders.[1381] However, it is argued that England's institutional fragmentation acted as a barrier and prevented the engagement of all parties.[1382]

It is argued that WFD has strengths, such as strong monitoring, assessment and reporting provisions.[1383] However, the reports from the Member States under article 5 provide an insufficient level of detail.[1384] These are mostly geared towards water, resulting in a limited relevance of soil policy.[1385] These reports fail to provide relevant

[1373] R. J. Rickson, 'Can control of soil erosion mitigate water pollution by sediments?' (2014) 468-469 Science of the Total Environment 1187
[1374] ibid
[1375] ibid
[1376] European Commission, 'Evaluation of soil protection aspects in certain programmes of measures adopted by Member States' (*Environment,* 7 August 2019) <https://ec.europa.eu/environment/soil/study1_en.htm> accessed 24 September 2019
[1377] Frelih-Larsen and others (n 40)
[1378] ibid
[1379] ibid
[1380] ibid
[1381] Laura De Vito, Malcolm Fairbrother and Duncan Russel, 'Implementing the Water Framework Directive and Tackling Diffuse Pollution from Agriculture: Lessons from England and Scotland' (2020) 12 Water 244
[1382] ibid
[1383] Frelih-Larsen and others (n 40)
[1384] European Commission (n 1376)
[1385] ibid

information on SOM decline, sealing, compaction, salinisation and landslides.[1386] Furthermore, the Directive's implementation to date is not robust in the Member States, which hinders the delivery of the direct aim of water protection.[1387] It is clear that wider and indirect focus of soil protection is, as well, not fully achieved.[1388] Overall, it can be concluded that WFD offers weak protection for soils (Table 5.2.), while achieving its primary objective, which is water quality.[1389]

Table 5.3. The main instruments considered in this research which implement the European legislative instruments in England and Wales.

EU Law	Implementation in England and Wales
Direct Payments Regulation (Consolidated version: 01/02/2020)	• Common Agricultural Policy Basic Payment and Support Schemes (England) Regulations 2014, SI 2014/3259 • Common Agricultural Policy (Integrated Administration and Control System and Enforcement and Cross Compliance) (Wales) Regulations 2014, SI 2014/3223 (W.328) • Common Agricultural Policy Basic Payment Scheme (Provisional Payment Region Classification) (Wales) Regulations 2014, SI 2014/1835 (W.189) • Common Agricultural Policy Basic Payment and Support Schemes (Wales) Regulations 2015, SI 2015/1252 (W.84) • Common Agricultural Policy Basic Payment and Support Schemes (England) (Amendment) Regulations 2018, SI 2018/1026
Horizontal Regulation (Consolidated version: 01/02/2020)	• Common Agricultural Policy (Control and Enforcement, Cross-Compliance, Scrutiny of Transactions and Appeals) Regulations 2014, SI 2014/3263
Rural Development Regulation (Consolidated version: 01/03/2019)	• Rural Development (Enforcement) (England) Regulations 2007 (revoked), SI 2007/75 • Rural Development Programmes (Wales) Regulations 2014, 2014/3222 (W.327) • Rural Development Programme (Transfer) (England) Regulations 2018, SI 2018/964
Animal Feed Directive (Consolidated version: 27/02/2015)	• Feeding Stuffs (Sampling and Analysis) and the Feeding Stuffs (Enforcement) (Amendment) (England) Regulations 2003, SI 2003/1503 • Animal Feed (England) Regulations 2010, SI 2010/2503 • Animal Feed (Wales) Regulations 2010, SI 2010/2652 (W.220) • Animal Feed (Composition, Marketing and Use) (England) Regulations 2015, SI 2015/255

[1386] ibid
[1387] Frelih-Larsen and others (n 40)
[1388] ibid
[1389] Campaign to Protect Rural England (n 791)

	• Animal Feed (Composition, Marketing and Use) (Wales) Regulations 2016, SI 2016/386 (W.120) • Feeding Stuffs, the Feeding Stuffs (Sampling and Analysis) and the Feeding Stuffs (Enforcement) (Amendment) (Wales) Regulations 2003, SI 2003/1850 (W.200)
Organics Regulation	• Organic Products Regulations 2009, SI 2009/842
Water Framework Directive (Consolidated version: 20/11/2014)	• Nitrate Pollution Prevention Regulations 2008, SI 2008/2349 • Environmental Damage (Prevention and Remediation) Regulations 2009, SI 2009/153 • Environmental Damage (Prevention and Remediation) (Wales) Regulations 2009, SI 2009/995 (W.81) • Environmental Damage (Prevention and Remediation) (Amendment) Regulations 2009, SI 2009/3275 • Environmental Permitting (England and Wales) Regulations 2010, SI 2010/675 • Environmental Permitting (England and Wales) (Amendment) (England) Regulations 2014, SI 2014/2852 • Water Environment (Water Framework Directive) (England and Wales) Regulations 2017, SI 2017/407 • Reduction and Prevention of Agricultural Diffuse Pollution (England) Regulations 2018, SI 2018/151
Groundwater Directive (Consolidated version: 11/07/2014)	• Groundwater (England and Wales) Regulations 2009 • Environmental Permitting (England and Wales) Regulations 2010, SI 2010/675 • Environmental Permitting (England and Wales) (Amendment) (England) Regulations 2014, SI 2014/2852
Nitrates Directive (Consolidated version: 11/12/2008)	• Protection of Water against Agricultural Nitrate Pollution (England and Wales) Regulations 1996, SI 1996/888 • Protection of Waste Against Agricultural Nitrate Pollution (Amendment) (Wales) Regulations 2002, SI 2002/2297 (W.226) • Nitrate Vulnerable Zones (Additional Designations) (England) (No. 2) Regulations 2002, SI 2002/2614 • Nitrate Pollution Prevention Regulations 2008, SI 2008/2349 • Nitrate Pollution Prevention (Wales) Regulations 2013, SI 2013/2506 (W.245) • Nitrate Pollution Prevention Regulations 2015, SI 2015/668 • Nitrate Pollution Prevention (Wales) (Amendment) Regulations 2015, SI 2015/2020 (W.308) • Nitrate Pollution Prevention (Amendment) Regulations 2016, SI 2016/1190
Sewage Sludge Directive (Consolidated version: 04/07/2018)	• Sludge (Use in Agriculture) Regulations 1989, SI 1989/1263 • Sludge (Use in Agriculture) (Amendment) Regulations 1990, SI 1990/880
Pesticides Directive	• Plant Protection Products (Sustainable Use) Regulations 2012, SI 2012/1657

(Consolidated version: 26/07/2019)	
Environmental Liability Directive (Consolidated version: 26/06/2019)	• Environmental Damage (Prevention and Remediation) Regulations 2009 (revoked), SI 2009/153 • Environmental Damage (Prevention and Remediation) (Wales) Regulations 2009, SI 2009/995 (W.81) • Environmental Damage (Prevention and Remediation) (England) Regulations 2015, SI 2015/810 • Environmental Damage (Prevention and Remediation) (England) (Amendment) Regulations 2015, SI 2015/1391 • Environmental Damage (Prevention and Remediation) (Amendment) (Wales) Regulations 2015, SI 2015/1394 (W.138) • Environmental Damage (Prevention and Remediation) (Wales) (Amendment) (No.2) Regulations 2015, SI 2015/1937 (W.291) • Environmental Damage (Prevention and Remediation) (England) (Amendment) Regulations 2017, SI 2017/1177 • Environmental Damage (Prevention and Remediation) (England) (Amendment) Regulations 2019, SI 2019/1285
Industrial Emissions Directive (Consolidated version: 06/01/2011)	• Environmental Permitting (England and Wales) (Amendment) Regulations 2013, SI 2013/390 • Offshore Combustion Installations (Pollution Prevention and Control) Regulations 2013, SI 2013/971 • Carbon Capture Readiness (Electricity Generating Stations) Regulations 2013, SI 2013/2696
Waste Framework Directive (Consolidated version: 05/07/2018)	• Waste (England and Wales) Regulations 2011, SI 2011/988 • Waste (Miscellaneous Provisions) (Wales) Regulations 2011; SI 2011/971 (W.141) • Waste (England and Wales) (Amendment) Regulations 2012, SI 2012/1889 • Waste (England and Wales) (Amendment) Regulations 2014, SI 2014/656 • Hazardous Waste (Miscellaneous Amendments) Regulations 2015, SI 2015/1360 • Hazardous Waste (Miscellaneous Amendments) (Wales) Regulations 2015, SI 2015/1417 (W.141) • Waste (Meaning of Recovery) (Miscellaneous Amendments) (Wales) Regulations 2016, SI 2016/691 (W.189)
Landfill Directive (Consolidated version: 04/07/2018)	• Landfill (England and Wales) Regulations 2002, SI 2002/1559 • Landfill Allowances Scheme (Wales) Regulations 2004, SI 2004/1490 (W.155) • Landfill (Scheme Year and Maximum Landfill Amount) Regulations 2004, SI 2004/1936 • Landfill Allowances and Trading Scheme (England) Regulations 2004 (revoked), SI 2004/3212

	• Landfill Allowances and Trading Scheme (England)(Amendment) Regulations 2005 (revoked), SI 2005/880 • Waste Management (England and Wales) Regulations 2006, SI 2006/937 • Environmental Permitting (England and Wales) Regulations 2007, SI 2007/3538 • Environmental Permitting (England and Wales) Regulations 2010, SI 2010/675
Mining Waste Directive (Consolidated version: 07/08/2009)	• Environmental Permitting (England and Wales) (Amendment) Regulations 2009, SI 2009/1799 • Major Accident Off-Site Emergency Plan (Management of Waste from Extractive Industries) (England and Wales) Regulations 2009, SI 2009/1927 • Environmental Permitting (England and Wales) Regulations 2010, SI 2010/675 • Waste (England and Wales) Regulations 2011, SI 2011/988 • Environmental Damage (Prevention and Remediation) Regulations 2009, SI 2009/153 • Environmental Damage (Prevention and Remediation) (Wales) Regulations 2009, SI 2009/995 (W.81)
Environmental Impact Assessment Directive (Consolidated version: 15/05/2014)	• Town and Country Planning (Environmental Impact Assessment) (Amendment) Regulations 2015, SI 2015/660 • Town and Country Planning (Environmental Impact Assessment) (Wales) Regulations 2016 (revoked), SI 2016/58 (W.28) • Town and Country Planning (Environmental Impact Assessment) (Wales) (Amendment) Regulations 2016, SI 2016/971 (W.240) • Town and Country Planning (Environmental Impact Assessment) (Wales) Regulations 2017, SI 2017/567 (W.136) • Town and Country Planning (Environmental Impact Assessment) Regulations 2017, SI 2017/571 • Town and Country Planning and Infrastructure Planning (Environmental Impact Assessment) (Amendment) Regulations 2018, SI 2018/695 • Town and Country Planning (Environmental Impact Assessment) (Wales) (Amendment) Regulations 2019, SI 2019/299 (W.76)
Strategic Environmental Assessment Directive (Consolidated version: 21/07/2001)	• Environmental Assessment of Plans and Programmes Regulations 2004, SI 2004/1633 • Environmental Assessment of Plans and Programmes (Wales) Regulations 2004, SI 2004/1656 (W.170)

5.2.3.6. Diffuse Pollution Regulations

Diffuse pollution can be defined as pollution from widespread activities with no single specific source.[1390] These sources are non-point sources, i.e., without a single point of origin, such as agriculture, forestry and construction.[1391] As mentioned earlier, soil erosion contributes to diffuse water pollution, which is a significant issue in the UK.[1392] Modern industrial farming methods require the use of a large amount of fertilisers and manure, and these nutrients are transferred to waterbodies.[1393] These substances cause loss of species in waterbodies by increasing the risk of eutrophication,[1394] which results in excessive plant production, blooms of harmful algae,[1395] dead zones and fish deaths.[1396] Diffuse pollution is difficult to regulate due to several reasons, such as multi-functionality of land use, the relevant property rights and the bio-physical uncertainties.[1397]

Diffuse Pollution Regulations[1398] and other existing measures, implement article 11(3)(h) of WFD,[1399] which requires the Member States to implement basic measures to prevent or control the input of pollutants from diffuse sources.[1400] These measures aim to prevent diffuse water pollution, which is the contamination of water by fertilisers, manure and soil from agricultural activities.[1401]

Although the Regulations do not have soil specific targets or objectives, they encourage better land management and reduction in pollution and soil erosion.[1402] The instrument provides rules for two activities to achieve its aim. First, the application and storage of fertilisers; and second, the management of soil and livestock. These rules also require land managers to take reasonable precautions related to these aspects.[1403]

The objectives of the rules on the application and storage of fertilisers is maximising the uptake of nutrients by crops, and improving soil structure to reduce the

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1390 'EEA Glossary' (*European Environment Agency*) <https://www.eea.europa.eu/help/glossary/eea-glossary> accessed 30 September 2019
1391 ibid
1392 John Boardman, 'The need for soil conservation in Britain – revisited' (2003) 34 Royal Geographical Society 339
1393 'Diffuse sources' (*European Environment Agency*) <https://www.eea.europa.eu/archived/archived-content-water-topic/water-pollution/diffuse-sources> accessed 30 September 2019
1394 ibid
1395 Lucy Ngatia and others, 'Nitrogen and Phosphorus Eutrophication in Marine Ecosystems' (14 January 2019) <https://www.intechopen.com/books/monitoring-of-marine-pollution/nitrogen-and-phosphorus-eutrophication-in-marine-ecosystems> accessed 2 October 2019
1396 'What is eutrophication?' (*National Ocean Service*, 6 December 2019) <https://oceanservice.noaa.gov/facts/eutrophication.html> accessed 2 October 2019
1397 Smith and others (n 983)
1398 Reduction and Prevention of Agricultural Diffuse Pollution (England) Regulations 2018, SI 2018/151 (hereinafter 'Diffuse Pollution Regulations')
1399 Water Framework Directive (n 1367), art 11(3)(h)
1400 Department for Environment, Food and Rural Affairs, 'Explanatory Memorandum to the Reduction and Prevention of Agricultural Diffuse Pollution (England) Regulations 2018' (2018 No. 151) <https://www.legislation.gov.uk/uksi/2018/151/pdfs/uksiem_20180151_en.pdf> accessed 12 August 2019
1401 ibid
1402 ibid
1403 Diffuse Pollution Regulations (n 1398), regs 4(3), 10(5)

loss of nutrients and sediment to water.[1404] The Regulations prohibit the application of organic manure and manufactured fertilisers under some circumstances to protect nearby surface and ground waters.[1405] Also, it has provisions that limits the amount of organic manure and manufactured fertilisers to be applied to agricultural land as well as other factors that must be taken into consideration while applying them.[1406] Besides, cultivated agricultural land management rules in this instrument require land managers to consider recent soil sampling and analysis results (including soil pH and levels of nitrogen, phosphorous, magnesium and potassium) when planning manure and fertiliser applications.[1407] Indeed, better nutrient management is crucial to reduce excess nutrients in the system and associated diffuse pollution.[1408]

An examination of the rules related to the management of soil and livestock finds that they aim to prevent or reduce soil erosion and runoff to waters.[1409] These objectives are intended to be achieved through several rules, such as prevention of poaching (i.e., trampling damage to the soil)[1410] or locating livestock feeder in certain areas.[1411] They also require the land manager to consider certain individual factors that may lead to a higher risk of diffuse pollution.[1412]

Diffuse Pollution Regulations do not directly cite any soil ES (Table 5.2.); however, are expected to indirectly contribute to water quality regulation and water supply regulation when the objectives of reducing and preventing pollution of inland freshwaters, surface waters and groundwater from agricultural activities are achieved.

It can be argued that Diffuse Pollution Regulations provide indirect protection for soils as its main focus is on the control of diffuse water pollution rather than protecting or conserving soil in situ.[1413] However, this instrument is still capable of providing soil protection in an indirect manner and this level of soil protection can be viewed as modest (Table 5.2.).

[1404] Department for Environment, Food and Rural Affairs (n 1400)
[1405] Diffuse Pollution Regulations (n 1398), reg 3
[1406] ibid, reg 4
[1407] ibid, reg 5
[1408] Posthumus and others (n 936)
[1409] Diffuse Pollution Regulations (n 1398), reg 10
[1410] ibid, reg 10(1)
[1411] ibid, reg 10(2)
[1412] ibid, reg 10(3)
[1413] Posthumus and others (n 936)

5.2.3.7. Groundwater Directive

Groundwater is a crucial element of the water cycle and supplies around one third of the UK's drinking water.[1414] Land use may influence the groundwater quality in short and long terms.[1415] Because, pollutants are introduced to groundwater after percolation through soil or subsoil (indirect input) as well as without percolation (direct input).[1416] Thus, land use regulations can play an important role in groundwater protection.[1417]

The Groundwater Directive[1418] aims to control groundwater pollution,[1419] to prevent or limit inputs of pollutant into groundwater, and to avoid deterioration of the status of all bodies of groundwater.[1420] It sets measures including criteria for the assessment of good groundwater chemical status;[1421] and criteria for the identification and reversal of significant and sustained upward trends and for the definition of starting points for trend reversals.[1422] Therefore, it represents a proportionate and scientifically sound response to the requirements of WFD.[1423] Supporting WFD, the Groundwater Directive sets additional clear and precise substance standards.

There are neither soil specific targets or objectives nor explicit soil threats or ES references in the Directive (Table 5.2.). However, it is expected to impact on soil pollution and soil quality[1424] due to the strong interdependencies of groundwater and soil ecosystems.[1425] It is also worth mentioning that the Directive, considering the references in its preamble, is expected to contribute to water supply regulation as a soil ES.

As a result of this lack of direct emphasis on soils, only a limited number of substances in the Groundwater Directive are of interest in soil protection.[1426] To conclude, the Directive has an indirect focus on soil protection and can be considered as a very weak legal instrument in this context (Table 5.2.).

1414 'Groundwater Daughter Directive' (*EUGRIS*, 18 December 2007) <http://www.eugris.info/displayresource.aspx?r=6294> accessed 13 August 2019

1415 'EUGRIS encyclopaedia' (*EUGRIS: portal for soil and water management in Europe*) <http://www.eugris.info/eugris-soil-water-encyclopedia.asp> accessed 2 October 2019

1416 Environment Agency, 'Groundwater protection technical guidance' (*GOV.UK*, 14 March 2017) <https://www.gov.uk/government/publications/groundwater-protection-technical-guidance/groundwater-protection-technical-guidance#inputs> accessed 2 October 2019

1417 'EUGRIS encyclopaedia' (n 1415)

1418 Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration [2006] OJ L 372/19 (hereinafter 'Groundwater Directive')

1419 ibid, art 1(1)

1420 ibid, art 1(2)

1421 ibid, art 1(1)(a)

1422 ibid, art 1(1)(b)

1423 'Groundwater' (*Environment*, 7 August 2019) <https://ec.europa.eu/environment/water/water-framework/groundwater/framework.htm> accessed 2 October 2019

1424 S. M. Rodrigues and others, 'A Review of Regulatory Decisions for Environmental Protection: Part I – Challenges in the Implementation of National Soil Policies' (2009) 35 Environment International 202

1425 Kraemer and others (n 1369)

1426 Frelih-Larsen and others (n 40)

5.2.3.8. Nitrates Directive

Nitrogen is one of the vital nutrients that promote plant growth.[1427] On the other hand, high levels of nitrogen concentrations cause detrimental results for human health and the environment.[1428] Indeed, the nitrogen cycle has been highly disturbed by the manufacture and use of inorganic fertilisers. Moreover, excessive application of these fertilisers has resulted in nitrogen runoff or leaching, which is a fundamental cause of water pollution.[1429] Besides, when excess nitrogen reaches rivers, estuaries and coastal waters, it causes eutrophication. Thus, it is critical to reduce anthropogenic nitrogen input to marine ecosystems.[1430]

The Nitrates Directive,[1431] as another integral part of WFD,[1432] is one of the most significant instruments in the protection of waters against agricultural pressures.[1433] Its principal aims are reducing water pollution caused or induced by nitrates from agricultural sources and preventing further pollution,[1434] and promoting the use of good farming practices.[1435]

Excess nitrogen in soil has several sources, such as atmospheric deposition, excess spreading of organic materials (animal slurries, sewage sludge and food wastes) and excessive application of mineral fertilisers.[1436] Heavy metals in slurries and manures are not directly controlled, but are indirectly regulated under the Nitrates Directive due the limits set by the directive on nutrient inputs from these sources, especially within Nitrate Vulnerable Zones (NVZ).[1437] NVZs designated under the Directive are all known areas in the Member States whose waters, including groundwater, are or are likely to be affected by nitrate pollution.[1438] Indeed, these can include land areas, which drain into waters vulnerable to high nitrate levels or eutrophication, or areas that are designated as being at risk from agricultural nitrate pollution.[1439] NVZs are defined as those waters containing

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[1427] European Commission, 'The Nitrates Directive' (*Environment*, 7 August 2019) <https://ec.europa.eu/environment/water/water-nitrates/index_en.html> accessed 12 August 2019
[1428] ibid
[1429] ibid
[1430] Daniel J. Conley and others, 'Controlling Eutrophication: Nitrogen and Phosphorus' (2009) 323 Science 1014
[1431] Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources [1991] OJ L 375/1 (hereinafter 'Nitrates Directive')
[1432] European Commission (n 1427)
[1433] ibid
[1434] Nitrates Directive (n 1431), art 1
[1435] European Commission (n 1427)
[1436] Department for Environment, Food and Rural Affairs, 'The total costs of soil degradation in England and Wales – SP1606' Appendix J Diffuse Pollution <http://sciencesearch.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=16992> accessed 13 August 2019
[1437] ibid
[1438] Nitrates Directive (n 1431), art 3(2)
[1439] 'Nitrate vulnerable zones' (*GOV.UK)* <https://www.gov.uk/government/collections/nitrate-vulnerable-zones> accessed 2 October 2019

nitrate concentration of more than 50 mg/l, or zones that are susceptible to contain such nitrate concentration unless necessary measures are taken.[1440] It is clear that NVZs are designated based on water quality parameters.[1441] This designation is for mitigating the adverse impacts of the use of fertilisers on drinking water and marine ecosystems and limiting the input of organic fertilisers and manure.[1442] Therefore, the purpose is to reduce this over-release of nutrients to waterbodies and to mitigate over-saturation of soils with these substances.[1443] The requirements of the Member States for NVZs are developing and implementing action programmes and revising these every four years.[1444]

It is worth emphasising that there are no soil specific targets or objectives in this Directive (Table 5.2.). The Directive's main aim mentioned above requires the implementation of soil management measures that potentially contribute to soil protection.[1445] Therefore, this legal instrument is expected to have positive effects in addressing soil pollution as it is a key instrument addressing nitrogen pollution due to farming.[1446] The Nitrates Directive also provides guidelines on the Member States' Codes of Good Agricultural Practice[1447] that have a particular focus on soil and fertiliser application on land.[1448] This Directive clearly provides direct protection for soils from the specific threat of pollution by aiming to maintain the natural balance of fertilisers and manure on farmland.[1449]

The Nitrates Directive is seen as a potentially effective legal instrument for soil protection for several reasons. It has clear and precise provisions on nitrogen application in agriculture.[1450] These provisions are also directly linked to CAP CC provisions.[1451] It is argued that the Directive's requirements can also contribute to addressing erosion in an indirect manner as they include maintaining minimum levels of vegetative cover during rainy periods as a measure that can be adopted by the Member States.[1452] Indeed, minimising uncultivated land would help reducing erosion risk, but also would reduce phosphorus runoff that can also contribute to eutrophication in waterbodies.[1453] Lands

[1440] 'Groundwater' (n 1423)
[1441] Frelih-Larsen and others (n 40)
[1442] Kraemer and others (n 1369)
[1443] ibid
[1444] Nitrates Directive (n 1431), art 5
[1445] Frelih-Larsen and others (n 40)
[1446] Louwagie and others (n 1168)
[1447] Nitrates Directive (n 1431), annex II
[1448] Paleari (n 49)
[1449] Kraemer and others (n 1369)
[1450] Frelih-Larsen and others (n 40)
[1451] ibid
[1452] ibid
[1453] Stephen R. Carpenter, 'Eutrophication of aquatic ecosystems: Bistability and soil phosphorus' (2005) 102 PNAS 10002

under permanent crops also increases the amount of SOM and improves soil structure while minimises erosion risk and leaching of nitrates.[1454] Nutrient runoff and nitrate leaching can also result in non-compliance with the maximum target levels of water pollution.[1455]

Another indirect impact of the Directive is on compaction as it introduces restrictions on when manure can be applied.[1456] These restrictions can regulate the traffic on soils during particular seasons and help reducing the risk of compaction.[1457] It is suggested that preserving soil structure and eliminating compaction also enable reducing the amount of nitrate and phosphorus run-off.[1458]

From a soil ES perspective, as the Directive aims to reduce water pollution caused or induced by nitrates,[1459] it can be argued that in addition to its water related ES references (Table 5.2.), it may indirectly contribute to protection of biomass production and biodiversity by tackling nitrogen pollution in soils. Also, it introduces a number of good agricultural practices that may be adopted by the Member States, containing one related to the maintenance of a minimum quantity of vegetation cover,[1460] which indirectly supports primary production and nutrient cycling.

In the UK, there is slow, but steady reduction of nitrate levels in surface and ground waters.[1461] Considering the abovementioned aspects, it can be argued that Nitrates Directive offers strong soil protection (Table 5.2.). However, there are still several weaknesses. Most importantly, the controls only apply where waters are at specified risks.[1462] This limitation prevents the Directive to offer comprehensive and robust soil protection.[1463]

The UK government affirms that the Directive is flawed as it leaves too much detail of implementation to the Member States, and the scientific justification for the figures are unclear, such as the 50 mg/l limit for nitrates in surface and ground waters and the 170 kg N ha^{-1} whole-farm limit for livestock manures.[1464]

[1454] A. Mudgal and others, 'Effects of long-term soil and crop management on soil hydraulic properties for claypan soils' (2010) 65 Journal of Soil and Water Conservation 393
[1455] ibid
[1456] Frelih-Larsen and others (n 40)
[1457] ibid
[1458] B. Ulén and others, 'Soil tillage methods to control phosphorus loss and potential side-effects: a Scandinavian review' (2010) 26 Soil Use and Management 94
[1459] Nitrates Directive (n 1431), art 1
[1460] ibid, annex IIB
[1461] HM Government (n 803)
[1462] Frelih-Larsen and others (n 40)
[1463] ibid
[1464] House of Commons Environment, Food and Rural Affairs Committee, 'Implementation of the Nitrates Directive in England - Seventh Report of Session 2007–08'

It is argued that, in some Member States including the UK, the compliance with the Directive is poor.[1465] NVZs include about 55% of land in England,[1466] and 2.4% of land in Wales.[1467] It is reported that there are farmers that were applying 250 N ha^{-1} (which is allowed in non-NVZ areas) rather than following the 170 N ha^{-1} limitation found in the Directive,[1468] which constitutes a significant breach.[1469]

Furthermore, the Directive allows an extensive use of derogations by Member States, such as Northern Ireland.[1470] The negative outcome of this was seen in the Netherlands where the target value was exceeded in some regions of the country as a result of the large use of derogations, which hindered the Directive's influence.[1471]

Overall, management measures are tools to reach the primary objective and achieving a robust soil protection is not the Directive's principal goal.[1472] This situation is another example of soil usually being either a tool used by European legislators to achieve other environmental objectives or simply a secondary concern.[1473]

5.2.3.9. Sewage Sludge Directive

The Sewage Sludge Directive[1474] aims to encourage the use of sewage sludge in agriculture whilst regulating the practice to prevent harmful effect on soils, vegetation and humans.[1475] It prohibits sludge use where the concentration of one or more heavy metals in the soil exceeds the limit values found in Annex IA, and requires the Member States to take the necessary steps to ensure that those limit values are not exceeded as a result of the use of sludge.[1476] Therefore, the Directive has a soil focused objective of regulating the use of sewage sludge in agriculture in a way that prevents harmful effects

[1465] Louwagie and others (n 1168)
[1466] 'Nitrate vulnerable zones' (n 1439)
[1467] Natural Resources Wales, 'Nitrate vulnerable zones' <https://naturalresources.wales/about-us/what-we-do/water/nitrate-vulnerable-zones/?lang=en> accessed 13 June 2019
[1468] 'Written evidence submitted by Brighton ChaMP for Water' (January 2018) <http://data.parliament.uk/WrittenEvidence/CommitteeEvidence.svc/EvidenceDocument/Environmental%20Audit/Nitrate/written/77053.html> accessed 2 October 2019
[1469] Louwagie and others (n 1168)
[1470] Commission Implementing Decision (EU) 2019/1325 of 27 May 2019 granting a derogation requested by the United Kingdom with regard to Northern Ireland pursuant to Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources (notified under document C (2019) 3816) C/2019/3816 [2019] OJ L 206
[1471] Hans J. M. Van Grinsven, Aaldrik Tiktak and Carin W. Rougoor, 'Evaluation of the Dutch implementation of the Nitrates Directive, the Water Framework Directive and the National Emission Ceilings Directive' (2016) 78 Wageningen Journal of Life Sciences 69
[1472] Frelih-Larsen and others (n 40)
[1473] Paleari (n 49)
[1474] Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture [1986] OJ L 181/6 (hereinafter 'Sewage Sludge Directive')
[1475] European Commission, 'Sewage Sludge' (*Environment*, 7 August 2019) <https://ec.europa.eu/environment/waste/sludge/> accessed 13 August 2019
[1476] Sewage Sludge Directive (n 1474), art 5(1)

on soil.[1477] For this, the Directive prohibits the use of sludge on agricultural land before treatment, unless it is injected or incorporated into the soil.[1478] Treated sludge is defined as sludge which has undergone biological, chemical or heat treatment, long-term storage or any other appropriate process so as significantly to reduce its fermentability and the health hazards resulting from its use.[1479] However, the Directive does not specify treatment processes,[1480] but there are some examples provided for treatment processes in the UK Sewage Sludge in Agriculture Code of Practice.[1481] The ban on the use of untreated sludge use on agricultural land is also introduced by the Safe Sludge Matrix, which is a voluntary agreement.[1482] It is argued that the matrix improved sewage sludge quality requirements concerning its use in agricultural crops, by providing dual criteria for pathogen reduction requirements for conventionally and enhanced treated sewage sludge.[1483] However, its effect is limited as it has no statutory requirements.

The requirement of treating sewage sludge before applying is emphasised in this Code of Practice.[1484] Untreated liquid sludge releases nitrogen slowly, and the benefits to crops are realised over a long time.[1485] Also, sludge contains viruses, bacteria and other pathogens, and the risks from these depend on how the sludge has been treated.[1486] Sewage sludge may also contain harmful toxics, such as heavy metals, detergents, various salts and pesticides due to effluents from municipal and industrial premises.[1487] Thus, sewage sludge requires regular monitoring and understanding of long-term impacts on soils.[1488]

Sewage Sludge Directive also restricts the use of sludge on soil in which fruit and vegetable crops are growing,[1489] and on land that is intended for cultivation of fruit and

1477 ibid, art 1
1478 ibid, art 6(a)
1479 ibid, art 2(b)
1480 Vassilis Inglezakis and others, 'European Union legislation on sewage sludge management' (2014) 23 Fresenius Environmental Bulletin 635
1481 Department for Environment, Food and Rural Affairs (n 851)
1482 British Retail Consortium, Water UK and ADAS, 'The Safe Sludge Matrix – Guidelines for the Application of Sewage Sludge to Agricultural Land' (April 2001) <http://adlib.everysite.co.uk/resources/000/094/727/SSMatrix.pdf> accessed 12 January 2019
1483 A. Christodoulou and K. Stamatelatou, 'Overview of legislation on sewage sludge management in developed countries worldwide' (2016) 73 Water Science & Technology 453
1484 Department for Environment, Food and Rural Affairs (n 851)
1485 ibid
1486 ibid
1487 R. P. Singh and M. Agrawal, 'Potential benefits and risks of land application of sewage sludge' (2008) 28 Waste Management 347
1488 B. Petrie, R. Barden and B. Kasprzyk-Hordern, 'A review on emerging contaminants in wastewaters and the environment: current knowledge, understudied areas and recommendations for future monitoring' (2015) 72 Water Research 3
1489 Sewage Sludge Directive (n 1474), art 7(b)

vegetable crops for a 10-month period prior to the harvest of crops.[1490] This provision is intended to protect human health, rather than the soil itself.[1491]

The Directive, however, aims to establish specific initial Community measures in connection with soil protection[1492] and stresses that the use of sewage sludge must not impair the quality of the soil and of agricultural products.[1493] Thus, the Directive is one of the most important legal instruments under this topic as soil protection from sewage sludge used on agricultural land is a central objective of this instrument.[1494]

Unlike most of other EU legal instruments, the Directive has several soil-specific targets (Table 5.2.). It introduces multiple types of emission limit values that would be guidance for the Member States in addressing soil contamination.[1495] It also provides rules that apply to the use of sludge.[1496] It also specifically sets out limit values for concentrations of a number of heavy metals (namely cadmium, copper, nickel, lead, zinc, mercury, chromium) in sewage sludge intended for agricultural use and in soil to which sludge is applied.[1497] If the concentration of these exceeds the limit values set out in Annex IA Member States must prohibit the use of sewage sludge.[1498] The Member States are also required to introduce the maximum quantities of sludge (in tonnes of dry matter), which may be applied to soil per unit of area per year while observing the limit values for heavy metal concentration in sludge which is laid down in accordance with Annex IB.[1499] The Directive requires the Member States to ensure observance of the limit values for the quantities of heavy metal introduced to soils per unit of area and unit of time as set out in Annex IC.[1500] Also, it is a requirement introduced by the Directive to use sludge in a way that considers the nutrient requirements of plants and soil quality.[1501] Where soil is rather more acidic, the Member States must consider increased mobility and availability to the crop of heavy metals and shall reduce the limit values they have laid down in accordance with the Annex if necessary.[1502] Finally, the Directive gives flexibility to the Member States to introduce more stringent measures than found in the Directive if conditions

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1490 ibid, art 7(c)
1491 European Commission (n 1475)
1492 Sewage Sludge Directive (n 1474), preamble
1493 ibid, preamble
1494 Kraemer and others (n 1369)
1495 Sewage Sludge Directive (n 1474), art 5
1496 ibid, art 8
1497 ibid, art 4, annexes IA, IB and IC
1498 ibid, art 5(1)
1499 ibid, art 5(2)
1500 ibid, art 5(2)(b)
1501 ibid, art 8
1502 ibid, art 8

demand,[1503] which has been followed by a number of Member States for limit values of heavy metals.[1504]

The Directive directly addresses soil pollution through prohibiting the use of sludge where heavy metal concentration in soil is above the Annex IA limits,[1505] or where fruit or vegetables crops are growing,[1506] adopting the restriction when the application of sludge may impair soil quality.[1507] The Directive also contributes to limiting the risk of erosion and SOM loss indirectly as the use of sludge on agricultural soils can support SOM content and reduce erosion while supporting soil health and biodiversity (Table 5.2.).[1508]

Considering soil ES, as sludge is a potential source of carbon in agricultural soils, the Directive is expected to contribute to carbon sequestration implicitly. Also, it may contribute to soil biodiversity, biomass production and platform for human activities by addressing pollution threat from sludge use.[1509] Additionally, it contributes to allowing sludge use, as source of nutrients,[1510] thus potentially supports nutrient cycling, primary production and water related ES of soils.

Overall, the Directive has a direct focus on soils and arguably provides very strong protection for soils (Table 5.2.). Although the Directive seems as a strong legal instrument, it does not find application as much as other laws, as only about 1% of UK farmland receives sludge, which renders its effects limited.[1511]

It is also argued that the European law does not include all harmful chemical compounds that may occur in sewage sludge.[1512] Generally, the limits for heavy metals in sludge set by the Member States are significantly below the Directive's requirements.[1513] The UK regulations set maximum concentration limits in soils receiving sludge and maximum annual metal loading rates (as a 10 year average),[1514] however, do not specify any limit value for concentrations of heavy metals in sludge.[1515] Indeed, the

[1503] ibid, art 12
[1504] Frelih-Larsen and others (n 40)
[1505] Sewage Sludge Directive (n 1474), art 5(1)
[1506] ibid, art 7
[1507] ibid, art 8
[1508] Frelih-Larsen and others (n 40)
[1509] ibid
[1510] ibid
[1511] Department for Environment, Food and Rural Affairs, 'Long Term Sewage Sludge Experiments - Frequently Asked Questions' <http://randd.defra.gov.uk/Document.aspx?Document=SP0130_6422_INF.pdf> accessed 3 October 2019
[1512] Bartlomiej Michal Cieślik, Jacek Namieśnik and Piotr Konieczka, 'Review of sewage sludge management: standards, regulations and analytical methods' (2015) 90 Journal of Cleaner Production 1
[1513] Inglezakis and others (n 1480)
[1514] Department for Environment, Food and Rural Affairs (n 1511)
[1515] European Commission, 'Disposal and recycling routes for sewage sludge Part 2 – Regulatory report' (October 2001) <https://ec.europa.eu/environment/archives/waste/sludge/pdf/sludge_disposal2.pdf> accessed 3 October 2019

Sewage Sludge in Agriculture Code of Practice provides maximum permissible concentrations of PTEs in soil after application of sewage sludge.[1516] For zinc, copper and nickel, the maximum permissible concentrations vary with soil pH, as crop damage from phytotoxic elements is more likely to occur on acid soils.[1517]

The Sewage Sludge Directive was seen as a first step towards the harmonisation of sewage sludge utilisation at the Union level. It contains only minimum requirements and permits stricter national measures.[1518] This aspect allows the Member States to use large discretion in implementing the Directive. The UK government implemented the Directive untouched supported by a number of guidance documents.[1519] The implemented Regulations define heavy metal concentration limits in soil[1520] (Table 5.3.). Sewage Sludge in Agriculture Code of Practice requires monitoring PTE levels in sludge and in the soil for sludge producers.[1521] Farmers and landowners must consider these levels before deciding to spread sludge on land.[1522] It also requires sludge producers to test sewage sludge every 6 months for the amount of dry matter, OM, pH, nitrogen and phosphorus, as well as PTE levels.[1523] Also, producers are required to test soils to determine whether PTE levels in soil are below the maximum permissible concentration.[1524] The Code of Practice explicitly state that sludge must not be applied on arable land and grassland, if it will cause soil PTE levels to exceed the given limits.[1525]

The UK Code of Good Agricultural Practice contains advisory provisions for sludge application and guidance for which legal obligations must be followed for sludge application.[1526] It is clear that the responsibility for meeting the legal limits on metals in the sludge and in the soil to which it is applied is on sludge producers.[1527]

Overall, the major problems with the use of sewage sludge are the regulation of other non-hazardous sludge and the effects of long-term accumulation of heavy metals to the topsoil.[1528] The Directive is argued to be an effective one due to the fact that it sets clear and achievable standards for quality of sludge applied to soil, but it is relatively old

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[1516] Department for Environment, Food and Rural Affairs (n 851)
[1517] Food and Agriculture Organization of the United Nations (n 1030)
[1518] L. Spinosa, 'Evolution of sewage sludge regulations in Europe' (2001) 44 Water Sci Technol 1
[1519] B. Crathorne and others, 'Implementation of HACCP controls under the new Sludge (Use in Agriculture) Regulations' in Proceedings of CIWEM/Aqua Enviro 7th European Bio Solids and Organic Residuals Conference, 18–20th November 2002
[1520] Sludge (Use in Agriculture) Regulations 1989, sch 1
[1521] Department for Environment, Food and Rural Affairs (n 851)
[1522] ibid
[1523] ibid
[1524] ibid
[1525] ibid
[1526] Department for Environment, Food and Rural Affairs (n 816)
[1527] ibid
[1528] Inglezakis and others (n 1480)

and its revision has stalled.[1529] There is a need for such revision that would update standards and address additional soil protection measures[1530] as there has been a marked improvement in both scientific understanding and sludge quality since the Directive. Indeed, it is argued that the improvement should be continuous, and the enforcement should be strengthened.[1531]

5.2.3.10. Pesticides Directive

The Pesticides Directive,[1532] adopted alongside the Plant Protection Products Regulation,[1533] has the objective of achieving a sustainable use of pesticides in the EU.[1534] It seeks to accomplish this by promoting the use of Integrated Pest Management (IPM) and of alternative approaches or techniques, such as non-chemical alternatives to pesticides.[1535]

IPM includes consideration of available plant protection methods and integration of appropriate measures that discourage the development of harmful organisms and are able to justify the use of plant protection products and methods in ecologic and economic terms.[1536] IPM highlights the focus on reducing or minimising the risks from these to human health and the environment.[1537] The bottom line is that it supports the growth of a healthy crop with the least possible disturbance to ecosystems whilst encourages natural pest control methods.[1538] Accordingly, the UK's 25 Year Environment Plan commits to protecting crops while reducing the environmental impact of pesticides and to putting IPM at the heart of a holistic approach.[1539]

The Directive requires the Member States to submit their national action plans (NAP),[1540] which contain all measures prescribed in the Directive[1541] to reduce the risks and impacts of pesticide use on human health and the environment[1542] and describe how

[1529] Frelih-Larsen and others (n 40)
[1530] ibid
[1531] Inglezakis and others (n 1480)
[1532] Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides [2009] OJ L 309/71 (hereinafter 'Pesticides Directive')
[1533] 'Sustainable use of pesticides' (*www.parliament.uk*, 15 January 2018) <https://publications.parliament.uk/pa/cm201719/cmselect/cmeuleg/301-ix/30112.htm#footnote-035> accessed 8 October 2019
[1534] Pesticides Directive (n 1532), art 1
[1535] ibid, art 1
[1536] ibid, art 3(6)
[1537] ibid, art 3(6)
[1538] European Commission, 'Integrated Pest Management' (*Plants*) <https://ec.europa.eu/food/plant/pesticides/sustainable_use_pesticides/ipm_en> accessed 4 July 2020
[1539] HM Government (n 803)
[1540] Pesticides Directive (n 1532), art 4
[1541] ibid, arts 5-15
[1542] ibid, art 4(1)

these measures will be implemented to achieve the quantitative objectives and targets following the timetables set in the NAPs.[1543] These plans should also encourage the development and introduction of IPM and of alternative approaches or techniques to reduce dependency on the use of pesticides.[1544] The Directive's approach is based partly on the precautionary principle.[1545] It is argued that the elements of the Directive have been achieved voluntarily by British farmers through a number of measures, such as continued professional development and regularly testing and maintaining their equipment.[1546]

The Directive does not have any specific targets or objectives for soil protection (Table 5.2.). However, it requires that applied pesticides are targeted as specifically as possible and have the least side effects on humans, non-target organisms and the environment.[1547] As mentioned before, pesticides can have detrimental effects on soils. Thus, it is discussed that the requirement for the Member States to minimise or prohibit the use of pesticides in specific areas[1548] has an impact on soils.[1549] Indeed, through this provision, the Directive is preventing pollution from the irresponsible use of pesticides.[1550] It tackles pesticide pollution from agriculture, especially through the provisions focused on appropriate approaches to application and awareness, limiting emissions to drinking water and applications in sensitive areas and provisions on handling and storage.[1551]

Although the Directive does not contain provisions directly related to soil, it can be argued that it may benefit soils through its clear regulatory framework for the marketing and use of pesticides; its specific focus on human health and the environment, which clearly includes soil protection; and its direct relevance to CAP CC provisions.[1552]

On the other hand, there are challenges in its implementation as the Member States view IPM as an education tool for farmers and have no method in place to assess compliance with IPM principles.[1553] NAPs do not set targets for ensuring national

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[1543] Frelih-Larsen and others (n 40)
[1544] Pesticides Directive (n 1532), art 4(1)
[1545] 'Sustainable use of pesticides' (n 1533)
[1546] Rebecca Lamb, 'Implementing the Sustainable Use Directive – The UK's Voluntary Initiative' (2016) 27 Outlooks on Pest Management 70
[1547] Pesticides Directive (n 1532), annex III (5)
[1548] ibid, art 12
[1549] Paleari (n 49)
[1550] Louwagie and others (n 1168)
[1551] Frelih-Larsen and others (n 40)
[1552] ibid
[1553] European Parliament, 'Report on the implementation of Directive 2009/128/EC on the sustainable use of pesticides' (2017/2284(INI)) <http://www.europarl.europa.eu/doceo/document/A-8-2019-0045_EN.html> accessed 11 October 2019

implementation of the Directive,[1554] as seen in the UK NAP for the Sustainable Use of Pesticides.[1555] Indeed, the UK failed to set high-level measurable targets for pesticide use reduction.[1556] It has been recommended that DEFRA should clarify the definition and practical implementation of IPM through NAP.[1557] In addition, detecting non-compliances are difficult, which limits the enforcement of this instrument.[1558]

Only one ES is directly addressed by the Directive, which is recreation (Table 5.2.), by minimising or prohibiting pesticide use in specific areas.[1559] Additionally, the Directive views soil as a filter for water purification,[1560] thus implicitly contributes to water quality regulation service of soils. Also, by promoting IPM and agricultural practices, such as target specific use of pesticides, habitat and biodiversity (non-target organisms) are being safeguarded.[1561] Lastly, tackling pesticide pollution may contribute to biomass production and biodiversity.[1562]

It can be argued that, considering the aspects mentioned above, Pesticides Directive provides weak protection for soils through its indirect approach (Table 5.2.).

5.2.3.11. Summary

So far, this section has looked at the laws related to soil protection from agricultural pressures. Agriculture is one of the most important economic aspects in the UK and has a particular focus in the existing legislation as agricultural practices in the UK use most of the country's land area. Indeed, European and UK soil protection laws are mostly focused on the impacts of agriculture. Also, the most critical soil degradation processes, namely erosion, organic carbon decline, soil biodiversity decline, compaction, contamination, and salinisation, are closely linked to agriculture.

It is clear that most laws considered in this section are implementation of European legislation. However, there is no specific focus on soil in these instruments. It is argued that soil protection policy is an incoherent by-product of a number of European

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[1554] ibid

[1555] Department for Environment, Food and Rural Affairs, 'UK National Action Plan for the Sustainable Use of Pesticides (Plant Protection Products)' (February 2013) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/221034/pb13894-nap-pesticides-20130226.pdf> accessed 11 October 2019

[1556] European Parliament (n 1553)

[1557] Peter Lundgren, 'Cutting Pesticide Use & Promoting Integrated Pest Management In UK Agriculture – A Farmer's Perspective' (November 2018, *Friends of the Earth*) <https://cdn.friendsoftheearth.uk/sites/default/files/downloads/cutting-pesticide-use-farmers-perspective_1.pdf> accessed 11 October 2019

[1558] Frelih-Larsen and others (n 40)

[1559] Pesticides Directive (n 1532), art 12 (a)

[1560] ibid, recital 15

[1561] Glæsner, Helming and de Vries (n 43)

[1562] Kraemer and others (n 1369)

environmental laws. Indeed, most legal instruments discussed so far, fail to introduce soil specific targets or objectives (Table 5.2.). A few instruments contain direct provisions for soil; however, these are not sufficient for comprehensive soil protection from these pressures (Table 5.2.). Another striking detail is that some agriculture-related soil threats are not considered or even mentioned by any of these legal instruments; namely compaction and salinisation (Table 5.2.). It is clear that most soil threats are linked and this absence in law leads to the fractured protection of soils from other threats that get specific attention in legislation. The fact that these threats are intensified by some agricultural practices requires an additional focus on the limitations and restrictions of the use of some procedures. Some of these practices are repeatedly considered by law, such as use of fertilisers, whilst others not as frequently, such as tillage (Table 5.2.).

Considering soil ES, some legislative instruments directly and explicitly mention a number of ES (Table 5.2.). It is argued that addressing these individually in various directives fails to account for the multifunctionality of soils. For example, while provisioning and regulating ES are the most addressed ones, such as food production, biodiversity and water storage, water quality regulation and water supply regulation; most supporting and cultural services are not directly mentioned as often (Table 5.2.). Indeed, this analysis revealed that no supporting and cultural services was directly referred to, other than cultural and natural heritage (Table 5.2.).

In addition to the explicit references in the legal texts, some ES can be protected as an expected outcome of the adoption of the legislative instruments as mentioned above. The most common implicitly protected ES are provisioning (biodiversity and biomass production) and regulating services (water quality and water supply regulation). On the other hand, although nutrient cycling and primary production are commonly mentioned in an implicit manner, most cultural services are not protected adequately. Overall, some soil ES are not covered in legislation at all, threatening the continuous flow of these crucial benefits.

5.3. Industrial Activities and Waste Management

5.3.1. Industrial Activities and Waste Management in the United Kingdom

Industrialisation has a significant role in the economic growth and development of a country. Historically speaking, high-income countries have focused more on industrial development rather than supporting natural resources in order to eliminate poverty. Indeed, industrialisation maintains a steady increase in national income, which stimulates economic stability and leads to improved life standards.

In the UK, the second biggest pressure on soils stems from industrial activities and waste management. Humans rely upon the provision of raw materials for industrial development, which puts more pressure on NC.[1563] Besides, industrial activities generate a significant share of the overall pollution due to their emissions of air pollutants, discharges of wastewater and the generation of waste.[1564] The accumulation of industrial waste should be managed properly to overcome the detrimental impacts on the environment.[1565] There are other categories of waste, such as household waste, sewage and commercial industries. In 2016, the UK generated 221.0 million tonnes of total waste, with England responsible for 85% of the UK total.[1566]

5.3.2. Directly Related Threats

The most relevant threat to industrial activities and waste management is pollution as a result of traditional and unsustainable management and disposal methods.[1567] Also, compaction can be seen as a relevant pressure on soils that are affected by industrial activities where heavy machinery is used.[1568]

5.3.2.1. Pollution

As mentioned in chapter three, when contamination reaches a point where it becomes a risk to soils, pollution occurs which poses a significant threat to soil quality. Thus, the actual threat is pollution rather than contamination but, in the UK, the concept of contaminated land is commonly used by the legislatures, e.g., in EPA 1990.

It is apparent that contamination can appear as an impact of urbanisation (e.g., landfills, waste management or industrial activities).[1569] Indeed, alongside with agriculture, industrial land use and operations generate a high level of contamination.[1570] The most important sources of contamination in soils are seen as those connected with anthropogenic activities,[1571] such as point pollution due to metal mining and smelting,

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[1563] HM Government, 'Our Waste, Our Resources: A Strategy for England' (2018) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/765914/resources-waste-strategy-dec-2018.pdf> accessed 13 June 2020

[1564] European Commission, 'The Industrial Emissions Directive' (*Environment*, 7 August 2019) <https://ec.europa.eu/environment/industry/stationary/ied/legislation.htm> accessed 3 February 2020

[1565] HM Government (n 1563)

[1566] Department for Environment, Food and Rural Affairs, 'UK Statistics on Waste' (19 March 2020) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/874265/UK_Statistics_on_Waste_statistical_notice_March_2020_accessible_FINAL_rev_v0.5.pdf> accessed 14 June 2020

[1567] HM Government (n 1563)

[1568] Muhammad Farrakh Nawaz, Guilhem Bourrié and Fabienne Trolard, 'Soil compaction impact and modelling. A review' (2013) 33 Agronomy for Sustainable Development 291

[1569] Stolte and others (n 20)

[1570] Gregory and others (n 731)

[1571] Brian J. Alloway, 'Sources of heavy metals and metalloids in soils' in Brian J. Alloway (ed), *Heavy metal in soils – Trace metals and metalloids in soil and their bioavailability* (3rd edn, Springer 2013) industrial production, waste disposal and diffuse pollution by industrial activities, car emissions, application of agrochemicals and manure containing veterinary drugs.[1572] Pollution occurs due to aggressive industrial and economic activities, which results in the introduction of several chemicals into the soil: heavy metals, coal tars, oils and fuel, chemical substances and compounds, toxic materials (e.g., asbestos, silica) and radioactive by-products.[1573] Therefore, contaminated land is generally found around heavy industrial sites (e.g., factory, mills, refineries), large farms with high and extended use of chemical fertilisers, ancient and modern mines, power plants, military testing sites, and landfills.[1574]

These soils can be degraded as a result of contamination and removal or burial of the soil.[1575] Commonly, the treatment of contaminated sites often involves digging out contaminated soils and disposing of them in landfill.[1576] This practice merely involves moving the problem somewhere else.[1577] Some soils can now be remediated on site,[1578] which is more costly and time-consuming; however, eventually more sustainable in the long term as it preserves the soil resource.[1579]

Industrial land use resulting from the abovementioned activities can be seen as storing and disposal of waste and chemicals, accidents, spills and the demolition of buildings that contained toxic substances cause contamination by heavy metals, hydrocarbons and pathogens.[1580] Although the UK legislation gives the weight to historic sources of contamination, there are also issues related to ongoing contamination from continuing operations.[1581] Buildings demolished without the environmental safety regulations and materials and toxic elements disposed on site (e.g., cadmium, arsenic and lead) can be detrimental to human health.[1582]

Waste management also should be taken into consideration when determining soil pollution as a high level of pollutants are introduced to soils through waste disposal.[1583] The most common disposal method in the UK is landfill. Incineration, anaerobic

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[1572] Stolte and others (n 20)
[1573] Muhammad Aqeel Ashraf and others, 'Soil Contamination, Risk Assessment and Remediation' in Hernandez-Soriano M C (ed), *Environmental Risk Assessment of Soil Contamination* (IntechOpen 2014)
[1574] ibid
[1575] 'UK Soil Degradation' (n 751)
[1576] ibid
[1577] ibid
[1578] ibid
[1579] ibid
[1580] ibid
[1581] Bell (n 27)
[1582] 'More action required to protect UK soil health' (*www.parliament.uk*, 2 June 2016) <https://old.parliament.uk/business/committees/committees-a-z/commons-select/environmental-audit-committee/news-parliament-2015/soil-health-report-published-16-17/> accessed 15 July 2021
[1583] Ashraf and others (n 1573)

digestion and other disposal methods are also used. It is estimated that each year 111 million tonnes, or 57%, of all UK of controlled waste (household, commercial and industrial waste) are disposed of in landfill sites.[1584] In addition, some waste from sewage sludge is placed in landfill sites, along with waste from mining and quarrying.[1585] Therefore, it is clear that landfills contribute to soil contamination at high levels if poorly designed.

There is another growing concern related to soil pollution as a result of electronic waste (e-waste) in dumpsites.[1586] It was found that there are concentrations of heavy metals in soils at various depths and distances away from the e-waste dumpsites, which mostly impact topsoil.[1587] It is argued that even high income nations with well-established waste management systems are struggling with the complex nature of e-waste.[1588] It was found that the UK produces 24.9 kg of e-waste per person, higher than the EU average of 17.7 kg.[1589] This trend shows that waste problems are not limited to traditional practices, and can be worsened due to development and technological advancements.

Overall, these numbers and stats show that contamination due to industrial activities and waste management are critical issues in the UK and the UK's industrial heritage has led to hundreds of thousands of sites across the country being polluted.[1590] The House of Commons Environmental Audit Committee stated that around 300,000 hectares of soil are affected by historic contamination from the UK's industrial past.[1591]

5.3.2.2. Compaction

In addition to contamination, compaction is another serious threat as a result of these pressures. Besides agricultural practices, such as tillage, wheel traffic from machinery and heavy livestock, the utilisation of heavy machinery in industrial activities, such as excavators, can lead to compaction. The adverse impact of brownfield development (the further development of developed land previously used for commercial

1584 Department for Environment, Food and Rural Affairs (n 1566)
1585 ibid
1586 Oladunni Bola Olafisoye, Tejumade Adefioye and Otolorin Adelaja Osibote, 'Heavy Metals Contamination of Water, Soil, and Plants around an Electronic Waste Dumpsite' (2013) 22 Pol. J. Environ. Stud. 1431
1587 ibid
1588 Keshav Parajuly and others, 'Future E-Waste Scenarios' (2019) <http://www.step-initiative.org/files/_documents/publications/FUTURE%20E-WASTE%20SCENARIOS_UNU_190829_low_screen.pdf> accessed 20 January 2020
1589 'Waste statistics - electrical and electronic equipment' (*Eurostat*) <https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Waste_statistics_-_electrical_and_electronic_equipment#Electronic_equipment_.28EEE.29_put_on_the_market_and_WEEE_collected_by_country> accessed 15 July 2021
1590 'More action required to protect UK soil health' (n 1582)
1591 House of Commons Environmental Audit Committee, *Soil Health* (HL 2016-17, 180)

or industrial purposes) on soils and soil properties is extensive.[1592] In the UK, most brownfield developments include the restoration to a green after-use of mineral operations, landfill sites and underground infrastructure networks.[1593] In these cases, the success of green after-use is dependent on how the soil was removed, stored and reinstated prior to, during and following the industrial use.[1594] The removal and storage of soil frequently have harmful effects on soil physical properties, including structure loss and compaction.[1595] Where brownfield development results in a non-green after-use, soil can be removed permanently, which causes all soil functions to be lost.[1596] Moreover, when subsoil in industrial and construction sites are compacted, adding back the topsoil that was removed will not restore the soil or soil functions.[1597]

The next section will discuss the legal instruments that regulate industrial activities and waste management and seek to critically analyse whether they effectively protect soils.

5.3.3. Legal Analysis – Industrial Activities and Waste Management

Although the EU mentions the importance of eliminating the threats of contamination, it fails to address compaction in its imperative documents, the Roadmap to a Resource Efficient Europe[1598] and the 7th EAP.[1599] European law does not address the threat of compaction in a direct manner either; however, contamination from waste management and industrial activities is dealt with in a number of legislative instruments, which will be discussed below.[1600] As mentioned before, the Roadmap to a Resource Efficient Europe encourages the Member States to establish an inventory of contaminated sites, and a schedule for remedial work by 2015.[1601] These vague provisions are merely in the form of non-binding recommendations.

Another non-binding document in the European environmental policy is EAP, which does not set any mandatory requirements for the Member States. It emphasises that, as mentioned before, addressing pollution is crucial for the Member States.[1602] It also urges the integration of consideration on water protection and biodiversity

[1592] Gregory and others (n 731)
[1593] ibid
[1594] ibid
[1595] ibid
[1596] ibid
[1597] Environment Agency (n 752)
[1598] Commission (n 1046)
[1599] Environment Action Programme (n 1051)
[1600] Glæsner, Helming and de Vries (n 43)
[1601] Commission (n 1046)
[1602] Environment Action Programme (n 1051)

conservation into decisions relating to land use supporting the objective of 'no net land take' by 2050,[1603] which is likely to impact soil protection.

The UK recognises the importance of ensuring better soil management during these industrial activities and waste management practices.[1604] The Plan recognises that better waste management on land will prevent waste reaching waterbodies and a joint land-marine approach is needed.[1605] This objective can contribute to the protection of soils from potential impacts of waste management; however, it is not a refined and direct approach to tackling soil pollution.

The Construction Code of Practice for the Sustainable Use of Soils on Construction Sites offers a number of good practice methods to avoid or minimise compaction,[1606] though this document is a more relevant to construction development and will be discussed in the relevant section. The UK government also recognised compaction as one of the main threats, alongside erosion and SOM loss.[1607] Besides, the Plan acknowledges compaction as a serious threat to soil health and aims to reverse the current trends.[1608] Nonetheless, these documents are not legally binding.

The most important binding legal instruments in the UK dealing with contaminated land are EPA[1609] for identification and remediation; and the Environmental Damage Regulations 2015,[1610] which implements the European Environmental Liability Directive for prevention and remediation in the most serious cases. These instruments will be discussed in this section.

5.3.3.1. Part IIA of the Environmental Protection Act

Contaminated land in the UK is a legacy of historical industrial activities and waste disposal practices.[1611] Indeed, the UK has been specifically focused on historic contamination.[1612] However, it is worth noting that the ongoing operations also create contamination, which leads to a serious issue.[1613]

1603 ibid
1604 Department for Environment, Food and Rural Affairs (n 53)
1605 HM Government (n 803)
1606 Department for Environment, Food and Rural Affairs (n 823)
1607 Department for Environment, Food and Rural Affairs (n 53)
1608 HM Government (n 803)
1609 Environmental Protection Act 1990
1610 Environmental Damage (Prevention and Remediation) (England) Regulations 2015, SI 2015/810
1611 'Development on Potentially Contaminated Land and/or for a Sensitive End Use – Technical Guide for Planning Applicants and Developers' (September 2018) <https://www.hertsmere.gov.uk/Documents/04-Environment-Refuse--Recycling/Environmental-Health/Pollution-Control/Herts-and-beds-guidance-revision-2018.pdf> accessed 4 May 2020
1612 Bell (n 27)
1613 ibid

Most soils contain different levels of contaminants. Though, some soils pose an unacceptable level of risk.[1614] These areas are mostly seen as former landfills or past industrial sites.[1615] As mentioned, a piece of land can be considered as contaminated land, merely if it poses such an unacceptable level of risk.[1616]

Part IIA of EPA deals with the identification and remediating contaminated land in the UK where it poses abovementioned unacceptable risk levels, which is a directly soil relevant objective.[1617] This regime is clearly not preventative addressing soil threats. Rather, this law comprises of details, such as liability (i.e., the responsible person for contamination).[1618]

The Act contains several direct references to contaminated land. It defines the concept: Any land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land, that significant harm is being caused or there is a significant possibility of such harm being caused; or significant pollution of controlled waters is being caused or there is a significant possibility of such pollution being caused.[1619]

It also defines harm and ecological harm as harm to the health of living organisms or other interference with ecological systems of which they form part and, in the case of man, includes harm to his property.[1620]

The definition of contaminated land implies that for the land to be considered as contaminated land under Part IIA, three elements of a contaminant linkage (i.e., contaminant, receptor and pathway) must exist in relation to that land, as well as evidence of the actual presence of contaminants.[1621] A contaminant is a substance which is in, on or under the land and which has the potential to cause significant harm to a relevant receptor, or to cause significant pollution of controlled waters.[1622] A receptor is something that could be adversely affected by a contaminant through a pathway.[1623] Therefore, contaminated land causes or may cause a significant risk of significant harm to a number of specified receptors.[1624] These receptors can be human health, controlled waters, property, livestock and crops, and ecological systems.[1625]

[1614] Department for Environment, Food and Rural Affairs (n 833)
[1615] ibid
[1616] ibid
[1617] Environmental Protection Act (n 1609), part IIA
[1618] Bell (n 27)
[1619] Environmental Protection Act (n 1609), s 78A (2)
[1620] Environmental Protection Act (n 1609), s 78A (4)
[1621] Department for Environment, Food and Rural Affairs (n 833)
[1622] ibid
[1623] ibid
[1624] ibid
[1625] ibid

In terms of non-human receptors, the guidance provides two tables relevant to the classification.[1626] The first table provides that any ecological system, or living organism forming part of such a system, within a location which is subject to statutory protection.[1627] Ecological systems are classified as receptors only if they are under a statutory protection (such as Special Areas of Conservation, potential Special Protection Areas and Ramsar sites).[1628] This restriction hinders effective soil protection as it leads to a situation where some former industrial sites or landfills with high levels of soil pollution may not fall under the scope of this law only because they are not within the boundaries of a protected area. Hence, these areas will not be subject to remediation and the ecological system will remain impacted.

Part IIA also regulates the legal and financial responsibility for the remediation of land. The polluter must pay to remediate the contamination. The polluter is the person who caused or knowingly permitted each linkage in terms of section 78F (2) of Part IIA (who the Statutory Guidance refers to as Class A persons).[1629] If Class A persons cannot be found, the owners or occupiers of the land in terms of section 78F(4) of Part IIA (Class B persons) will be identified and found liable.[1630] This regime was found highly complex and difficult to implement or enforce effectively or efficiently.[1631] The liability system was argued to be designed to transfer the liability of the actual polluter to others who purchase the land, which had already been contaminated before.[1632] A knowing permitter is a person who is aware of the contamination at a site, has the power to remediate it; however, fails to do so after a reasonable opportunity.[1633] It is questionable whether this approach is in line with the overarching environmental law principle of polluter pays.[1634]

As implied above, local councils play a fundamental role within this system by providing reports to the Environment Agency, which obtained broad regulatory powers to manage soil-contamination related issues under EPA. Every local council is under the duty of developing a strategy to identify all contaminated sites within their region.[1635] In cases where contamination is determined to be significant, the council is under the duty of taking action to eliminate or diminish the risk to the natural environment and local

[1626] ibid
[1627] ibid
[1628] ibid
[1629] ibid
[1630] ibid
[1631] Valerie Fogleman, 'The Contaminated Land Regime: Time for a Regime That Is Fit for Purpose (Part 1)' (2014) 6 IJLBE 43
[1632] ibid
[1633] ibid
[1634] Emma Lees, 'Interpreting the Contaminated Land Regime: Should the 'Polluter' Pay?' (2012) 14 Env L Rev 98
[1635] Department for Environment, Food and Rural Affairs (n 833)

people.[1636] The regime's operation has been questioned, as regulators are burdened by a noteworthy lack of resource.[1637] Their limitation is mainly due to the lack of technical expertise and financial incompetency.[1638] Indeed, these authorities cannot afford to clean up land at a faster rate.[1639] On the other hand, they are still reluctant to recover their costs from Class B persons.[1640] Enforcing authorities believe that the homeowners under these circumstances are innocent and should not to bear the burden of remediation.[1641] This is an important reason behind the lack of resources.[1642] Besides the lack of financial competency, local authorities with the primary role and regulatory duties under this regime also lack the necessary technical knowledge to deal with contaminated land cases.[1643]

When analysing this Act, this regime's capacity for protecting the multi-functionality of soil should also be discussed. The Act does not directly mention any soil functions or ES (Table 5.2.). It can indirectly foster soil biodiversity, refugia and primary production by addressing contamination issues. Soil multifunctionality is not the primary consideration under this law as this regime pushes a 'development managerialist' approach to contaminated land, rather than handling it as a matter of environmental quality or public health.[1644] This perspective considers that contamination poses health and environmental problems, but frames the problem in economic terms, as an obstacle to economic development.[1645]

Also, under this regime, remediation of a site may impact the survival of species that have adapted to the conditions at that site, such as arsenic tolerance in earthworms at mine spoil sites in the UK.[1646] Where remediation activity causes more harm than no remediation, it affects functioning of ecosystems.[1647] Thus, the regime fails to consider the fact that preservation of function has a substantial importance for terrestrial ecosystem protection.[1648]

[1636] ibid
[1637] Lloyd Andrew Brown, 'The contaminated land regime and austerity' (2016) 3 IJLBE 210
[1638] ibid
[1639] Lees (n 1634)
[1640] ibid
[1641] ibid
[1642] ibid
[1643] Brown (n 1637)
[1644] Philip Catney and others, 'Dealing with Contaminated Land in the UK through 'Development Managerialism'' (2006) 8 Journal of Environmental Policy and Planning 331
[1645] ibid
[1646] R. Smith and others, 'Assessing significant harm to terrestrial ecosystems from contaminated land' (2005) 21 Soil Use & Management 527
[1647] ibid
[1648] ibid

Overall, the introduction of Part IIA has not halted the issues related land contamination stemming from the planning process. It is expected that contamination issues will continue to threaten the UK soils, as the government policy encourages the redevelopment of brownfield sites without introducing a robust legal system that would consider protecting soil functions and ES.[1649] Considering this, it can be concluded that the Act provides weak protection for soils (Table 5.2.).

5.3.3.2. Environmental Liability Directive

Environmental Liability Directive (ELD) is the first polluter pays regime created under European law.[1650] It sets out the rules for this principle.[1651] A company causing environmental damage is liable for the damage, thus must take all the necessary preventive or remedial steps and bear the related costs.[1652] For liability, the Directive does not require fault or negligence of the operator.[1653] Thus, strict liability applies to land and water damage and biodiversity damage caused by the occupational activities listed in Annex III of the Directive.[1654] These activities are potentially damaging to the environment,[1655] e.g., energy industries, production and processing of metals, mineral industries, chemical industries and waste management.[1656] When operators carry out occupational activities other than those listed in Annex III, they can still be liable for damages to protected species or natural habitats.[1657] However, this approach is rather fault-based, which requires a causal link between the activity and the damage to be established.[1658] Besides, where environmental damage has not yet occurred, but there is an imminent threat of such damage, the operator shall take the necessary preventive measures without delay. In certain cases, there is a requirement to inform the competent authority of all relevant aspects of the situation.[1659]

1649 'Development on Potentially Contaminated Land and/or for a Sensitive End Use – Technical Guide for Planning Applicants and Developers' (n 1611)
1650 Valerie Fogleman, 'Enforcing the Environmental Liability Directive: Duties, Powers and Self-Executing Provisions' (2006) 4 Env. Liability 127
1651 Environmental Liability Directive (n 813), art 1
1652 'The polluter-pays principle and environmental liability' (*EUR-Lex*, 5 October 2016) <https://eur-lex.europa.eu/legal-content/EN/LSU/?uri=CELEX:02004L0035-20130718> accessed 3 June 2020
1653 'Environmental Liability Directive: A Short Overview' <https://ec.europa.eu/environment/legal/liability/pdf/Summary%20ELD.pdf> accessed 24 January 2020
1654 'Background' (*www.parliament.uk*, 12 July 2007) <https://publications.parliament.uk/pa/cm200607/cmselect/cmenvfru/694/69405.htm> accessed 24 January 2020
1655 ibid
1656 Environmental Liability Directive (n 813), art 3(1)
1657 'Environmental Liability' (*Environment*, 11 September 2019) <https://ec.europa.eu/environment/legal/liability/index.htm> accessed 24 January 2020
1658 Environmental Liability Directive (n 813), art 3(1); ibid
1659 Environmental Liability Directive (n 813), art 6

The UK implementation of the Directive (Table 5.3.) relates to the prevention and remediation of environmental damage in the most serious cases in the UK.[1660] The primary enforcing authority is the relevant local authority,[1661] which carries the duty of inspecting their risk areas to identify contaminated land.[1662] Operators, as mentioned before, are under the responsibility of taking all practicable steps to prevent environmental damage in case there is an imminent threat of damage.[1663] For environmental damage that has already occurred, the operator must prevent further damage.[1664] In case the regulator decides that environmental damage has occurred, it can serve a remediation notice on the liable operator to establish the measures that must be taken.[1665] If there is a possibility of a new development on contaminated land, then planning authorities can impose conditions in the planning permission that require remediation before the development.[1666] If the developer does not comply with conditions, this will be a criminal offence punishable by a fine.[1667] So, the remediation liability is on those who caused or knowingly permitted the contamination.[1668] If these cannot be found, liability passes to the owners of the land, regardless of whether they were responsible for the contamination under EPA rules mentioned above.[1669]

The Directive defines the concept of environmental damage, including damage to protected species and natural habitats, which is any damage that has significant adverse effects on reaching or maintaining the favourable conservation status of such habitats or species,[1670] water damage, which is any damage that significantly adversely affects the ecological, chemical and quantitative status and ecological potential.[1671] Besides, it covers land damage, which is any land contamination that creates a significant risk of human health being adversely affected as a result of the direct or indirect introduction, in, on or under land, of substances, preparations, organisms or micro-organisms.[1672] A mandatory risk-assessment procedure considers the characteristic and function of the soil, the type and concentration of the harmful substances, preparations, organisms or micro-organisms, their risk and the possibility of their dispersion.[1673]

[1660] Stankovics, Tóth and Tóth (n 804)
[1661] Environmental Damage (Prevention and Remediation) (England) Regulations (n 1610), regs 10 and 11
[1662] Stankovics, Tóth and Tóth (n 804)
[1663] Environmental Damage (Prevention and Remediation) (England) Regulations (n 1610), reg 13(1)
[1664] ibid, reg 14(1)
[1665] ibid, reg 13(2)
[1666] Stankovics, Tóth and Tóth (n 804)
[1667] ibid
[1668] ibid
[1669] ibid
[1670] Environmental Liability Directive (n 813), art 2(1)(a)
[1671] ibid, art 2(1)(b)
[1672] ibid, art 2(1)(c)
[1673] ibid, annex II

ELD's scope was found to be different from most environmental liability regimes that focus on the remediation of previously occurred environmental damage rather than preventing and remediating new damage.[1674] These also tend to consider pollution rather than other types of environmental damage.[1675] These aspects make ELD's scope much broader than other liability systems. Clearly, ELD has a focus on remedying of environmental damage through the restoration of the environment.[1676] This objective can be achieved by replacing damaged natural resources by identical, equivalent or similar natural components.[1677] If measures taken on the impacted site do not return to the baseline condition, complementary measures can be taken elsewhere.[1678] ELD's strengths stem from the implementation of the polluter pays principle and the ecosystem approach to remediation.[1679] Also, as mentioned, it is significant due to the fact that it has introduced a requirement for compensatory remediation where there is environmental damage.[1680]

The Directive does not have any direct or specifically soil-related targets or objectives (Table 5.2.); however, it has a direct and explicit link to point source contamination as it is focused on local emissions of pollutants that change the status of land.[1681] This aspect makes the instrument highly relevant to growing attention around emissions to land and addressing emissions where a change in the status occurs.[1682] ELD also has an indirect and implicit link to diffuse contamination.[1683] It intends to reduce incidents and ensure remediation of emissions both to land and water.[1684] Eventually, this aspect is expected to support reductions in diffuse pollution levels.[1685]

The Directive has a considerable impact on soil protection.[1686] Yet, environmental damage only covers land contamination that has an impact on human health.[1687] Unless soil degradation creates such a risk for human health, the provisions will not be relevant

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1674 Valerie Fogleman, 'The duty to prevent environmental damage in the environmental liability directive; a catalyst for halting the deterioration of water and wildlife' (2019) <https://link.springer.com/content/pdf/10.1007/s12027-019-00586-6.pdf> accessed 24 January 2020
1675 ibid
1676 'Environmental Liability Directive: A Short Overview' (n 1653)
1677 ibid
1678 ibid
1679 'Environmental Liability Directive 2004/35/EC- UK report to the European Commission on the experience gained in the application of the Directive' <https://ec.europa.eu/environment/legal/liability/pdf/eld_ms_reports/UK.pdf> accessed 24 January 2020
1680 ibid
1681 Frelih-Larsen and others (n 40)
1682 ibid
1683 ibid
1684 ibid
1685 ibid
1686 Paleari (n 49)
1687 European Commission, 'Soil protection – The story behind the Strategy' (2006) <https://ec.europa.eu/environment/archives/soil/pdf/soillight.pdf> accessed 20 September 2019

to the purposes of this Directive.[1688] Environmental damage covers only the most serious cases, which is expected to cover less than 1% of the total number of cases of damage in England and Wales. It is significant that the damage to soils is not always noticeable or detectable in a short period of time, which means that the damage can create several human health related issues in the long run. Therefore, this Directive is not completely focused on determining or preventing soil degradation. Also, damage to protected species and natural habitats are under the scope of environmental damage under ELD, as seen in EPA, if these are already protected. In addition, ELD covers damage to soil from contamination and biodiversity decline,[1689] but only if occurred after the implementation time.[1690] It does not apply to historical contamination or to damage prior to its entry into force.[1691] According to the Directive, it is merely applicable to the pollution events that occurred after April 2007, which leaves the question unanswered as to how the Member States should deal with pollution that has occurred before this date.[1692] Also, it applies to pollution resulting only from specified occupational activities. These aspects weaken the effectiveness of the instrument from a soil protection point of view.

There is also inconsistency among the Directive's implementation by the Member States, such as in the thresholds for triggering preventative measures.[1693] Also, the Directive refers to 'land' rather than 'soil'.[1694] Land contamination and remediation are subtly different from those focused on soil and the protection of soil functions and services.[1695] Although when translated in different languages, these may be used interchangeably, this aspect may come across as another reason of the inconsistent implementation in different Member States.[1696]

It is argued that the polluter pays regime in the Directive is not straightforward as assigning liability on soil contamination cases is not always simple.[1697] It is rather complex as different countries adopt different approaches to assign legal responsibilities and to address soil remediation in terms of funding (combining private and public funding).[1698] In the UK, for example, the largest proportion of land development and

[1688] Irene L. Heuser, 'Milestones of Soil Protection in EU Environmental Law' (2006) 3 JEEPL 190
[1689] Glæsner, Helming and de Vries (n 43)
[1690] Paleari (n 49)
[1691] European Commission (n 1687)
[1692] Frelih-Larsen and others (n 40)
[1693] ibid
[1694] ibid
[1695] ibid
[1696] ibid
[1697] Rodrigues and others (n 1424)
[1698] ibid

remediation projects are driven and funded by the private sector.[1699] Indeed, the ELD leaves a significant discretion for implementation.[1700]

The Directive does not contain any mention of soil ES directly; however, it has indirect effects on a number of soil ES through implicit references. The first can be seen as refugia as the Directive has several references to habitat protection and damage to protected species and natural habitats are within the scope of environmental damage.[1701] Besides, by reducing pollution incidents, the Directive can indirectly contribute to some ES, namely platform for human activities, filtering and regulating water and nutrient cycling.[1702]

Unlike most of the European soil laws that aim only at preventing acceleration of soil contamination, it addresses remediation of new problems of contaminated soil and land damage.[1703] Indeed, ELD introduced a clear framework for land protection, which inevitably results in soil protection.[1704] Especially, the installations found in Annex III contributed to this outcome.[1705] The binding requirements for polluters to address emissions to land help enhancing soil quality.[1706] Additionally, the requirements to protect biodiversity and water indirectly benefit soil protection.[1707] Overall, ELD can be seen as a modest legal instrument considering the level of protection it offers for soils (Table 5.2.).

5.3.3.3. Industrial Emissions Directive

Another key instrument that regulates industrial activities is the Industrial Emissions Directive.[1708] It aims to reduce harmful industrial emissions across Europe, precisely through better application of Best Available Techniques (BAT).[1709] BAT is defined as the most effective and advanced stage in the development of activities and their methods of operation, which indicates the practical suitability of particular techniques for providing the basis for emission limit values and other permit conditions

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1699 ibid
1700 House of Commons Environment, Food and Rural Affairs Committee, 'Implementation of the Environmental Liability Directive – Sixth Report of Session 2006–07' (12 July 2007) <https://publications.parliament.uk/pa/cm200607/cmselect/cmenvfru/694/694.pdf> accessed 18 June 2020
1701 Environmental Liability Directive (n 813), arts 2(1), 3
1702 Frelih-Larsen and others (n 40)
1703 Glæsner, Helming and de Vries (n 43)
1704 Frelih-Larsen and others (n 40)
1705 ibid
1706 ibid
1707 ibid
1708 European Commission (n 1564); Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) [2010] OJ L 334/17, art 1 (hereinafter 'Industrial Emissions Directive')
1709 European Commission (n 1564)

designed to prevent and, where that is not practicable, to reduce emissions and the impact on the environment as a whole.[1710]

A significant feature of the Directive is its integrated approach.[1711] The permit that is required for certain activities must consider the whole environmental performance of the plant, covering emissions to air, water and land, generation of waste, use of raw materials, energy efficiency, noise, prevention of accidents, and restoration of the site upon closure.[1712] By using this approach, the Directive aims to prevent the scattered approach that controls emissions into air, water or soil separately.[1713] This approach encourages shifting of pollution from one environmental medium to another rather than protecting the environment as a whole.[1714] So, the objective is to prevent pollution at source, rather than shifting it.

The Directive has a specific aim of preventing industrial pollution on 'land', which would cover 'soil'.[1715] The individual chapters found in the Directive are for major types of industrial installations, which is relevant to soil protection, as the pollution risk can be limited by regulating industrial activities and requiring these activities to abide by permits.[1716] However, this soil component is not necessarily given priority.[1717]

Remarkably, this Directive is the only legislative piece in the EU that defines soil.[1718] This definition is important for preventing the risk that soil-related provisions are interpreted and implemented in an inconsistent way across European countries.[1719] There are further direct references to soils, regarding permit requirements and emission limit values,[1720] site closure[1721] and delivery of waste to incinerators.[1722] Arguably, the Directive aims to address soil pollution in a direct manner.[1723] It addresses the prevention of emissions from entering soil.[1724] The no-degradation approach to soil resources with a duty of remediation were incorporated in this Directive.[1725]

Besides, the Directive has requirements for soil monitoring and baseline reporting at industrial installations. An installation is a stationary technical unit within which one

[1710] Industrial Emissions Directive (n 1708), art 3(10)
[1711] European Commission (n 1564)
[1712] ibid
[1713] Industrial Emissions Directive (n 1708), recital 3
[1714] ibid, recital 3
[1715] Frelih-Larsen and others (n 40)
[1716] ibid
[1717] ibid
[1718] Industrial Emissions Directive (n 1708), art 3(21)
[1719] Paleari (n 49)
[1720] Industrial Emissions Directive (n 1708), art 14 and annex II
[1721] ibid, art 22
[1722] ibid, art 52
[1723] Glæsner, Helming and de Vries (n 43)
[1724] ibid
[1725] Kibblewhite, Miko and Montanarella (n 38)

or more activities listed in Annex I or in Part 1 of Annex VII are carried out, and any other directly associated activities on the same site which have a technical connection with the activities listed in those Annexes and which could have an effect on emissions and pollution.[1726] The Directive's effectiveness have been strengthened through the requirement for a baseline report assessing the state of soil and groundwater contamination in the application for a permit.[1727] This report produced at the start of operations enables a quantified comparison with the conditions of the site once activities end.[1728] The report also helps determine the operators' legal obligations of restoring the site to its former state or mitigating any significant risks to human health or the environment.[1729]

From a soil threats perspective, it is clear that the Directive explicitly addresses both diffuse and point source contamination by requiring the management of installations (Table 5.2.).[1730] In addition, its provisions on biowaste can promote alternative solutions for soil fertility, potentially addressing SOM-related issues.[1731]

The Directive does not have any direct references to soil ES listed in Table 3.1. (Table 5.2.). On the other hand, controlling emissions and pollution from installations may indirectly contribute to carbon sequestration, soil biodiversity[1732] and nutrient cycling.[1733] Also, it can be assumed that controls for inputs from installations to soil can contribute to the structure of soil that would support human occupation (platform).[1734]

The Directive is potentially an effective instrument for soil protection considering its integrated approach and its requirements for full environmental assessment, operation to BAT, and clear enforcement procedures.[1735] Also, the provisions on site closure[1736] paved the way for the Member States to adopt a system of background reports that show the state of soils and contamination.[1737]

The Directive also shows some weaknesses regarding diffuse emission sources.[1738] First of all, BATs are found difficult for operators to define in the case of diffuse sources, which eventually causes problems for regulators to set out permit

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[1726] Industrial Emissions Directive (n 1708), art 3(3)
[1727] ibid, art 12(1)(e)
[1728] Bettina Lange, 'The EU Directive on Industrial Emissions: Squaring the Circle of Integrated, Harmonised and Ambitious Technology Standards?' (2011) 13 Env L Rev 199
[1729] ibid
[1730] Frelih-Larsen and others (n 40)
[1731] ibid
[1732] ibid
[1733] Glæsner, Helming and de Vries (n 43)
[1734] Frelih-Larsen and others (n 40)
[1735] ibid
[1736] Industrial Emissions Directive (n 1708), art 22
[1737] Frelih-Larsen and others (n 40)
[1738] ibid

conditions.[1739] Monitoring diffuse sources is another area that may generate problems as these may not always be precise.[1740] Weak monitoring can lead to non-compliances and operators may wish not to disclose pollution incidents.[1741]

It can be concluded that the Directive potentially provides strong soil protection through its soil related objectives and references (Table 5.2.).

5.3.3.4. Waste Framework Directive

When waste management facilities are uncontrolled, it becomes a critical source of local soil pollution, thus proper waste management is critical for soil protection. Waste Framework Directive[1742] presents a number of basic waste management principles. It regulates the Member States' requirement to take necessary measures to ensure that waste management is carried out without risking environmental media including soils.[1743] Therefore, it can be argued that it has direct reference to soil protection.[1744]

The Directive contains provisions for waste disposal and recovery. The recycling and re-use of contaminated wastes may indirectly contribute to a more sustainable remediation of contaminated sites and for the prevention of soil contamination.[1745] It can be argued that the Directive's waste management measures are explicitly linked to addressing diffuse and point source contamination as these measures should take into account soil protection.[1746] Indeed, the Directive contains clear provisions for waste management facilities to operate with the consideration of protecting soils.[1747] Another strength of the Directive is that standards may be set to ensure effective soil protection. It also contains provisions about biowaste, which have the potential to encourage alternative solutions for soil fertility that could address SOM loss.[1748] However, it is uncertain whether the soil related provisions have been considered in regulatory decisions at Member State levels.[1749] It is important to add that although waste control is specifically designed for soil protection under the Directive, the legal instrument does not include any soil protection targets or objectives (Table 5.2.).

[1739] ibid
[1740] ibid
[1741] ibid
[1742] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives [2008] OJ L 312/3 (hereinafter 'Waste Framework Directive')
[1743] ibid, art 13
[1744] Paleari (n 49)
[1745] Rodrigues and others (n 1424)
[1746] Frelih-Larsen and others (n 40)
[1747] ibid
[1748] ibid
[1749] ibid

From a soil ES perspective, the Directive does not explicitly mention soil ES in its text (Table 5.2.). However, there is indirect and implicit consideration of several services. To start with, controlling pollutant inputs from waste management activities to soil is expected to contribute to soil structure and inevitably platform service of soils.[1750] Also, as waste management measures should not put soils and animals at risk,[1751] it should protect soil biodiversity and refugia. Additionally, it indirectly contributes to nutrient storage function of soils which supports nutrient cycling ES.[1752]

Considering these arguments, the Directive comes across as a weak legal instrument for soil protection (Table 5.2.).

5.3.3.5. Landfill Directive

The requirements of the Waste Framework Directive are supplemented by the Landfill Directive.[1753] The Directive's overall objective is to prevent or reduce, particularly, the pollution of surface water, groundwater, soil and air, and on the global environment, including the greenhouse effect, as well as any resulting risk to human health, from landfilling of waste, during the whole life-cycle of the landfill.[1754] This objective is to be achieved through strict operational and technical requirements on waste and landfills.[1755] Landfilling is the least preferable alternative in waste management practices according to the waste management hierarchy.[1756] Thus, it should be limited to minimum and if waste needs to be landfilled, landfills which comply with the requirements of Directive must be selected.[1757] Additionally, the Directive requires that a strategy on biodegradable waste is introduced that achieves the progressive diversion of biodegradable municipal waste from landfill.[1758]

The Directive was a fundamental change to the previous UK waste management practices.[1759] In the UK, besides the implementation of the Directive (Table 5.3.), there is an 'Environmental permitting guidance: The landfill directive'[1760] document, which aims

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[1750] ibid
[1751] Waste Framework Directive (n 1751), art 13
[1752] Glæsner, Helming and de Vries (n 43)
[1753] Department for Environment, Food and Rural Affairs, 'Environmental Permitting Guidance – The Landfill Directive for the Environmental Permitting (England and Wales) Regulations 2010' (March 2010) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69347/pb13563-landfill-directive-100322.pdf> accessed 5 February 2020
[1754] Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste [1999] OJ L182/1 (hereinafter 'Landfill Directive'), art 1(1)
[1755] ibid, art 1(1)
[1756] European Commission, 'Waste' (*Environment*, 7 August 2019) <https://ec.europa.eu/environment/waste/landfill_index.htm> accessed 4 February 2020
[1757] ibid
[1758] Landfill Directive (n 1754), arts 5(1) and (2)
[1759] Environment, Food and Rural Affairs Committee, *Waste Policy and the Landfill Directive* (HC 2004–05, 102)
[1760] Department for Environment, Food and Rural Affairs (n 1753)

helping readers understand the permitting requirements of the Directive. Also, there are the Landfill Allowance Trading Scheme (LATS) for England and the Landfill Allowance Scheme for Wales. There are set targets for the UK for landfill diversion.[1761] LATS was set up for England to meet those targets.[1762] These objectives provide confidence that England will meet its share of the UK target to switch waste management practices from landfill in 2020 without placing additional burdens on local authorities.[1763] The national policies should be in line with the government's Waste Review.[1764]

The Directive's overall objective mentioned above,[1765] is a clear soil focused aim. Although the Directive requires a permit for landfills to operate and introduces permit conditions,[1766] including provisions on monitoring and requirements for after-care with the aim of controlling the landfill by minimising the potential risks to the environment;[1767] these provisions do not explicitly mention 'soil'.

Only the requirements found in Annex I of the Directive sets out specific rules for both soil and water protection.[1768] These provisions specifically are related to location of landfills,[1769] and location and design of landfills.[1770] It also considers the location of landfills their distance from residential and recreational areas.[1771] It can be argued that the Directive aims to protect physical and cultural environment for mankind, which is a soil ES.[1772] From these provisions, it is clear that the Landfill Directive aims to address one particular soil threat (pollution);[1773] therefore, it is directly relevant to soil protection (Table 5.2.).

The Directive regulates the landfill form of waste disposal and controls diffuse and point source contamination as a result of landfills through a set of clear and well-established rules. Indeed, the Directive has an explicit link to both types of contamination. It may also indirectly address the threat of soil sealing as sealing is a result of containment of landfill sites.[1774] Considering these, the Directive, so far, has been a useful tool for protecting soil by advancing the closure of landfills and increasing the use of alternative

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1761 'Landfill Allowance Trading Scheme' (1 April 2012) <https://www.legislation.gov.uk/ukia/2012/176/pdfs/ukia_20120176_en.pdf> accessed 14 February 2020
1762 ibid
1763 ibid
1764 ibid
1765 Landfill Directive (n 1754), art 1 (1)
1766 ibid, recital 18
1767 ibid, arts 7, 8, 9
1768 ibid, annex I (3)
1769 ibid, art 8
1770 ibid, art 14
1771 ibid, annex I
1772 Glæsner, Helming and de Vries (n 43)
1773 Landfill Directive (n 1754), art 1(1)
1774 Frelih-Larsen and others (n 40)

waste management options.[1775] On the other hand, it is known that there are cases of non-compliance, i.e., landfills run illegally without the required permits and conditions attached.[1776]

In addressing soil threats, it is argued that the Directive should contain more detailed definitions of concepts in order to minimise pollution and environmental impact.[1777] The Directive was found vague in terms of the definitions of a number of key concepts, such as municipal solid waste and biodegradable waste.[1778] These definitions are critical as they will have a substantial effect on the Directive's implementation.[1779] For example, the scope of municipal solid waste may make a drastic change in the amounts of waste.[1780] As the Directive controls the amount and the quality of waste that is going into landfills, these details have the potential to impact the level of soil contamination.[1781]

Some soil ES are directly considered in the text (Table 5.2.), and there are a few others which have an implicit reflection in the Directive. Besides the abovementioned physical and cultural environment for humankind, gas and climate regulation are implicitly mentioned as measures that should limit the production of methane gas from landfills to reduce global warming, through the requirements of landfill gas control.[1782] Additionally, nutrient cycling is implicitly mentioned as soil is seen as a storage reservoir for waste and nutrients.[1783] Finally, the Directive addresses the protection of soil as a source of raw materials through encouraging prevention, recycling and recovery of waste and making the wasteful use of land unnecessary.[1784]

Overall, the Directive was found as a potentially effective instrument for protecting soils from the threat of contamination. Considering the points discussed so far, it can be argued the Directive provides a modest level of soil protection (Table 5.2.).

[1775] European Environment Agency, 'Diverting waste from landfill – Effectiveness of waste-management policies in the European Union' (2009) <https://www.eea.europa.eu/publications/diverting-waste-from-landfill-effectiveness-of-waste-management-policies-in-the-european-union/download> accessed 12 June 2019
[1776] Frelih-Larsen and others (n 40)
[1777] Ana Dajić and others, 'Landfill design: need for improvement of water and soil protection requirements in EU Landfill Directive' (2016) 18 Clean Technologies and Environmental Policy 753
[1778] Stephen Burnley, 'The impact of the European landfill directive on waste management in the United Kingdom' (2001) 32 Resources, Conservation and Recycling 349
[1779] ibid
[1780] ibid
[1781] Kraemer and others (n 1369)
[1782] Landfill Directive (n 1754), recital 16
[1783] Glæsner, Helming and de Vries (n 43)
[1784] ibid

5.3.3.6. Mining Waste Directive

In Europe, waste from extractive operations is one of the leading waste streams.[1785] These operations inevitably include the removal of materials, such as topsoil, to access mineral resources, which damages soils.[1786] Also, mining activities increase the risk of soil erosion.[1787] In addition, some activities, such as non-ferrous metal mining contain dangerous substances (e.g., heavy metals), and these substances become more available through extraction.[1788] Extraction operations generate residues that end up in tailing ponds, which are large dams.[1789] When rocks are ground to fine particles and are mixed with water and chemicals, this result in slurry that contains heavy metals and toxic materials (tailings and the waste left).[1790] As mining companies try to lower the costs of these operations, they sometimes put this slurry back into mineshaft (backfill) or store the residue behind earthen dams (tailing ponds).[1791] Therefore, there is always a risk of accidents resulting in the collapse of dams or heaps that store tailings that would release harmful substances back to the soil.[1792]

The scope of the Mining Waste Directive[1793] covers waste from other mineral extractions.[1794] Through this instrument, the EU aims to protect the natural environment from potentially long-term impacts of extractive operations, such as soil pollution arising from acid or alkaline drainage and leaching of heavy metals.[1795] In a nutshell, this Directive has the objectives of ensuring safe management of mining waste and preventing or reducing impacts from day to day management of mining waste facilities, such as waste heaps and tailings ponds, including providing measures for planning and licensing of such facilities and managing their closure and after care.[1796] It is seen as a strong piece of legislation from the point of introducing adequate provisions for managing the most hazardous extractive waste.[1797] However, it is important to note that this Directive only

[1785] European Commission, 'Extractive Waste' (*Environment*, 16 October 2019) <https://ec.europa.eu/environment/waste/mining/index.htm> accessed 29 January 2020
[1786] ibid
[1787] ibid
[1788] ibid
[1789] Tilak Ginige, 'Mining Waste: The Aznalcóllar Tailings Pond Failure' (2002) 11 European Energy and Environmental Law Review 76
[1790] ibid
[1791] ibid
[1792] European Commission (n 1785)
[1793] Directive 2006/21/EC of the European Parliament and of the Council on the management of waste from extractive industries and amending Directive 2004/35/EC [2006] OJ L 102/15 (hereinafter 'Mining Waste Directive')
[1794] Department for Environment, Food and Rural Affairs, 'Environmental Permitting Guidance - The Mining Waste Directive For the Environmental Permitting (England and Wales) Regulations 2010' (May 2010) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69323/pb13636-ep2010miningwaste.pdf> accessed 29 January 2020
[1795] European Commission (n 1785)
[1796] Sergiy Moroz, 'The Mining Waste Directive — will it address the toxic burden?' (2007) 19 Environmental Law and Management 232
[1797] ibid

applies to currently active mines and does not address issues related to legacy mines.[1798] Though, these abandoned mines are seen as more of a problematic issue in Europe, due to the fact that older practices of mine closures did not consider environmental protection has not been considered until recently.[1799] Also, it is argued that the Directive does not impose upon the backfilling of all excavation voids, which can lead to operators leaving the excavation voids as they are, which increases pollution risk.[1800]

The Directive has a particular focus on soil protection.[1801] This focus is especially seen in its soil related objective. The Directive ensures that any adverse impacts on the environment, in particular water, air, soil, fauna, flora and landscape, and any resultant risks to human health from the extractive industries are prevented or reduced.[1802]

Additionally, the Directive explicitly addresses a number of soil threats, i.e., erosion and pollution.[1803] Regarding erosion, the Directive states that construction of a new waste facilities or modification of an existing waste facilities must include measures that guarantees that soil loss is minimised to a degree that is technically possible and economically viable.[1804] However, the Directive does not mention what these specific measures would be and contains measures that are intended to prevent only the acceleration of erosion.[1805]

In terms of pollution, the Directive ensures that disposal and application of contaminants are conducted in a manner that does not create risks to soil and assesses the risks that are posed by harmful substances to organisms in the environment.[1806] Indeed, when placing extractive waste back into excavation voids that that will be allowed to flood after closure, the operator is responsible for taking the necessary measures to prevent or minimise soil pollution.[1807] During the construction and management of new waste facilities, these should be designed, constructed, managed and maintained in a manner that prevents soil pollution.[1808] The Member States are under the requirement of ensuring that the operator takes appropriate measures to prevent soil pollution whilst placing extractive waste back into the excavation voids for rehabilitation and construction

[1798] Konstantinos Kostarelos and others, ‘Legacy Soil Contamination at Abandoned Mine Sites: Making a Case for Guidance on Soil Protection’ (2015) 94 Bull Environ Contam Toxicol 269
[1799] A. Abdaal, G. Jordan and P. Szilassi, ‘Testing Contamination Risk Assessment Methods for Mine Waste Sites’ (2013) 224 Water Air Soil Pollut 1416
[1800] Moroz (n 1796)
[1801] Paleari (n 49)
[1802] Mining Waste Directive (n 1793), art 1
[1803] Glæsner, Helming and de Vries (n 43)
[1804] Mining Waste Directive (n 1793), art 11(2)(a)
[1805] Glæsner, Helming and de Vries (n 43)
[1806] ibid
[1807] Mining Waste Directive (n 1793), art 13
[1808] ibid, arts 11(2)(a) and (b)

purposes.[1809] The Directive bans abandonment, dumping or uncontrolled deposition of extractive waste.[1810]

Other than the direct reference to one soil ES in the preamble (Table 5.2.), there is an indirect focus on several other soil ES in the Directive, namely refugia, biodiversity and gene pool by assessing the risk caused by harmful substances to organisms, and raw materials by addressing soil as a source of these, and nutrient cycling by viewing soil as storage for waste and nutrients.[1811]

It is argued that the Mining Waste Directive limits the emissions from waste management activities to soil more directly than the Waste Framework Directive.[1812] Using these arguments, it can be concluded that although the Directive has a number of weaknesses, it has the potential for providing strong soil protection (Table 5.2.).

5.3.3.7. Summary

This section has discussed the effectiveness of legal instruments related to soil protection from industrial activities and waste management. It is clear that most of these activities are beneficial for a country's economy and a number of them are unavoidable. Yet, there are various soil threats linked to these industrial activities and waste management practices, such as pollution and compaction.

The majority of legal instruments are implemented from the EU law and the instruments discussed in this section have a specific focus and direct protection granted to soils. Some of these instruments have soil specific targets and objectives, while all have direct soil-relevant provisions (Table 5.2.). The direct approach to soil protection is also clear from the fact that these instruments explicitly and implicitly mention some soil threats, the former commonly being soil pollution, and the latter being SOM loss and sealing for some instruments (Table 5.2.). However, similar to agriculture focused instruments, the legal instruments analysed in this section do not consider all relevant threats, especially compaction. This omission results in a lack of robust and complete legal protection for soils.

Soil ES are not commonly granted direct protection by these instruments. Indeed, other than a limited number of instruments, law neglects soil ES by failing to mention them explicitly (Table 5.2.). A small number of explicit mentions are about the services of platform, recreation, heritage and water quality regulation services (Table 5.2.). The

[1809] ibid, art 10
[1810] ibid, art 4
[1811] Glæsner, Helming and de Vries (n 43)
[1812] Frelih-Larsen and others (n 40)

most common implicit focus is seen in nutrient cycling, platform, biodiversity and refugia services. On the other hand, other services lack adequate protection from continuous pressures, which threatens the multifunctionality of soils in the long run.

5.4. Development

5.4.1. Importance of Development for the United Kingdom

Construction is one of the largest industries in the UK.[1813] It includes the development and construction of residential and non-residential buildings, construction work on civil engineering projects, and specialist construction activities (such as plumbing and electrical installation).[1814] According to the 2011 Construction Strategy, three main sectors of construction are commercial and social (around 45%), residential (around 40%) and infrastructure (approximately 15%).[1815]

In 2019, the construction sector's output was documented as £117 billion, which was 6% of total output.[1816] The construction industry employed 2.4 million people, which was 7% of the total.[1817] A number of 343.000 registered construction businesses represent 13% of the total number of businesses in the UK. [1818] It is worth mentioning that mostly self-employed contractors represent a high number of unregistered businesses in this industry.[1819] These numbers show the importance of development and the industry for the UK economy and also portrays that there will be a likely growth in the construction industry.[1820]

5.4.2. Directly Related Threat – Sealing

Most spatial planning decisions are driven by short-term economic interests,[1821] resulting in several environmental issues, including progressive degradation of soils.[1822]

[1813] 'Industries in the UK' (*www.parliament.uk*, 30 December 2019) <https://researchbriefings.parliament.uk/ResearchBriefing/Summary/CBP-8353> accessed 18 February 2020
[1814] Chris Rhodes, 'Construction industry: statistics and policy' (*Briefing Paper*, 16 December 2019) <http://researchbriefings.files.parliament.uk/documents/SN01432/SN01432.pdf> accessed 21 June 2020
[1815] Cabinet Office, 'Government Construction Strategy' (May 2011) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/61152/Government-Construction-Strategy_0.pdf> accessed 18 February 2020
[1816] Rhodes (n 1814)
[1817] ibid
[1818] ibid
[1819] ibid
[1820] 'Construction Skills Network forecasts 2019-2023 – UK' (*CITB*, 25 February 2019) < https://www.citb.co.uk/about-citb/construction-industry-research-reports/search-our-construction-industry-research-reports/forecasts/csn-forecasts-2019-2023-uk/#:~:text=According%20to%20the%20latest%20Construction,CSN)%20report%202019%2D2023%3A&text=168%2C500%20construction%20jobs%20will%20be,in%20the%20next%20five%20years.> accessed 15 June 2020
[1821] Hans-Peter Haslmayr and others, 'Soil function evaluation in Austria — Development, concepts and examples' (2016) 264 Geoderma 379
[1822] ibid

Soil degradation can occur through the process of local soil pollution as a direct effect of urbanisation,[1823] due to construction work and accidental spillage or the use of chemicals, over-compaction of soil through the use of heavy machinery or the storage of construction materials, mixing construction waste with soil.[1824]

Besides these potential adverse impacts, the most common and expected negative consequence of the increase in urban development is soil sealing.[1825] Sealing occurs mainly by covering soil with impermeable materials, effectively sealing it and significantly damaging soil's physical, chemical and biological properties, including drainage.[1826] It is the most intense form of land take and an irreversible process,[1827] reducing soil's ability to deliver vital ES.[1828] The percentage of soil sealing was 3.1% in 2015; and at current rates, over 1% of England's land will be converted to built development each decade.[1829]

5.4.3. Legal Analysis – Development

At the EU level, numerous important official documents were drafted, following the need for addressing soil sealing as a threat for soil functioning. The EU policy makers are aware of sealing and its potential impacts on natural resources. Still, soil sealing is not tackled satisfactorily. Indeed, documents mentioned are generally non-binding, which hinders their full implementation and effectiveness.[1830]

The EU has pointed out the need to develop best practices to mitigate the adverse effects of sealing on soil functions.[1831] The Roadmap to a Resource Efficient Europe proposed that European policies should consider their direct and indirect impacts on land use with the general aim of achieving no net land take by 2050, and the Member States should better integrate the environmental impacts of land use in their decision making and limit land take and soil sealing.[1832]

1823 Stolte and others (n 20)
1824 Department for Environment, Food and Rural Affairs (n 823)
1825 ibid
1826 ibid
1827 'Soil Sealing' (n 643)
1828 Natural England, 'Summary of evidence: Soils' (19 May 2015) <http://publications.naturalengland.org.uk/file/4964581401165824> accessed 14 June 2020
1829 European Environment Agency, 'Percentage soil sealing by country' (25 May 2020) <https://www.eea.europa.eu/data-and-maps/daviz/percentage-sealing-by-country-1#tab-chart_6> accessed 20 June 2020
1830 Gundula Prokop and others, 'Report on best practices for limiting soil sealing and mitigating its effects' (April 2011) Technical Report – 2011 – 050
1831 European Commission (n 644)
1832 Commission (n 1046)

Alongside the Roadmap, the EU recognises the threat of sealing in the 7th EAP through targeting the growing issue of land take due to urbanisation[1833] and set a target of no net land take by 2050.[1834] In its priority objective 1.23, soil degradation due to sealing is highlighted.[1835] Responding to soil sealing, the Commission called for further efforts to strengthen the regulatory context, develop networks, share knowledge, produce guidelines and identify examples of best practice can also contribute to better soil protection.[1836] However, there are no binding and clear targets for addressing or mitigating soil sealing in the 7th EAP.

The European Commission also published the report 'Overview of best practices for limiting soil sealing or mitigating its effects in EU-27',[1837] which presents land take and soil sealing trends in the EU.[1838] It offers a comprehensive overview of the current Member State policies and technical measures to reduce and mitigate sealing.[1839] It also provides a useful analysis of the relevant policies and potential best practice measures in the Member States.[1840] However, the document needs an update in this version to reflect more recent trends and numbers, which will be useful for countries to take into account in developing their action plan mitigating soil sealing.

Based on this technical report and the contribution of national soil sealing experts,[1841] following the Roadmap's anticipation to publish guidelines on best practice,[1842] the Commission also published 'Guidelines on best practice to limit, mitigate or compensate soil sealing'.[1843] These guidelines comprise a detailed set of best practices to limit, mitigate and compensate for soil sealing effects in Europe,[1844] collect examples of law and policies, funding schemes, local planning tools, information campaigns and other best practices implemented in the EU.[1845] These guidelines are addressed to competent authorities in the Member States at multiple levels and professionals dealing with land planning and soil management.[1846] This document comprises of relevant information on soil sealing, i.e., its drivers, impacts, available options, and relevant good

[1833] Environment Action Programme (n 1051)
[1834] Glæsner, Helming and de Vries (n 43)
[1835] Environment Action Programme (n 1051)
[1836] ibid
[1837] Prokop and others (n 1830)
[1838] ibid
[1839] ibid
[1840] ibid
[1841] European Commission (n 644)
[1842] Commission (n 1046)
[1843] European Commission, 'Guidelines on best practice to limit, mitigate or compensate soil sealing' SWD (2012) 101 (hereinafter 'Soil Sealing Guidelines')
[1844] Frelih-Larsen and others (n 40)
[1845] European Commission (n 644)
[1846] ibid

practices.[1847] The critical weakness of these guidelines, similar to the other documents mentioned so far, is that they set no mandatory requirements.[1848]

None of the existing binding EU legislation addresses the threat of soil sealing.[1849] Indeed, it has been discussed that there are merely strategies to address soil sealing.[1850] However, there is not sufficient binding legislation targeting this threat.[1851] Soil sealing is therefore another important threat to address in policies, which leaves urban soils as a significant gap in the existing legislation.[1852]

At the national level, the Plan has a reference to soil compaction as a significant threat to the UK soils.[1853] It does not mention the threat of soil sealing or contamination from construction work and activities,[1854] even though it is widely accepted in the UK policy that soil sealing is a critical threat to soil functionality.[1855] The UK also underlines the importance of the sustainable use of soils.[1856] It requires sustainability appraisal, and strategic environmental assessment of all spatial plans, and environmental impact assessment for major development proposals.[1857] These two procedures explicitly require consideration of impacts on soils.[1858] The general weakness of the planning system in terms of soil protection is that restrictions to soil sealing are stemmed from voluntary agreements and non-binding measures, such as the Construction Code of Practice for the Sustainable Use of Soils on Construction Sites mentioned earlier. It is worth mentioning that this Code offers several recommendations for decreasing the risk of compaction in construction sites, which is an additional threat resulting from construction development.[1859]

The UK government, in its soil strategy, recognised the fact that a certain degree of soil sealing is an unavoidable result of development.[1860] This threat has been raised as an issue and the planning system increasingly acknowledges the significance of lessening sealing impacts, particularly in relation to urban drainage and maintaining green infrastructure.[1861] Thus, it is widely accepted that there must to be a balance among the

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[1847] Soil Sealing Guidelines (n 1843)
[1848] Frelih-Larsen and others (n 40)
[1849] Glæsner, Helming and de Vries (n 43)
[1850] ibid
[1851] ibid
[1852] ibid
[1853] HM Government (n 803)
[1854] ibid
[1855] Department for Environment, Food and Rural Affairs (n 53)
[1856] 'UK Soil Degradation' (n 751)
[1857] ibid
[1858] ibid
[1859] Department for Environment, Food and Rural Affairs (n 823)
[1860] Department for Environment, Food and Rural Affairs (n 53)
[1861] ibid

environmental, economic and social costs and benefits of the development and land use.[1862]

Overall, it is crucial to consider multiple aspects of the planning system and law to understand the UK policy approaches to addressing the adverse impacts of urbanisation.[1863] The sustainable use and protection of urban soils is planned to be achieved through several schemes.[1864] These schemes mainly aim to maximise the use of construction, demolition and excavation waste through screening to separate aggregates and soils that can be recycled; using permeable paving and vegetated (usually grassed) roofs in new buildings which increases water storage and reduces urban flooding potential.[1865] Within the planning system, brownfield sites, which are mostly comprised of previously used properties,[1866] are now prioritised for development in urban areas.[1867]

5.4.3.1. Environmental Impact Assessment Directive

The Environmental Impact Assessment (EIA) Directive requires the provision of a high level of protection of the environment and to contribute to the integration of environmental considerations into the preparation of projects that may have likely significant adverse effects on the environment.[1868]

The Directive does not have any specific soil targets or objectives (Table 5.2.). However, it has a particular focus on soils in a number of articles. Recital 9 directly mentions the aim of reducing projects' impacts on soil and land.[1869] It highlights the Thematic Strategy for Soil Protection and the Roadmap to a Resource-Efficient Europe, which emphasise the significance of the sustainable use of soil.[1870] It mentions Rio 2012 that recognises the economic and social significance of good land management, including soil, and the need for urgent action to reverse land degradation.[1871]

Also, the requirement for an assessment of the direct and indirect significant effects of a project on the natural environment, also includes biodiversity, land and

[1862] ibid
[1863] Prokop and others (n 1830)
[1864] 'UK Soil Degradation' (n 751)
[1865] ibid
[1866] Philip Catney, Tiziana Cianflone and Kris Wernstedt, 'Revitalizing Contaminated Land in Italy, the United Kingdom and the United States' in Richard C. Hula, Laura A. Reese and Cynthia Jackson-Elmoore, *Reclaiming Brownfields: A Comparative Analysis of Adaptive Reuse of Contaminated Properties* (Routledge 2016)
[1867] 'UK Soil Degradation' (n 751)
[1868] Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment Text with EEA relevance [2014] OJ L 124/1 (hereinafter 'EIA Directive'), preamble
[1869] ibid, recital 9
[1870] ibid, recital 9
[1871] ibid, recital 9

soil.[1872] According to the Directive, impact assessments should identify, describe and assess the direct and indirect significant effects of a project on soils in the light of each individual case.[1873] So, there is a potential link to soil as a platform for human activity in the Directive by requiring a description of the environmental impacts that development projects or plans might have on soil.[1874] However, this requirement applies when EIA is mandatory, i.e., for projects (listed in Annex I) that are considered as having significant effects on the environment.[1875]

The characteristics of projects must be considered regarding the use of soil.[1876] Also, the locations of projects should be selected with a particular consideration the existing and approved land use and the relative abundance, availability, quality and regenerative capacity of soil.[1877] It can be argued that EIAs and the development consent with environmental conditions may have relevance to soil protection. Because if soil was an emphasised resource in the assessment to be affected by the project, the conditions could propose development of the project in a less damaging way for the soil.[1878]

Additionally, the EIA report provided by the developer should contain a description of any possible significant effects of the project on the environment resulting from the use of soil.[1879] Description of the project includes a description of the location of the project, a description of the physical characteristics of the whole project, a description of the main characteristics of the operational phase of the project, an estimate of expected residues and emissions (such as soil and subsoil pollution), and quantities and types of waste produced during the construction and operation phases.[1880] So, the Directive is argued to have direct relevance to soil protection.[1881]

It is notable that the Directive also specifically touches upon several soil threats. The Directive suggests that public and private projects should limit the adverse impacts on land and soil, regarding SOM, erosion, compaction and sealing.[1882] Therefore, it is discussed that the Directive's requirements may contribute to limiting a number of soil related threats, i.e., compaction, pollution, erosion, flooding/landslides, loss of soil biodiversity, loss of SOM and sealing.[1883] For example, mandatory EIA includes a

[1872] ibid, art 3
[1873] ibid, art 3(1)
[1874] Frelih-Larsen and others (n 40)
[1875] Paleari (n 49)
[1876] EIA Directive (n 1868), annex III
[1877] ibid, annex III
[1878] Frelih-Larsen and others (n 40)
[1879] EIA Directive (n 1868), art 5 and annex IV
[1880] ibid, annex IV
[1881] Paleari (n 49)
[1882] EIA Directive (n 1868), recital 9
[1883] Frelih-Larsen and others (n 40)

description of the factors likely to be significantly affected by the project, including potential impacts on soil.[1884]

In terms of soil ES protection, the Directive has an indirect tone. Indeed, there are no explicit references to soil ES (Table 5.2.). Soil habitat can be potentially protected though the objective of avoiding, preventing, reducing and, if possible, offsetting significant adverse effects on protected species and habitats.[1885] Also, soil biodiversity is indirectly protected as the significant adverse effects of projects on biodiversity should be identified, described and assessed.[1886] These requirements are the same for raw materials and cultural heritage.[1887] There is also an implicit relevance to soil as a platform for human activity.[1888] The mandatory undertaking of EIA includes a description of the factors that might be significantly affected by the project,[1889] therefore is likely to impact all soil ES.[1890]

The Directive has some weaknesses in terms of soil protection, such as its lack of explicitly set mandatory soil-relevant outcomes or targets (Table 5.2.).[1891] Developers that determine the less harmful alternatives of a project are free to select the most suitable measures to ensure high level of soil protection.[1892] However, developers' approaches to this requirement are likely to vary depending on the characteristics of each project.[1893] EIA Directive, on the other hand, has several strengths, such as offering a framework for determining whether a project with likely environmental impacts shall undertake an EIA prior to development consent is granted, including information on the likely impacts on soil and alternative practices. Considering these aspects of the Directive, it can be concluded that this instrument has the potential to offer strong protection for soils from development pressures (Table 5.2.).

5.4.3.2. Strategic Environmental Assessment Directive

The Strategic Environmental Assessment (SEA) Directive[1894] aims to ensure that a high level of environmental protection is considered while preparing, adopting and

[1884] EIA Directive (n 1868), art 3 and annex IV
[1885] ibid, recital 11
[1886] ibid, art 3(1)(b)
[1887] ibid, art 3(1)(d)
[1888] Frelih-Larsen and others (n 40)
[1889] EIA Directive (n 1868), art 3 and Annex IV
[1890] Frelih-Larsen and others (n 40)
[1891] ibid
[1892] ibid
[1893] ibid
[1894] Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment [2001] OJ L 197/30 (hereinafter 'SEA Directive')

implementing plans and programmes.[1895] A procedure for assessing the environmental impacts of plans and programmes is set out in this Directive. The procedure includes steps of scoping,[1896] preparing the environmental report,[1897] public consultation and participation,[1898] decision making,[1899] and monitoring.[1900] The Directive also makes subject to a screening procedure, plans and programmes different from those listed in article 3(2), but which set out the scheme for future development consent of projects, as well as plans and programmes which determine the use of small areas at a local level and minor modifications to plans and programmes, but only if they are likely to have significant environmental effects.[1901]

SEA is required for plans and programmes that are prepared for agriculture, forestry, fisheries, energy, industry, transport, waste and water management, telecommunications, tourism, town and country planning or land use and which set the framework for future development consent of projects listed in the EIA Directive.[1902] SEA is also mandatory for plans and programmes that have been determined to require an assessment under the Habitats Directive.[1903] If plans and programmes do not fall under these criteria, the Member States must carry out a screening procedure to determine the likely significant environmental impacts.[1904] If there are significant effects, SEA will be required.[1905]

Annex II narrows the discretion of the Member States by setting a significance criterion for screening of plans and programmes.[1906] This standard is also limited by the general objective of the Directive of guaranteeing a high degree of environmental protection.[1907]

In terms of soil protection, the Directive does not introduce any soil focused targets or objectives (Table 5.2.). However, the Directive requires the information to be provided following an assessment of the effects of strategic actions on environmental aspects.[1908] SEA Directive has direct relevance to soil protection, as this is laid out in the

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1895 'Assessment of the certain effects of plans and programmes on the environment (SEA)' (*EUR-Lex*, 11 October 2018) <https://eur-lex.europa.eu/legal-content/EN/LSU/?uri=CELEX:32001L0042> accessed 11 February 2020
1896 SEA Directive (n 1894), art 3
1897 ibid, art 5
1898 ibid, arts 6 and 7
1899 ibid, art 8
1900 ibid, art 9
1901 ibid, art 3
1902 ibid, art 3(2)(a)
1903 ibid, art 3(2)(b)
1904 European Commission, 'Strategic Environmental Assessment - SEA' (*Environment*, 6 February 2018) <https://ec.europa.eu/environment/eia/sea-legalcontext.htm> accessed 5 June 2019
1905 ibid
1906 'Assessment of the certain effects of plans and programmes on the environment (SEA)' (n 1895)
1907 ibid
1908 SEA Directive (n 1894), annex I(f)

Annex and related to the information to be submitted.[1909] As the Directive offers a framework to assess the environmental effects of selected plans and programmes by requiring that these include information on likely significant effects on soil, its requirements may indirectly contribute to all soil threats and functions.[1910] However, the Directive is not a strong law in terms of soil conservation as it does not explicitly set soil-relevant mandatory requirements, outcomes, or specific mechanisms to avoid further soil degradation due to certain plans or programmes, beyond monitoring.[1911]

It is argued that although SEA Directive does not explicitly address any threats, soil functions or ES (Table 5.2.), it potentially offers further information on the status of specific soil threats and functions affected by development.[1912] It is argued that soil has to be analysed for each individual case, not only with regard to its structural and physico-chemical status but also with regard to soil functions.[1913] Besides, the likely changes under potential impacts following from strategic actions should be considered.[1914] Therefore, it can be seen as an important tool to draw attention to the protection of soil functions and ES.

Similar to the EIA Directive, there is a link in the SEA Directive to soil as a platform for human activity.[1915] Other soil ES that are implicitly given reference by the Directive are soil biodiversity, habitat and refugia, raw materials, cultural heritage. The likely effects on these aspects must be included in the information to be provided in an environmental report of the environmental assessment.[1916] It is discussed that through the mandatory undertaking of a SEA for selected plans and programmes, all soil ES can potentially be indirectly protected.[1917]

In sum, although SEA has the potential for environmental protection by making the existing legislation more effective, there are weaknesses.[1918] The key weakness of SEA as an environmental protection instrument is that the methods for achieving the aims of the SEA are not made available in a complete form to be used for soil protection.[1919]

[1909] Paleari (n 49)
[1910] Frelih-Larsen and others (n 40)
[1911] ibid
[1912] ibid
[1913] Robert Mayer, 'Soil Resources and SEA' in Michael Schmidt, Elsa João and Eike Albrecht (eds), *Implementing Strategic Environmental Assessment* (Springer 2005)
[1914] ibid
[1915] Frelih-Larsen and others (n 40)
[1916] SEA Directive (n 1894), art 5 and annex I
[1917] Frelih-Larsen and others (n 40)
[1918] Mayer (n 1913)
[1919] ibid

SEA also fails to offer scales for the evaluation of effects.[1920] Overall, it can be discussed that SEA Directive offers modest protection for soils (Table 5.2.).

5.4.3.3. Summary

This section has focused on the most relevant legal instruments to threats stemming from development pressure. The most striking associated threat with development is seen as soil sealing. It is clear that soil sealing has been shown a degree of attention.[1921] However, this attention is not supported by necessary measures.[1922] In this section, it has been explained that soil sealing is directly controlled by one non-binding legislative provision.[1923] Several documents at the EU and national levels focusing on sealing and the adverse impacts of development and construction are non-binding.

In this section, EIA and SEA Directives have been analysed. Both provide protection for soils in a direct manner though explicit soil references; however, do not include any soil specific targets or objectives (Table 5.2.). EIA Directive mentions explicitly a number of soil threats, namely erosion, soil pollution, compaction, sealing, SOM loss (Table 5.2.). However, SEA Directive has an implicit focus on numerous soil threats (i.e., compaction, erosion, SOM loss, sealing, soil pollution, desertification, salinisation) (Table 5.2.).[1924]

Finally, it is worth mentioning that these Directives fail to give direct references to particular soil ES; however, are expected to indirectly contribute to all soil ES through mandatory environmental assessments, which would identify likely adverse impacts that could threaten soil functions and ES.[1925]

5.5. Conclusion

This chapter critically analysed whether the existing laws and policies found in the UK law fail to protect soils, including soil functions and ES. This analysis was done through a pressure perspective in which, firstly, the most threatening pressures on the UK soils were established, i.e., agriculture, industrial activities and waste management, and development. Then, the most relevant legal instruments were identified, their

[1920] ibid
[1921] Paleari (n 49)
[1922] ibid
[1923] ibid
[1924] Frelih-Larsen and others (n 40)
[1925] ibid

effectiveness were critically discussed and the level of soil protection they offer was scrutinised, and the weaknesses and strengths found in these laws were introduced.

Table 5.2. lays out several key points that are crucial for this analysis. These points include soil specific targets or objectives found in the legal instruments, their relevance to soil protection (direct or indirect), their soil focused provisions, explicitly and implicitly mentioned soil threats and direct references to ES in these instruments. Also, it introduces an analysis regarding the level of protection given to soils.

This analysis concluded that only 8 legal instruments out of 20 have soil specific targets or objectives. Also, merely 5 threats are explicitly mentioned in these laws, i.e., pollution (9 times), erosion (5 times), SOM loss, sealing and compaction (each 2 times). This distribution is in line with the implicit mention of soil threats, pollution (10 times), SOM loss (8 times), erosion (7 times), compaction (5 times), sealing (3 times). Using these numbers, it can be argued that other than erosion and pollution, most soil threats are overlooked although they are in direct relationship with the pressures on soils (Table 5.1.).

Considering ES, this analysis revealed that most commonly provisioning, i.e., food production, biodiversity (each 3 times) and regulating services, i.e., water quality regulation (3 times), are explicitly mentioned in these legislative instruments. This result supports the previously mentioned argument that cultural and supporting ES are usually being ignored by policy and decision makers.

As a result of this analysis, out of 20, 14 legal instruments were found to have direct relevance to soil protection. 5 of these 20 legal instruments have no soil focused provisions. Finally, only 1 law was found to provide very strong soil protection, while 6 are strong, 5 are modest, 5 are weak and 3 are very weak. However, it is worth emphasising that the effectiveness of Sewage Sludge Directive, which is found to be a very strong instrument, is likely to be decreased by the fact that its application is applies to a very limited land area.

The overall approach to soil protection in the UK law is fragmented and the legal instruments analysed in this chapter provide inadequate protection for soils. Generally, soil has been merely protected through provisions scattered in different policy areas in which the actual aim is the protection of other environmental aspects, such as water or air. More comprehensive documents are seen in the form of guidance or recommendation, but these are non-binding and unenforceable. The most striking issue with these frameworks is that soil has been a secondary concern for policy makers. This approach resulted in a continuous neglect for soil in policy. Even where there is a somewhat stronger soil protection, additional challenges, such as implementation by the Member States, damage the potential for robust soil protection.

Incorporating these results from this analysis, including the insufficient consideration and protection for ES, the next chapter will provide recommendations, which can be utilised for a future reform in soil protection laws. The next chapter will critically appraise numerous approaches for integrating the importance and value of ES into policy and decision making. A novel framework developed through the findings of this appraisal will be introduced. For these framework recommendations, a holistic approach combining scientific, economic and societal insights will be adopted. This approach has a potential for reshaping the current legal approach to soil protection in a way that it effectively protects the valuable benefits we obtain from soils.

CHAPTER SIX

The Ecosystem Services Framework and Soil Protection

6.1. Introduction

The previous chapter demonstrated that the UK soil protection legislation is mainly ineffective for protecting soils and soil ES. This chapter will highlight the need to integrate ES into policy and decision making processes, which would potentially strengthen the legal framework for soil protection.

There are numerous international and national soft law instruments that suggest the benefits of incorporating ES into law and policy. The World Soil Charter 2015 defends the argument that eliminating or minimising soil degradation is more cost-effective than rehabilitation after the harm occurs, and its Principle 10 states that there is a need for a soil focused ES framework.[1926] SDGs, especially Goal 15, focus on terrestrial ecosystems,[1927] and it was found that most ES make important contributions to achieving targets across several different SDGs.[1928] ES also have a specific focus in the UK's CBD Sixth, and latest, National Report.[1929] In the report, the importance and monetary value of ES are reflected.[1930] It was stated that a number of ES have been declining since 1990, i.e., provisioning of some wild-caught fish and supply of clean water, regulating of hazards (such as flooding, erosion and fire), noise, soil quality and pollination, and some supporting services, such as nutrient cycling, reported by the UK National Ecosystem Assessment.[1931] Finally, there is a NC approach in the key document in the UK's policy, the Plan.[1932] These documents show that there is an understanding of the significant role of ES in policy.

Additionally, the withdrawn proposal for the Soil Framework Directive, which would have established a legal framework for soil protection across the EU, recognised the need to protect soil functions and ES through a comprehensive approach. This legislative instrument aimed to provide protection for soil and its capacity to perform its environmental, economic, social and cultural functions and emphasise the degradation process that would potentially hinder these functions. The concept of soil ES, reflecting soil quality, has the potential for soil protection and the development of a principle of soil protection value.[1933] Soil functions and ES enable identification of which object should

[1926] 'New World Soil Charter endorsed by FAO members' (*2015 International Year of Soils*, 17 June 2015) <http://www.fao.org/soils-2015/news/news-detail/en/c/293552/> accessed 24 May 2019
[1927] United Nations (n 11)
[1928] Sylvia L. R. Wood and others, 'Distilling the role of ecosystem services in the Sustainable Development Goals' (2018) 29A Ecosystem Services 70
[1929] JNCC (n 771)
[1930] ibid
[1931] ibid
[1932] HM Government (n 803)
[1933] Carole Hermon, 'Soil protection in law' in Carole Hermon (ed), *Ecosystem Services and Soil Protection* (Université Toulouse 1 Capitole 2018)

be protected, which results in justified conservation efforts in the eyes of the public.[1934] Therefore, there is an identifying and justifying elements to it.[1935] As mentioned above, this Directive did not progress and is not binding, but it is significant for reinforcing the position that soil can be provided further protection by incorporating the concept of ES to its conservation. However, soils still suffer from the absence of a robust framework specifically protecting ES and linking them to soils.

This chapter aims to critically explore possible solutions that can reshape the existing legal approach to environmental protection in a way that effectively protects these valuable benefits. The first objective is to determine the existing policy challenges and how to address these. The second objective is to devise a novel framework providing a set of recommendations, developed through the critical examination of the recommendations found in the literature.

6.2. Existing Policy Challenges

6.2.1. Lack of Awareness in Public

We may be aware of the importance of nature, but we do not view nature's benefits as services. The concept of ES is about human survival and well-being.[1936] Although ES has been in the middle of criticism because of its anthropocentric focus, it is a unique concept in environmental protection, as it places humans in the focus of nature conservation. This concept, therefore, supports a paradigm shift in how we protect nature. It makes environmental protection relevant to everyone, not only to the citizens of high-income countries but also to less advantaged communities, such as indigenous peoples. The concept emphasises that environmental protection is an inclusive humanity issue.

The idea of ES is not yet mainstreamed in policy and decision making. For ES to become more established in these processes, the general public should be made fully aware of these benefits. This awareness of ES values can lead to a behavioural change,[1937] which can aid ES protection to be institutionalised in policy and decision making.[1938] Facilitating opportunities for educating the public on these matters can also strengthen stakeholder participation in decision making and help in reaching its full potential.[1939]

[1934] ibid
[1935] ibid
[1936] Ruhl (n 202)
[1937] UNEP, 'Incorporating Biodiversity and Ecosystem Service Values Into National Biodiversity Strategies and Action Plans' <https://www.unep-wcmc.org/system/dataset_file_fields/files/000/000/004/original/Guidance_doc_NBSAP_A4_FINAL.pdf?1395066492> accessed 7 May 2019
[1938] Richard M. Cowling and others, 'An Operational Model for Mainstreaming Ecosystem Services for Implementation' (2008) 105 PNAS 9483
[1939] Baveye, Baveye and Gowdy (n 749)

Public awareness especially important for soil protection. Soils are mostly ignored by the public, often referred as dirt, and their functions are inevitably ignored as mentioned in the previous chapters. Therefore, the societal attitude to soils affects how well we understand and appreciate what soils offer.[1940] By describing soil ES and their importance, the public becomes more aware of the significance of soils for humans.[1941] The current lack of knowledge leads to a situation where soils are overlooked by law makers and eventually soils are not the main focus of laws.[1942]

The importance of education as a base for an ES framework, therefore, is high.[1943] Some argue that education should be the first step of a framework and followed by monetary valuation, which would be taken into account in financial transactions (discussed below).[1944] Thus, ES can be used as a tool for emphasising the significance and value of soils as the public tends to value soil more when its benefits are communicated openly.[1945] Especially, the contribution of soils beyond food production needs full appreciation.

In England, the Catchment Sensitive Farming Scheme is a good example of developing awareness. It is run by Natural England, in partnership with the Environment Agency and DEFRA, and aims to raise awareness of diffuse water pollution from agriculture by giving free training and advice to farmers.[1946] This scheme demonstrates that starting to raise awareness at a small scale can generate big impact.

Building a knowledge base also creates the opportunity for incorporating soil into the existing ES frameworks. However, first, processes, functions and services of soil should be clearly defined and communicated. This identification should also include EDS. Considering the previously mentioned criticism towards the concept as regards to the terminology can generate a negative attitude, it is neither ethical nor scientific to highlight only the positive aspects of this assessment.

A solution to lack of awareness could be ES being mainstreamed as a principle. The connectivity of the concept to the principle of sustainable development can be used as a tool to raise awareness in public. Soil is NC or stock, yielding a sustainable flow of useful goods and services. This notion also supports intergenerational equity and

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[1940] D. H. Yaalon and R. W. Arnold, 'Attitudes toward soils and their societal relevance: then and now' (2000) 5 Soil Science 165
[1941] Baveye, Baveye and Gowdy (n 749)
[1942] ibid
[1943] ibid
[1944] ibid
[1945] Julia P. G. Jones, 'How can we communicate all that nature does for us?' (*The Conservation*, 27 April 2012) <https://theconversation.com/how-can-we-communicate-all-that-nature-does-for-us-94761> accessed 3 October 2020
[1946] De Vito, Fairbrother and Russel (n 1381)

sustainable use of natural resources. The public should be made aware of the fact that if we continue to degrade our natural resources, nature may not have the capacity to offer the same benefits to future generations.

It is discussed that SDGs for the 2015–2030 period have paid insufficient attention to the significance of soils.[1947] SDGs can be a great tool for highlighting the benefits of soils as these goals are already popular, and there is a high level of interest in the part of the general public for the concept of sustainable development. Therefore, it can be seen as an opportunity to reflect soils through SDGs or similar initiatives that will replace or support these goals in near future. We need to make sure that the concept of ES and the high interest towards it do not have a shelf life and are elapsed. Therefore, there is a constant need for further research and policy solutions for ES.

6.2.2. Insufficient Research

Studying and observing soils are commonly found challenging.[1948] This perception is in line with the fact that scientific research on soil is relatively recent, lacking some tools, such as soil health indicators (pH and SOM).[1949] Soil biodiversity, similarly, is largely unknown.[1950] Thus, our understanding of soil remains incomplete.[1951]

The relationship between the status of soil and its services is also absent.[1952] It is commonly accepted that there is a pressing issue of a lack of scientific studies that link soils to ecosystem functioning and services.[1953] As mentioned earlier, evident studies are mostly focused on provisioning services.[1954] Thus, we have a partial understanding of soil ES.[1955] This situation explains the lack of soil ES in policy established in chapter four. This finding also applies to the valuation studies of soil ES, where the complexity of nature and interrelations of ES and functions are difficult to capture.

In ES research, another problem is that there is a key issue of disparity among different classification frameworks. It is crucial to adopt a universally accepted classification and valuation framework, leaving no discretion. There is ambiguity in the use of terms, such as services, functions and processes, as mentioned in the first chapter.

1947 Adhikari and Hartemink (n 9)
1948 Ariane Chabert, ‘Agricultural soil, an essential yet neglected resource’ in Carole Hermon (ed), *Ecosystem Services and Soil Protection* (Université Toulouse 1 Capitole 2018)
1949 ibid
1950 ibid
1951 ibid
1952 Schwilch and others (n 163)
1953 Adhikari and Hartemink (n 9)
1954 ibid
1955 ibid

Such confusion may lead to double counting, which hinders an accurate valuation or assessment of these aspects.

The lack of proper valuation and market prices of public goods, in this case ES, can cause a market failure (the economic situation defined by an inefficient distribution of goods and services in the free market).[1956] Also, there is a lack of information at decision making level on how people benefit from specific ES.[1957] Beneficiaries of ES are different from those who gain from ecosystem transformation, so where property rights and other social and ecological context are not being considered in conservation, legitimacy and justice concerns can hinder environmental protection.[1958] A just system in which the provision of ES for human well-being and economic development should be supported.[1959] Thus, it is suggested that environmental law specialists have a considerable responsibility for engaging in research to explore the role of ES in regulating these aspects.

The way forward is more multidisciplinary research to develop knowledge and increase credibility. Functions of ecosystems are the result of several processes and interrelationships that occur within a multifaceted ecological whole.[1960] Only if a systemic approach is adopted is there an opportunity to understanding this complex system as a whole.[1961] It is appreciated that environmental issues can only be handled properly in a holistic and integrative manner, which includes diverse policy tools from all scales and scientific evidence.[1962]

Within this systemic approach, firstly, one definitive classification framework that has the potential to be accepted at a global scale should be adopted. Further research should focus on proposals for improvements in this universally accepted definition and classification framework, rather than proposing new frameworks that would create further disparity and confusion. This framework should be developed through holistic and interdisciplinary research that would include specialised experts in the field. Also, this ES research should be geared toward implementation, so the concept does not remain abstract.[1963]

[1956] R. Kerry Turner and Gretchen C. Daily, 'The Ecosystem Services Framework and Natural Capital Conservation' (2008) 9 Environ. Resource Econ. 25
[1957] ibid
[1958] ibid
[1959] ibid
[1960] Mélodie Fèvre, 'Ecosystem services, a functional concept' in Carole Hermon (ed), *Ecosystem Services and Soil Protection* (Université Toulouse 1 Capitole 2018)
[1961] ibid
[1962] Carolin Galler, Christian Albert and Christina von Haaren, 'From regional environmental planning to implementation: Paths and challenges of integrating ecosystem services' (2016) 18 Ecosystem Services 118
[1963] Cowling and others (n 1938)

It is important to add that, considering that soil has been disregarded in the existing ES frameworks, this new framework should have a specific focus for soil, water and air, and should give sufficient attention to each of these environmental media. The rationale behind this notion is that all environmental media are interrelated, and specific issues related to them affect the environment as a whole.

Soil research helps us understand whether soils can be managed to promote the activity of certain organisms in order to ensure the provision of specific ES.[1964] Specifically, it is argued that there is a need for better understanding and documentation of soil biodiversity, more comprehensive economic valuation of soil ES, and an understanding of how to maximise soil benefits to humans.[1965] Indeed, it is commonly accepted that a holistic approach and priority for soil research will provide a robust foundation for land management practices and lead to more sustainable management of natural resources.[1966] Such knowledge could be used to incorporate in different management options to identify the most effective ones.[1967] Here, again it is worth mentioning that the application of knowledge to practice is crucial for actual results in making decisions and the implementation of these decisions.

6.2.3. The Need for Stronger Stakeholder Participation

Ecosystem governance comprises of two processes, namely decision making and the implementation of the decision. There are different types of decisions that need to be made, e.g., local authorities' decisions on planning applications, government bodies' decisions to issue guidance and regulatory decisions in relation to corporations and individuals.[1968] While these decisions are being made, public bodies affect citizens' life as well as industry.[1969] If different stakeholders participate in these decision making processes, procedural justice would be established.[1970]

The link between ES and law and policy enables society to balance principles, such as public participation and equitable share of benefits from nature and public goods.[1971] It is important to adopt a cross-media approach that addresses the limitation of

[1964] Comerford and others (n 123)
[1965] ibid
[1966] D. S. Powlson and others, 'Soil management in relation to sustainable agriculture and ecosystem services' (2011) 36 Food Policy S72
[1967] Comerford and others (n 123)
[1968] Thomas Sikor and others, 'Toward an Empirical Analysis of Justice in Ecosystem Governance' (2014) 7 Conservation Letters 524
[1969] ibid
[1970] ibid
[1971] Ira R. Feldman and Richard J. Blaustein, 'Ecosystem Services as a Framework for Law and Policy' (2007) 37 Envtl. L. Rep. News & Analysis 10756

the existing environmental regulation.[1972] It is emphasised that achieving SDGs (such as eradicating hunger and ensuring environmental sustainability) require investment in ES as the concept is highly central for local communities.[1973] Although the academic community has not fully comprehended ES, we must incorporate our current knowledge into policy making, considering the urgency of disruption of ecosystems.[1974]

There are other problems related to the concept of stakeholder participation, such as the lack of resources for facilitating participation, which is also relevant to environmental justice. Most of the communities that rely on these services and utilise natural resources for their livelihood are disadvantaged ones, such as lower income groups or indigenous peoples. Although these communities provide traditional ecological knowledge through their direct and long-term contact with nature, which is a crucial component of conservation, international law does not effectively facilitate the participation of these communities. Indeed, these communities exist in one location for a very long time, which makes them the best witnesses of the changes in the flow of ES. As local ecological knowledge is collected over one's lifetime through vast observations and experience in interacting with ecosystems,[1975] it can be used for obtaining information on specific services and how to manage an ecosystem in more sustainably.

The reflection of the lack of participation at national level shows similarity. The effectiveness of the UK implementation of international law that requires meaningful participation in decision making is debateable. At the national level, there is an evident lack of influence on decisions, stemming from a low participation rate, which results from the fact that authorities inform the public on the matter insufficiently. It is argued that when it comes to ecological knowledge, the UK shows a diverse pattern, namely the uptake of such knowledge is somewhat limited in cases where planning and policy appraisal is the focus.[1976] However, it was found more widespread at the local level.[1977]

Land management and soil protection can be seen as areas in which local knowledge is extremely valuable. The UK farmers have in-depth knowledge of soils as agriculture is one of the leading sectors. An example can be given as farmers' detailed

[1972] ibid
[1973] ibid
[1974] ibid
[1975] P. Olsson and C. Folke, 'Local ecological knowledge and institutional dynamics for ecosystem management: a study of lake Racken watershed, Sweden' (2001) 4 Ecosystems 85
[1976] Andrew Jordan and Duncan Russel, 'Embedding the concept of ecosystem services? The utilisation of ecological knowledge in different policy venues' (2014) 32 Environment and Planning C: Government and Policy 192
[1977] ibid

understanding of the variations that occur in topography, vegetation and microclimate at the landscape scale.[1978]

Although local ecological knowledge is valuable, it is best utilised when combined with scientific findings and supported with a practical perspective.[1979] The main point here is the need for decision makers to evaluate various different management strategies regarding natural resources.[1980] Participation in decision making is important as it can further knowledge, contribute mutual learning and reveal implications for governance.[1981] However, there are challenges, such as the risk of ES being harmed while establishing learning and involving stakeholders.[1982] Thus, knowledge should be incorporated into action as quickly as possible.[1983]

Another perspective to stakeholder participation is the advantages it offers. These benefits are seen as further legitimacy through transparency. Indeed, transparency will be achieved by incorporating knowledge and information on the gains and losses of a decision. Also, a decision's pros and cons examined from three pillars of sustainability perspective will lead to more objective decisions.

Following the farmer example, a farmer using conventional farming methods, such as inorganic fertilisers, makes this decision on an economic perspective as he saves time and money by boosting the production. However, there are numerous externalities that are related to his decision. In this context, this externality can be an effect that a third party suffers without having a say in that decision. This point emphasises the importance of stakeholder involvement. Participation is also relevant for future generations because future generations will ultimately be affected by these decisions and cannot participate in decision making. Through more legitimate decisions that consider the needs of different communities as well as the current and future generations, this outcome can be partly avoided.

A similar approach was seen in the Natural Capital Project, which develops and applies tools and practical approaches to integrate NC into decisions.[1984] InVEST is software developed as a part of this project and provides simple models to inform decision

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[1978] Laxman Joshi and others, 'Soil and water movement: combining local ecological knowledge with that of modellers when scaling up from plot to landscape level' <http://apps.worldagroforestry.org/downloads/Publications/PDFS/bc04190.pdf> accessed 2 May 2020
[1979] ibid
[1980] Sitas and others (n 294)
[1981] ibid
[1982] Jordan and Russel (n 1976)
[1983] ibid
[1984] Mary Ruckelshaus and others, 'Notes From the Field: Lessons Learned From Using Ecosystem Service Approaches to Inform Real-World Decisions' (2015) 115 Ecological Economics 11

making.[1985] This practice does not have to be only through monetary metrics (e.g., how ES support food security and prevent malnutrition does not always have to be reflected in monetary terms).[1986] Also, it is crucial to have legitimate information that is unbiased and represents different stakeholders' views.[1987]

It is clear that in an ES-based framework, there should be incorporation of local knowledge and participation from stakeholders in developing potential scenarios that would result from different management options.[1988] It is argued that the benefit of an ES-based approach in decision making is not apparent in allocation of individual services but will be more evident in the interaction of resource use across a range of services.[1989]

The Ecosystem Services Framework (ESF), which will be introduced in this chapter, can be a useful approach if the essential political tools, namely local knowledge and stakeholder participation, are utilised. The UK planning system can be an example. An ideal planning system should benefit communities, the environment and the economy. Decisions should be fair and transparent in a system that gives the public the chance to participate and be heard in decisions that affect their environment and that of future generations.[1990] The related key issue in this system is that it is based on a development control permission granted at the local level. This leads to permissions granted by local planning authorities, which invoke a consultation process that gives significant weight to Not In My Backyard (NIMBY) pressures (public opposition to proposed developments only if they are in their local area).[1991] It is suggested that national government must take the decision to reduce the influence of NIMBY campaigns.[1992] Indeed, the impact of these campaigns in the planning process should be reduced as they deepen wealth inequality, which is increased by the current system.[1993] Through promoting further public participation as an essential part of the ESF, these inherited issues seen in the UK planning system can also be overcome. This point suggests that the ESF can be used to enhance various systems within the policy context.

[1985] ibid
[1986] ibid
[1987] ibid
[1988] Frank and others (n 294)
[1989] Mark Everard, *Ecosystem Services: Key Issues* (Taylor & Francis 2017) 58
[1990] Friends of the Earth, 'The English Planning System: An overview' (March 2020) <https://cdn.friendsoftheearth.uk/sites/default/files/downloads/English%20Planning%20System%20an%20overview%20FoE.pdf> accessed 21 July 2020
[1991] Christian Hilber, 'The UK planning system – fit for purpose?' (*PBC Today*, 6 July 2016) <https://www.pbctoday.co.uk/news/planning-construction-news/uk-planning-system-fit-purpose/26098/#:~:text=The%20trouble%20with%20the%20UK,the%20benefits%20of%20the%20intervention.> accessed 21 June 2020
[1992] Anthony Breach, 'Capital Cities' (*Centre for cities*, 11 June 2019) <https://www.centreforcities.org/reader/capital-cities-how-the-planning-system-creates-housing-shortages-and-drives-wealth-inequality/27704-2/> accessed 21 June 2020
[1993] ibid

In summary, an ideally functioning ESF could be useful for correcting political weaknesses in different policy areas. To achieve this, the ESF should enable local communities to use their rights to resources in their communities and have a significant voice in decisions about these resources that are likely to affect them.[1994] These communities and stakeholders should be given access to information[1995] and ample opportunities to challenge these decisions if necessary. These aspects facilitate a more environmentally just system in which costs and benefits are more evenly distributed.[1996]

6.2.4. Ignoring Ecosystem Disservices

Any framework would be weakened by the omission of EDS and downplaying of trade-offs unless these are included.[1997] Accordingly, if EDS are ignored, decision makers cannot evaluate the overall impact of a specific management option. An example can be given as many different aspects that contribute to ES in agriculture can also be a source of EDS, such as loss of biodiversity, agrochemical contamination and sedimentation of waterways, pesticide poisoning of non-target organisms, and emissions of GHG and pollutants.[1998]

These EDS generate a precise cost to humans. The problem can occur from the fact that the costs are not always borne by the same part of society, which leads to an inequality, as mentioned before. Mostly, this situation leads to environmental injustice.[1999] Therefore, incorporating EDS is crucial for safeguarding communities at multiple scales by ensuring that some parts of society are bearing the costs and being impacted by EDS, whilst the other part is enjoying the benefits (intra-generational equity among the current generation, across social strata and regions.). An example for intra-generational trade-offs between one renewable resource stock can be given as wood provision and recreational services provided by a forest.[2000] It can be argued through the same approach in inter-generational equity, which is a trade-off between the consumption of ES by today's people and the conservation of renewable resource stocks for future people, such as between present provision of agricultural goods and the maintenance of

[1994] Francis Irwin and Janet Ranganathan, ‘Restoring Nature’s Capital: An Action Agenda to Sustain Ecosystem Services’ (WRI Report 2007) <https://files.wri.org/s3fs-public/pdf/restoring_natures_capital.pdf> accessed 3 May 2020
[1995] ibid
[1996] ibid
[1997] Lele (n 213)
[1998] Power (n 232)
[1999] ibid
[2000] Stefanie Glotzbach and Stefan Baumgärtner, ‘The relationship between intragenerational and intergenerational ecological justice’ (2012) 21 Environmental Values 331

fertile soils for future agricultural production.[2001] Indeed, ES is a useful tool for assessing both intra- and inter-generational equity.[2002]

Such injustice can also be as a result of specific management options. Looking back at the farmer example, the farmer's choice of using pesticides might have adverse impacts on the local community's drinking water.[2003] The negative externalities can be reflected through better understanding and integration of EDS. Specifically in agriculture, it is discussed that incorporating the externalities into production costs might reduce these negative environmental impacts of agricultural practices.[2004]

Overall, it is clear that evaluating both EDS and ES for the management of ecosystems is crucial.[2005] The use of these concepts would lead to a greater comprehension of ecosystem functioning and eventually develop positive effects, while limiting negative ones.[2006] So, the ESF is useful for placing services and disservices under a common assessment framework for establishing a comprehensive overview of the net benefits of ecosystem functions for human well-being and the environment.[2007]

6.3. The Ecosystem Services Framework

An integrated ESF will respond to those who critic the concept of ES because this framework is not designed to supplant or replace the conservation factors already in place, but it should be complementary.[2008] The concept of ES should be seen as a tool to include ecological values and intrinsic values into the mix.[2009] In line with this argument, ignoring ES would leave the conservation policy incomplete.[2010] In the face of the emerging environmental issues and threats, we should use all potential tools to guarantee robust environmental protection.[2011]

The existing manner we have is reflected through the linear economy, which is focused on eternal economic growth. It is clear that we still have a long way to go to fully adopt circular economy, which is much more sophisticated and emphasises the understanding of human-environment relationship. Now that we are reaching the upper

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[2001] ibid
[2002] Everard (n 1989) 58
[2003] Power (n 232)
[2004] ibid
[2005] Carole Sylvie Campagne, Philip Roche and Jean-Michel Salles, 'Looking into Pandora's Box: Ecosystem disservices assessment and correlations with ecosystem services' (2018) 30 Ecosystem Services 126
[2006] ibid
[2007] Lyytimäki (n 228)
[2008] Ruhl (n 202)
[2009] ibid
[2010] ibid
[2011] ibid

limit of our NC and resources, we should indeed switch to a more intelligent model in decision making.

Similarly, in traditional decision making, the integrated nature of changes in ecosystems is not apparent to the decision maker as they consider one unit. For example, if the decision makers decide to increase the production of wheat, it may be beneficial for the economy, but at the same time, it decreases water quality, increases the emissions, causes a decline in bird habitats. Thus, this approach which is focused on irresponsible degradation of natural resources for economic growth is not sustainable in the long run. The use of ES has the potential for offering a more holistic, integrated and intelligent model for decision making.

These challenges stemming from the adoption of sustainable development and the weaknesses in our existing approach can be overcome by adopting ecosystem nexus that offers a more systemic thinking and understanding of the complex relationships in the social–ecological systems for delivering integrated solutions.[2012] Indeed, an ES-based framework is rather holistic; instead of focusing on biophysical measures, it will focus on ES measures.[2013] For example, a biophysical measure helps the understanding how a pollutant impairs water quality by assessing changes in oxygen levels in the water.[2014] An ES measure would highlight the changes in commercial fish catch, beach closures, recreational days, neighbouring property values, and lost value for future generations.[2015] Such an approach to law and policy will emphasise ES-dependent human needs and eventually address ecosystem-related issues.[2016]

Taking into account interactions amongst ecosystems, living organisms, and natural or managed environments in any public policy decision that has an environmental impact is crucial. This need is reflected in the principle of ecological solidarity, which also implies sharing costs related to maintaining ecosystems in good order with the geographical areas that benefit from them.[2017]

It is clear that adopting the ESF can address many problems that the existing approaches fail to resolve. It is essential to discuss how to implement such a framework: First, it is crucial to set a number of priorities through assessing the economic and non-economic justification for safeguarding well-known ES involving stakeholders,

[2012] Jianguo Liu, Wu Yang and Shuxin Li, 'Framing ecosystem services in the telecoupled Anthropocene' (2016) 14 Frontiers in Ecology and the Environment 27
[2013] Ori Sharon and others, 'Ecosystem services and judge-made law: A review of legal cases in common law countries' (2018) 32 Ecosystem Services 9
[2014] ibid
[2015] ibid
[2016] Feldman and Blaustein (n 1971)
[2017] Fèvre (n 1960)

monitoring the outcomes of safeguarding efforts, taking innovative actions towards safeguarding less-known ES.[2018] Also, obtaining information is vital so the information gap, especially on local ES, should be addressed.[2019] This gap can be about marginal values of ES or non-linear ecosystem responses to human impact.[2020] Another significant aspect is taking action. One method can be ES area maps to illustrate alternative land management options for more societal benefit and more sustainable outcomes as well as the future scenarios including the potential changes under these different management options.[2021]

The ESF presented in this present study has five consecutive steps that complete one another (Table 6.1.). Step one is identifying the issue, which concerns where we are in environmental, economic and social terms. This step includes the assessment of the state of ES and identification of the ecosystem changes due to the current practices, which inevitably includes local knowledge, sufficient information and interdisciplinary research. This step will allow us to understand the problem in an area that needs to be addressed and is a crucial step for step two. The second step is focused on where we wish to be in environmental terms. In this step, environmental objectives will be set, which are vital for producing a roadmap incorporating other pillars of sustainable development, i.e., economic and social dimensions. This integration will help setting more realistic goals. Step three requires developing different scenarios and potential policy instruments and choosing the best management approach. This step will use the information on the state of ES, then produce multiple management options and policy instruments. This step involves picking the most beneficial soil management approach, including win-win situations and, if necessary, trade-off situations. Here, we need to include EDS as well for more accurate results. This selection requires public participation, which increases legitimacy and credibility. The next step is the implementation and enforcement. Policy instruments and management options that are found to be the most beneficial ones should be properly implemented and implementation should be supported by enforcement. Enforcement might come across as the most challenging part, but it is crucial to support the adoption of these new practices by regulatory action. Here, environmental principles can be helpful guidance, such as polluter pays principle. The final stage of this framework is monitoring. This step will ensure that the adopted approach and instruments remain as the most sustainable options. This step will also help identify the changes in the

[2018] Daily (n 81)
[2019] ibid
[2020] ibid
[2021] ibid

circumstances, which will alert decision makers for a need for future reform that follows the recent changes and new requirements.

Table 6.1. The Ecosystem Services Framework.

This table shows the steps of the ESF and gives summarised information on the aims of these steps, related principles, targets and tools that can be used to realise them and the potential outcomes of each step.

	Aim	Overarching Principles	Targets	Tools	Expected Outcomes
Step 1	Identifying the environmental, economic and social issues	- Sustainable development	- Assessment of the state of the environment, including ES - Analysis of the effectiveness of law in protecting the environment and specific environmental media - Prioritising action points and areas (environmental, economic or social)	- Public education - Use of local knowledge - Further interdisciplinary research	- Greater public awareness - Increased knowledge on ecosystems and their functions and services - A clear classification scheme of soil processes, functions, services and disservices - Identified gaps in the existing law and policy
Step 2	Setting environmental objectives	- Sustainable development - Public participation	- Identification of a vision and a strategy to realise that vision and objectives	- Incorporation of information and knowledge obtained from Step 1 - Collaboration of government agencies and private actors including citizens - Environmental principles as guidance - Countries' national efforts and international commitments	- A set of environmental objectives that reflect the public's interests and are precise, implementable, realistic, operationalisable and unbiased without any potential conflicts between economic or social interests
Step 3	Developing scenarios and choosing the best management approach	- Sustainable development - Public participation	- Identification of more sustainable management options through identifying potential impacts of different scenarios	- Use of accurate and complete information from Step 1 in the light of the objectives from Step 2 - Scenario development - Identification the potential impacts of different options - Identification of synergies between different ES	- Multiple scenarios and management options for decision makers to choose from

Step 4	Implementation and enforcement	- Public participation - Polluter pays principle - Steward earns principle	- Full implementation of decisions and compliance	- Property rights - PES schemes for encouraging stewardship - Compensation as prevention schemes	- Appropriate implementation - Stronger enforcement and eventually further compliance - ES mainstreamed in the legal scene
Step 5	Monitoring	- Sustainable development - Public participation	- Continual monitoring of the state and provision of ES with the aim of addressing emerging risks at local, regional and national level - Understanding how well ES-related decisions and management options work in real-world and over time	- A set of indicators such as economic and biophysical	- A clear set of data on the state of ES - Continuous feedback for decision and policy makers on how well the existing approach works

6.3.1. Step 1: Identify the Issue

This step is targeted for understanding different aspects of the existing situation regarding ecosystems. Firstly, it should aim to reveal where we are in environmental, economic and social terms. A focus on the state of the environment will expose the areas that need action to be taken or to be prioritised. The reason for having the objective of understanding the existing economic and social situation is to truly establish whether we must prioritise these pillars. Indeed, the umbrella principle for this step is sustainable development. Therefore, we should make sure that these three areas of development are hand in hand, and not undermining each other. This first step of the framework also aims to recognise the law and policy related issues, meaning, we should identify the weaknesses, gaps and challenges in law and policy to pinpoint which areas require improvement.

In environmental policy, especially for ES, there exists several issues stemming from different geographical scales. Indeed, the most accurate geographic demarcations for ES policy may conflict with political or administrative demarcations.[2022] One way to overcome this could be seen as adopting Ecosystem Services Districts (ESD). The objective of such districts is to protect and maintain NC at the local level by identifying ES, their sources, users, ecological and economical characters.[2023] ESD, instituted legislatively or by local initiatives, have a potential for assisting in the provision and

[2022] Feldman and Blaustein (n 1971)
[2023] Irwin and Ranganathan (n 1994)

protection of ES by achieving administrative consensus among stakeholders or communities that are dependent a set of ES.[2024] This assessment would include the quantity and quality of the service, the geographic extent, and the type and degree of human modification. The analysis would also consider how changing one service would affect another. It would also look at the costs and benefits of alternative management options,[2025] which is found in the third step of this framework.

ESD have been considered in soil conservation in the US.[2026] These have been provided with legal authority, such as the power of taxation.[2027] A similar geographic demarcation for ES in the UK, excluding the legal authority, was used and proposed in the Ecosystem Accounts for Protected Areas in England and Scotland project.[2028] This project aimed to test and apply methods for NC accounting, and to generate a tool to inform ecosystem management decisions within these areas, and to map physical and monetary flows of 15 different ES.[2029] This study concluded that ecosystem accounts can be used in more specific spatial applications to improve evidence and decisions concerning the management of particular ecosystem assets and their service provision.[2030] It was also suggested that it allows a better understanding of the values of different ecosystems and their services and thereby facilitate engagement and access to funding, support policy development (considering trade-offs), and influence local government by making an economic case for investment in particular assets through highlighting the hidden benefits of their area.[2031]

This approach was found to be potentially useful for several reasons, including promoting understanding and awareness amongst key stakeholders (e.g., surrounding local authorities) and the general public, supporting decision making and management within the area itself (e.g., achieving an appropriate balance between competing priorities), and enhancing the ecosystem functionality of different land parcels to maximise the delivery of ES.[2032] These benefits include influencing legislative decisions,

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[2024] Feldman and Blaustein (n 1971)
[2025] Irwin and Ranganathan (n 1994)
[2026] Geoffrey Heal and others, 'Protecting Natural Capital Through Ecosystem Service Districts' (2001) 20 Stan. Envtl. L. J. 333
[2027] ibid
[2028] 'Ecosystem Accounts for Protected Areas in England and Scotland: Lake District National Park' (*Ecosystem Knowledge Network*) <https://ecosystemsknowledge.net/natcap-project/ecosystem-accounts-protected-areas-england-and-scotland-lake-district-national-park> accessed 21 June 2020
[2029] ibid
[2030] Chris White and others, 'Developing ecosystem accounts for protected areas in England and Scotland: Main Report' (2015) <http://sciencesearch.defra.gov.uk/Document.aspx?Document=13488_DevelopingecosystemaccountsforprotectedareasinEnglandandScotland-MainReport.pdf> accessed 20 June 2020
[2031] ibid
[2032] ibid

thus the concept of ESD should also comprise transferring knowledge into real-world issues and decisions to enable this outcome.

Firstly, mapping of ES under ESD would illuminate the different types of ES that could flow under different management approaches.[2033] It would also reveal and forecast the potential changes.[2034] This practice would indicate the need for certain ES under alternative future scenarios, such as climate change or land use options.[2035] One problem with these districts can be the jurisdictional and political contest.[2036] Political jurisdictions do not follow the boundaries of ES, so it is suggested that information exchange among different districts is vital.[2037] The ESD approach serves local needs as well as it has a potential for contributing to larger (national) systems regarding ES.[2038] On the other hand, districts can help with these conflicts by improving the link between resources to funding opportunities or land choice mechanisms.[2039]

Local districts responsible for a particular ES provision are found in many states, e.g., flood protection or water purification in a watershed.[2040] An example of management based on the natural geographical unit instead of according to administrative or political boundaries can be seen at the EU level in river basin management under the WFD. This system reflects a level of legal acceptance, which verifies the potential for an application of the concept to soil management.

ESD can be responsible for a specific service (e.g., flood protection) as seen in several countries and some districts consider construction of capital assets (e.g., dams) to ensure that the service is available.[2041] Natural assets (e.g., flood protection service of forests) are not always considered in a cost-benefit analysis (CBA).[2042] Establishing ESD can be proposed as a tool for developing and utilising knowledge about natural assets.[2043] This aspect is crucial as the natural asset option may be more cost-effective and provide additional services in some cases[2044] (as will be explained further below in the Catskills example).

[2033] Irwin and Ranganathan (n 1994)
[2034] ibid
[2035] ibid
[2036] Heal and others (n 2026)
[2037] Irwin and Ranganathan (n 1994)
[2038] Feldman and Blaustein (n 1971)
[2039] Irwin and Ranganathan (n 1994)
[2040] ibid
[2041] ibid
[2042] ibid
[2043] Heal and others (n 2026)
[2044] Irwin and Ranganathan (n 1994)

In the ESD context, mapping of ES can be used, which emphasises the spatial congruence of different services and identifying the optimal allocation of services.[2045] This practice would illuminate three sets of information: The levels and types of services that could be supplied under alternative land management regimes; and the degree of spatial congruence in the supply of different services.[2046] It would also help forecasting changes in both services, and in societal need for them, under alternative future scenarios of demographic, land use and climate change.[2047] This practice reveals ES that are produced and consumed locally or exported, or produced and consumed globally.[2048] Information from soil and ES assessments have been used by governments for planning and decision making, e.g., the EU Biodiversity Strategy sees ES mapping as an action to be included.[2049]

There is a clear lack of direct quantitative measurements of soil functions and ES. The problem emerges from the notion of estimating these through simple assumptions and approximations, which do not reflect the actual measurements without uncertainties.[2050] These uncertainties are also seen in the use of ES indicators.[2051]

In order to quantify soil ES directly, the Bayesian Belief Network (BBN) approach was found quite useful for two reasons: its emphasis on uncertainties,[2052] and its structured and standardised approach that incorporates expert knowledge into spatial analysis and decision support.[2053] Some studies have used the BBN approach to map uncertainties in multiple ES assessments with the aim of linking BBNs to geographic information systems (GIS) for forecasting the value of these services and quantify the uncertainties.[2054] Still, communicating uncertainties to ES quantification and valuation to decision makers is in its infancy.[2055]

A popular tool specific for soils in this sense is the Soil and Water Assessment Tool (SWAT), which is used to simulate the quality and quantity of surface and ground water and predict the environmental impact of land use, land management practices, and

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2045 ibid
2046 Heal and others (n 2026)
2047 ibid
2048 Daily (n 81)
2049 Commission, 'Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – EU Biodiversity Strategy for 2030: Bringing nature back into our lives' (Communication) COM (2020) 380 final
2050 Baveye, Baveye and Gowdy (n 749)
2051 ibid
2052 ibid
2053 D. Landuyt and others, 'A review of Bayesian belief networks in ecosystem service modelling' (2013) 46 Environ. Model. Softw. 1
2054 Adrienne Grêt-Regamey and others, 'Facing uncertainty in ecosystem services-based resource management' (2013) 127 Journal of Environmental Management S145
2055 ibid

climate change.[2056] It is widely used in assessing soil erosion prevention and control, non-point source pollution control and regional management in watersheds.[2057] SWAT can present significant outputs at several spatial and temporal scales.[2058] This is clearly a flexible tool; however, there are questions regarding whether it is the best approach for the link between soil ES and these forecasting at many scales.[2059] At this point, the need for further research to develop appropriate methods for this assessment must be emphasised.[2060]

Regarding soil assessments, there are challenges that may result in assessment output being rather incomplete or inaccurate. To start with, when assessment is focused on a shallow portion of soil, it may produce inaccurate results as the soil that needs to be considered may be below that depth.[2061] Because, different soil layers contain different proportions of soil material.

Another issue is the prediction of soil ES requires knowledge of dynamic properties of soils, and it is a major challenge to estimate these based on an assessment that produces data that does not change after being recorded. However, the UK Soil Observatory makes an important contribution to this.[2062] Furthermore, some have argued that there are three underlying properties of soils that determine all ES variables, namely texture, mineralogy and SOM.[2063] Nonetheless, it is not possible to extract information about each and every ES based on these properties; thus, further information from these maps and assessments should be obtained.[2064]

Most of the current frameworks focused on soil ES explicitly highlight services whilst failing to disentangle the complex links and underlying soil properties and processes.[2065] Another problem occurs where assessments are focused on one specific function or service. This issue generates crucial problems, such as trade-offs cannot be completely assessed in choosing the best management options. There are, indeed, challenges when it comes to measuring and quantifying ES.[2066] However, comprehensive

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[2056] 'SWAT – Soil & Water Assessment Tool' <https://swat.tamu.edu/> accessed 9 June 2020
[2057] ibid
[2058] W. Francesconi and others, 'Using the Soil and Water Assessment Tool (SWAT) to model ecosystem services: a systematic review' (2016) 535 J. Hydrol. 625
[2059] Baveye, Baveye and Gowdy (n 749)
[2060] Grêt-Regamey and others (n 2054)
[2061] David A. Robinson and others, 'On the Value of Soil Resources in the Context of Natural Capital and Ecosystem Service Delivery' (2014) 78 Soil Sci. Soc. Am. J. 685
[2062] Baveye, Baveye and Gowdy (n 749)
[2063] C. Palm and others, 'Soils: a contemporary perspective' (2007) 32 Ann. Rev. Environ. Res. 99
[2064] Xiong Xiong and others, 'Assessing uncertainty in soil organic carbon modeling across a highly heterogeneous landscape' (2015) 251-252 Geoderma 105
[2065] Changhong Su, Huifang Liu and Shuai Wang, 'A process-based framework for soil ecosystem services study and management' (2018) 627 Science of The Total Environment 282
[2066] Schwilch and others (n 163)

assessment is needed and when there is a service that is difficult to quantify, this should not be avoided.[2067] Also, this assessment should be comprehensive. Direct measurement of functions and services is challenging, so indicators can be employed to identify biotic or abiotic characteristics that are correlated with specific soil functions and ES.[2068] An ES indicator can be defined as information that communicates the characteristics and trends of ES, which serves for policy and decision makers to comprehend the state, trends and rate of change in ES.[2069] These indicators should be easily quantified[2070] and sensitive to minor changes, such as earthworms representing soil quality and being influenced by weather and food.[2071] It can be argued that these indicators provide such information but it is unlikely to determine what is a good indicator unless there is an actual measurement for soil functions and ES.[2072]

For soil functions and ES, biodiversity is seen as a useful indicator, which makes soil biodiversity maps useful for soil ES mapping. However, it should be considered that assessing soil biodiversity has its challenges.[2073] There is evidence that there may be threshold levels for soil biodiversity below which soil functions begin to decline.[2074] The causal link between these two concepts is still being studied.[2075]

Assessment of the existing environmental circumstances should include determining the current state of NC and the flow of ES. This assessment should extend to forecasting the state of these in future. This objective can be achieved by developing analytical tools for projecting future trends, such as Artificial Intelligence for Ecosystem Services (ARIES), which quantifies, maps and values ES to aid in conservation and spatial policy planning.[2076] Understanding the potential impacts of different management options is the focus of the third step of the ESF, which uses the information obtained in this first step. Also, evaluating the success of interventions and indicators to monitor

[2067] ibid
[2068] Dominati and others (n 13); Ulrike Wassen Hayek and others, 'Bringing ecosystem services indicators into spatial planning practice: Lessons from collaborative development of a web-based visualization platform' (2016) 62 Ecological Indicators 90
[2069] C. Layke and others, 'Indicators from the global and sub-global Millennium Ecosystem Assessments: an analysis and next steps' (2012) 17 Ecological Indicators 77
[2070] V. H. Dale and S. Polasky, 'Measures of the effects of agricultural practices on ecosystem services' (2007) 64 Ecol. Econ. 286
[2071] Heinz-Christian Fründ, Ulfert Graefe and Sabine Tischer, 'Earthworms as Bioindicators of Soil Quality' in Ayten Karaca (ed), *Biology of Earthworms* (Springer 2010)
[2072] Baveye, Baveye and Gowdy (n 749)
[2073] ibid
[2074] Heiki Setälä and Mary Ann McLean, 'Decomposition rate of organic substrates in relation to the species diversity of soil saprophytic fungi' (2004) 139 Oecologia 98
[2075] M. G. Kibblewhite, K. Ritz and M. J. Swift, 'Soil health in agricultural systems' (2008) 363 Phil. Trans. R. Soc. B 685
[2076] 'Artificial Intelligence for Ecosystem Services' <http://aries.integratedmodelling.org/> accessed 7 June 2020

biological, physical, and social changes is useful for the functionality of these tools,[2077] which can be seen in the final step of this framework.

This first step of the ESF will provide the necessary knowledge to mainstream ES in local land use planning strategies and policy, strategy, and management.[2078] First of all, it is crucial to identify, measure, monitor and value the services. Identifying NC and ES has been problematic as there are several classification frameworks, as mentioned before. Emphasising the recommendation for adopting one universally accepted classification framework, the identification must be done properly revealing NC, ecosystem structures and processes, functions, services. The blurred lines among these terms should be eliminated in order to prevent potential issues, such as double counting. This step should also include the identification of the beneficiaries of ES.[2079] This recognition is especially important where burdens and benefits are borne inequitably by different groups of society. Indeed, such situations magnify the existing environmental injustice.

Here, it must be highlighted that there is a need for multidisciplinary research. Identifying ecological structures, processes, functions and services of an ecosystem requires ecological research and tools.[2080] Biophysical assessment also provides information on the types and flows of ES.[2081] It is also important to obtain information from geographic research to locate NC that provide these services.[2082] Also, as mentioned earlier, integrating local knowledge into scientific research is extremely important for achieving the objectives.

Biophysical research outcomes should be properly communicated to researchers from other disciplines to be incorporated into further research. In this case, this knowledge will be used for understanding how these services benefit humans in financial terms.[2083] Inevitably, this calls for economic- and social-based research. A social-based assessment must identify the owners and beneficiaries of functions that deliver ES, markets for ES as well as limitations that hinder implementation.[2084] A biophysical assessment provides a case for safeguarding ES more than valuation assessment as the latter merely provides dubious estimates of the reduction of monetary values of ES.[2085]

[2077] Stephen R. Carpenter and others, 'Millennium Ecosystem Assessment: Research Needs' (2006) 314 Science 257
[2078] Cowling and others (n 1938)
[2079] Ruhl (n 202)
[2080] ibid
[2081] Cowling and others (n 1938)
[2082] Ruhl (n 202)
[2083] ibid
[2084] Cowling and others (n 1938)
[2085] ibid

Valuation assessment, informed by other social and biophysical assessments, can be effective in enabling informed trade-offs in CBA.[2086] Using economic valuation instead of biophysical assessment will result in obtaining partial information and risking a potential for sustainable management of ecosystems.[2087] These should be complementary. CBA's focus is measuring the marginal change in the provision of services with market values (e.g., water provision), comparing to a competing land use when there is trade of it (e.g., real estate).[2088] This is for market prices, not that all ES have market prices, but this does not mean that they do not have non-monetary value.[2089]

The assessment of the states of ES is already being done[2090] using several tools.[2091] These can be classified in different categories, namely ES impact assessment tools (ESR, Co$ting Nature), landscape-scale modelling and mapping tools (ARIES, EcoAIM, EcoServ, Envision, EPM, ESValue, InFOREST, InVEST, LUCI, MiMES, SolVES); site-scale modelling tools (EcoMetrix, LUCI); non-monetary valuation tools (EcoAIM, ESValue, SolVES); and monetary valuation tools (NAIS, Ecosystem Valuation Toolkit, Benefit Transfer and Use Estimating Model Toolkit).[2092] While suggesting the use of a specific tool is not in the scope of the present study, it must be noted that some tools are complementary, and others serve multiple purposes.[2093] Therefore, after careful consideration, a decision should be made regarding which ones to utilise in an assessment focused on a specific spatial or temporal scale. Again, it is crucial to promote continuity of multidisciplinary research in order to understand how effectively these tools offer desired outputs, track the development of new tools and expanded capabilities of existing tools.[2094] Tools with transparent, well-documented, and validated results, which are also flexible enough to quantify ES in different contexts are required in decision making processes.[2095] Indeed, the output of these tools can only be operationalised when incorporated in decision and policy making processes. Although scientists and lawyers

[2086] ibid
[2087] Tiina Häyhäab and Pier Paolo Franzese, 'Ecosystem services assessment: A review under an ecological-economic and systems perspective' (2014) 289 Ecological Modelling 124
[2088] Cowling and others (n 1938)
[2089] ibid
[2090] Thomas Elmqvist and others (eds), *Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities* (Springer 2013)
[2091] Bagstad and others (n 294)
[2092] ibid
[2093] ibid
[2094] ibid
[2095] ibid

strive for different goals, science can be used as a political tool to gain public approval[2096] and law has a vital role for operationalising scientific data within public policy.[2097]

The final limb of this first step of the framework is a legal analysis, such as the one presented in the previous chapter. Although law has an undeniably crucial role in the protection of these services, as seen in the present study, it is not always effective in achieving this objective. This stage requires a clear identification of opportunities and constraints for implementation.[2098] A specific legal analysis on the effectiveness of law should be produced, similar to the analysis presented in chapter five. Such an analysis can help identify the policy gaps, which can be eliminated partly or altogether. This legal analysis should focus on the specific environmental issues that are being addressed and an emphasis on how effective the law is in protecting ES. This analysis should also consider how well the less obvious services, such as supporting ES, are being safeguarded by the law.

The first step should achieve its abovementioned targets utilising necessary tools in the light of its aim and overarching principles (Table 6.1.). At this stage, there should be greater public awareness and increased knowledge regarding soil and soil ES. Also, a clear classification scheme that identifies soil processes, functions, services and disservices should be established. Accordingly, the current state of these should be revealed. The issues in law and policy that may result in impaired environmental protection should be identified as in chapter five. In the ESF, once there exists sufficient research output, the second step can be considered.

6.3.2. Step 2: Set Environmental Objectives

This step comprises of what is expected as the outcome of the adoption of this framework. It comprises of where we wish to be in environmental terms. Environmental objectives are set, which is a crucial step in framing conservation efforts or interventions. These objectives focus on environmental expectations, but also incorporate other pillars of sustainable development, i.e., economic and social pillars, in order to set more realistic and achievable goals, which fully encompass all the need of stakeholders.

The second step of the framework includes the identification of a vision, a strategy to realise that vision and a set of objectives.[2099] For example, Swedish environmental

[2096] John McEldowney and Sharon McEldowney, 'Science and Environmental Law: Collaboration across the Double Helix' (2011) 13 Environmental Law Review 169
[2097] Ruhl (n 202)
[2098] Cowling and others (n 1938)
[2099] ibid

policy is based on the Parliament's adopted principles, objectives, interim targets, strategies, and follow-up mechanisms.[2100] These aspects build a solid ground for increased efficiency and improved prioritisation in environmental policies and demonstrate that such a vision is realistic and workable.[2101]

The environmental objectives in this step should be precise, and ambiguity in their formulation should be avoided.[2102] They should also be realistic and operationalisable.[2103] The potential conflicts among different objectives should be properly considered.[2104] Indeed, when defining the objectives, there should be no biased approach towards economic or social pillar of sustainable development.[2105] However, with the limited amount of money that governments have, it is unclear how to decide where to put these resources in. Consequently, there will be competing interests at multiple levels of decision making.[2106] Finally, objectives should be supported by references to relevant overarching environmental principles. This relationship will support the holistic environmental policy and reflect the countries' international commitments alongside domestic efforts.

Effective governance comprises of the successful collaboration of governmental agencies and private actors (e.g., NGOs, companies, citizens), towards these mutual objectives, and within a system of rules and regulations, i.e., law and policy.[2107] It is clear that once these objectives are set, coordination and cooperation among multiple actors will be vital,[2108] which requires an enhanced public participation system to be in place. At this stage, it is also crucial to mainstream the rationale, benefits and mechanisms of ES protection into policy.[2109] This notion is closely related to the public awareness aspect mentioned earlier. First of all, decision makers must be made aware of the importance of a specific ES protection. Awareness and knowledge about environmental concerns through pragmatic solutions, such as social marketing, are needed to address this issue.[2110] These objectives should be clearly communicated to politicians, stakeholders and the public.[2111]

[2100] Karin Edvardsson, 'Using Goals in Environmental Management: The Swedish System of Environmental Objectives' (2004) 34 Environmental Management 170
[2101] ibid
[2102] ibid
[2103] ibid
[2104] ibid
[2105] K. Helming and others, 'Mainstreaming Ecosystem Services in European Policy Impact Assessment' (2013) 40 Environmental Impact Assessment Review 82
[2106] ibid
[2107] Galler, Albert and Haaren (n 1962)
[2108] ibid
[2109] Cowling and others (n 1938)
[2110] ibid
[2111] ibid

It is argued that when such objectives are established, implementation can be hindered due to their non-legally binding nature.[2112] This potential weakness is reflected in the crucial issue of environmental laws suffering from a lack of enforcement. Such a challenge delays or obstructs the positive outcome of environmental protection efforts and in this case, similarly, these environmental objectives may not be achieved if not implemented well. It is also important to reflect the public's interests in these objectives. This aspect will increase legitimacy of the objectives and assist implementation. Integrating economic valuation could help obtain and reflect stakeholders' preferences in the process.[2113]

6.3.3. Step 3: Develop Scenarios and Choose the Best Management Approach

This step deals with the process of developing multiple scenarios and policy instruments to allow selection of the best management approach for a specific area, considering win-win or trade-off situations. Here, EDS should also be included for more precise results. In this step, the information on the state of ES would be used while considering the environmental objectives from the previous step. Therefore, it is crucial to obtain accurate and complete information from Step 1 and have a set of realistic objectives from Step 2. In the third step, valuation can be a useful tool within a CBA context. However, it inevitably asks for effective public participation as each individual may value ES without a market price. Stronger participation also potentially increases legitimacy and credibility of decisions. Indeed, choosing one alternative should include the participation of different parties to incorporate their perspectives, the choice should be acceptable to the majority of stakeholders as well as future generations as a reflection of sustainable development. It is essential to consider how well legal instruments that facilitate public participation, such as the Aarhus Convention, are implemented. Although, such a legal analysis is outside the scope of this research, it is crucial to understand how satisfactory the public participation standards are in a country while implementing the ESF.

6.3.3.1. Impacts and Alternatives

In this context, management options should be investigated for different scenarios. This assessment is done by using a number of systems and tools, such as InVEST, which is a set of GIS models that predict the provision and value of ES and

[2112] Galler, Albert and Haaren (n 1962)
[2113] ibid

habitat provision given land use or land cover maps and related biophysical, economic and institutional data for the study region.[2114] The main focus here is to evaluate the impact of land use change and alternative scenarios.[2115] To give an example, where there are alternative options, such as ‘no agricultural expansion’, ‘no urban expansion’, ‘agricultural expansion’ or ‘forestry expansion’,[2116] this alternatives assessment reveals the potential impacts of a certain management option, including unintended impacts. Following the example, if ‘agricultural expansion’ resulted in more food production, but at the same time caused declines in habitat quality, water quality and carbon storage,[2117] there are several issues that need to be taken into consideration. Thus, such a scenario may generate high private returns for a landowner whilst producing the lowest social benefit because landowners are not financially rewarded for the provision of non-market ES.[2118] So, private land use decisions will tend to overemphasise the former and under provide the latter.[2119] Thus, such management options (like agricultural expansion) are likely to emerge because of private benefits.[2120] This will amplify the social gap and economic disparity, and inevitably will generate a bigger environmental justice issue. In the proposed ESF, these issues emerging from a traditional approach to land-use decisions should be addressed by considering synergies that occur among all ES. Using ES to assess the impacts enables a spatial understanding of these impacts. Such information leads to an understanding of related equity issues among different regions or groups (distribution of burdens and benefits).[2121] This practice is important for policies that aim to eliminate social and economic disparities.[2122]

The net private benefits of land use can be understood through the market value of returns to landowners. However, the actual value from land use is different and based on functions, non-marketed goods and appreciation for nature.[2123] It is also challenging to pinpoint land use or management patterns that would maximise net social benefits because functions of ecosystems may be non-linear and explainable through the whole land use.[2124] In case we do not have a full understanding of these less visible services and the interrelations among different functions and services, the predictions regarding some

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2114 Stephen Polasky and others, ‘The Impact of Land-Use Change on Ecosystem Services, Biodiversity and Returns to Landowners: A Case Study in the State of Minnesota’ (2011) 48 Environ Resource Econ 219
2115 ibid
2116 ibid
2117 ibid
2118 ibid
2119 ibid
2120 ibid
2121 Helming and others (n 2105)
2122 ibid
2123 Polasky and others (n 2114)
2124 ibid

models might often come with large errors.[2125] This difficulty highlights the need for a strong monitoring system that enables incorporating new information and adaption to new changes and eliminating errors for the present and future predictions. Such a system, based on scientific data, would account for the complex, unpredictable and dynamic nature of the ecological systems.[2126]

Similarly, the main issue with the current conservation programmes that inform law and policies is that these tend to focus on one aspect of the environment and overlook the additional implications of applying certain options. The ESF offers a more intelligent approach for environmental management by adopting a holistic understanding through the ecological solidarity principle, which considers interactions between ecosystems, living organisms, and natural or managed environments, in any public policy decision that has an environmental impact.[2127] This principle, which is lacking in the UK law, calls for leaving the idea that nature is merely surrounding raw material that we use for fulfilling our needs and desires.[2128]

As human needs and environmental conditions are changing over time; the supply of ES should be adaptable and flexible.[2129] We must identify and quantify uncertainties through the adoption of the precautionary principle. Indeed, we should avoid actions that would have detrimental consequences to ES.[2130] Another important aspect is the need for local information on ES because ecosystems are distinctive so one region's elements might not be valid for others.[2131] One crucial need is the need for institutions for safeguarding ES, such as a market for ES.[2132]

The overarching principle here should be not to make any development decisions without assessing its impacts on local, regional and global ES.[2133] It is interesting to look at impact assessment programmes mentioned in chapter five, which show some traction regarding an ES-based approach.[2134] Where there is going to be an impact assessment, it should be applied in such an approach that appropriately captures all effects including economic, environmental and social, associated with an investment or development.[2135] It can be argued that the existing EIAs and SEAs or just any assessment that measures

2125 ibid
2126 Craig Anthony Arnold and Lance Gunderson, 'Adaptive Law and Resilience' (2013) 43 Environmental Law Reporter 10426
2127 Fèvre (n 1960)
2128 Bruce Jennings, 'Ecological Solidarity' (2015) 8 Minding Nature 4
2129 Daily (n 81)
2130 ibid
2131 ibid
2132 ibid
2133 Ruhl (n 202)
2134 ibid
2135 ibid

the potential impacts of plans or projects cannot be fully effective because all aspects are not considered, such as detrimental effects on ES. This challenge should be addressed, and ES should also be incorporated into the existing procedures of these assessments.[2136]

Within an impact assessment, there are steps, such as identifying the policy problem, defining objectives, developing main policy options, analysing their impacts, comparing the options, monitoring or evaluating.[2137] These steps are in line with the steps of the ESF proposed here. Impact assessments are central tools for balancing economic demands and environmental protection needs. In the steps of impact assessments, ES can be considered while defining objectives to eliminate any bias towards the economic or social pillar of sustainable development; and analysing impacts of the policies which are serving other purposes with indirect impacts on ES.[2138] It is argued that ES are related to human well-being, so it enables the concept to be linked to the other two pillars of sustainable development, i.e., economic and social.[2139] Thus, the concept of sustainable development can be operationalised more definitely through mainstreaming ES in the policy development.[2140] This practice will improve the credibility of policy making and facilitate early stage public participation in policy design.[2141]

The similarities between impact assessments and the ESF show that this approach may find support and achieve realistic objectives as seen in the existing law regulating impact assessments. This resemblance makes the adoption easier and more probable and also reduces the likelihood of legal challenges that might be faced by policy makers in implementing the ESF.

6.3.3.2. Synergies and Trade-offs

Similar to the traditional impact assessments, ES assessment should also include the alternatives analysis as mentioned earlier.[2142] Indeed, assessing options of alternative scenarios is crucial for finding the best management option that protects as many services as possible. This step is about estimating the outcomes of adopting alternative options and will reveal what we can afford to lose, what is crucial to us and the future generations or whether we can mitigate or compensate for what is lost.

[2136] Helming and others (n 2105)
[2137] ibid
[2138] ibid
[2139] ibid
[2140] ibid
[2141] ibid
[2142] Ruhl (n 202)

As mentioned before, relationships between ES can occur as trade-offs, where one ES is reduced as a consequence of increased use of another ES, such as a land use choice may maximise one service's provision while undermining other services;[2143] but also as synergies, where the provision of two services increase or decrease simultaneously.[2144] Synergies, indeed, may result in win-win situations where both services' provision is maximised.

Trade-offs can be classified as a trade-off in time (benefit now, cost later). Temporal scale refers to whether the effects occur rapidly or slowly, and reversibility expresses the likelihood that the perturbed ES may return to its original state if the perturbation ceases.[2145] A trade-off in time is related to future generations and intergenerational equity. There is an ongoing discussion on how ethical it is to trade off the benefit we enjoy versus the same benefit to future generations with a discount rate.

Second, trade-offs can occur as trade-offs in space (win here, lose there). Spatial scale refers to whether the effects of the trade-off are felt locally or at a distant location.[2146]

Trade-offs can also be seen as a fairness trade-off (some win, some lose) and service trade-offs (manage one service, lose another).[2147] In the context of service trade-off, analysis most likely overlooks and undermines less obvious services, such as cultural services.[2148] Indeed, the quantitative scenario models are argued to be focused more on the provisioning and regulating services.[2149] This result can be avoided by effective public participation and if the value of other services is appropriately established.

Trade-off analysis also has challenges, such as the measuring of all or a broad range of ES being too ambitious.[2150] Also, measuring and valuing ES does not lead to increased use of this information.[2151] The use of information is even more challenged where there is non-market, public or collective services, such as supporting ones.[2152] Furthermore, the nature of these specific services makes the reestablishment or rehabilitation extremely difficult.[2153]

[2143] Polasky and others (n 2114)
[2144] Jon Paul Rodríguez and others, 'Trade-offs across Space, Time, and Ecosystem Services' (2006) 11 Ecology and Society 28
[2145] ibid
[2146] ibid
[2147] Sander Jacobs and others, 'Ecosystem Services Assessments: Science or Paradigm?' in Sander Jacobs, Nicolas Dendoncker and Hans Keune (eds), *Ecosystem Services: Global Issues, Local Practices* (Elsevier 2013)
[2148] Rodríguez and others (n 2144)
[2149] ibid
[2150] Eeva Primmer and Eeva Furman, 'Operationalising ecosystem service approaches for governance: Do measuring, mapping and valuing integrate sector-specific knowledge systems?' (2012) 1 Ecosystem Services 85
[2151] ibid
[2152] ibid
[2153] ibid

Successful management strategies should consider these multidimensional complications of ecosystem management and trade-off analysis, and assess these trade-offs at multiple spatial and temporal scales to minimise the risk posed by the potentially damaging options.[2154] In any case, there will be some kind of interactions when NC is managed for ES, which is inevitable.[2155] Even though these are tough decisions we still have to make them and suffer from the consequences, that is why trade-offs must be put on a negotiation table, and we need robust ecology and economics to comprehend them.[2156] Indeed, scientific and technological development that mitigate such trade-offs will improve ES and the way we make decisions that fully incorporate this analysis.[2157]

When it comes to soils, trade-offs between different land use options and related ES can be disproportional, so quantifying these will enable policy makers to make better decisions about demands for multiple services under limited land availability.[2158] So, the main challenge is to decide on different land use options.[2159] Including ES into the picture will give a broad understanding of what is actually being lost; for example, when a land is being converted for a specific use, such as commercial or agricultural.[2160] Here, the most important aspect is the functioning of that soil and the total value of land due to that soil's functioning.[2161] This added knowledge informs decision making and should become an essential part of this process.[2162] The issue is that there are not many people who are trained for integrating ES into decision making regarding where we should prioritise economic development or conservation.[2163] This issue, again, can be overcome through adopting the approach for further education, awareness and research in the field.

It should be noted that it does not have to be trade-offs between environment and development all the time, there are investments that allow win-win situations.[2164] Although it is likely to generate trade-offs when maximising provisioning services, as seen in the 'agricultural expansion' example above, considerate management can substantially reduce or even eliminate these trade-offs.[2165] Reflecting the principle of sustainable development, economic and social needs should go hand in hand with

[2154] Rodríguez and others (n 2144)
[2155] Ruhl (n 202)
[2156] ibid
[2157] Rodríguez and others (n 2144)
[2158] Heiki Setälä and others, 'Urban and Agricultural Soils: Conflicts and Trade-Offs in the Optimization of Ecosystem Services' (2014) 17 Urban Ecosystems 239
[2159] R. S. De Groot and others, 'Challenges in Integrating the Concept of Ecosystem Services and Values in Landscape Planning, Management and Decision Making' (2010) 7 Ecological Complexity 260
[2160] ibid
[2161] ibid
[2162] ibid
[2163] ibid
[2164] ibid
[2165] Power (n 232)

intelligent management of natural resources. This step requires a full understanding of the benefits of all ES and reducing EDS, maximising the win-win situations.[2166] All ES and EDS should be considered in these alternative scenario developments in order to fully capture the existing circumtances. These services are not valued properly; therefore, may have a higher value than other services. Characterisation, prior to economic valuation, is assessing the importance and value of ES (economic and non-economic) and is crucial because examining trade-offs will enable the determination of which actions would cause an irreversible loss of a service.

The use of a number of tools to identify if these trade-offs are beneficial. The RECARE project, which proposed an adapted framework for soil ES,[2167] assists in choosing the most beneficial land management option while revealing the win-win and trade-off situations by assessing the current threats to soils and finding innovative solutions to prevent soil degradation.[2168] ES should be approached holistically, so these aspects would be useful: biophysical realism of ecosystem data and models, consideration of local trade-offs, recognition of off-site effects, extensive involvement of stakeholders in assessment studies, which is important for understanding who benefits from ES because trade-offs also occur among beneficiaries.[2169] Again, this practice is crucial for achieving environmental justice. Revealing the state of soil ES is especially important as the effects can be masked for a long time, for instance by using fertilisers to compensate for reduced nutrient supply.[2170] Soil may be still be providing services but may not be in a good health.[2171] Rather than using mapping for decision making on land use,[2172] using this tool for soil management may be more beneficial for achieving sustainability and mitigating soil threats.

Stakeholder participation in negotiating different policy priorities, as mentioned above, makes it easier to achieve optimal value and sustainability.[2173] This process includes both individual (e.g., farmer) decisions and societal decisions determining land management choices that impact soil threats and NC. Land management includes physical practices on a piece of land (technologies: no-till, grass strips, rotational grazing and many more) and the ways and means (financial, material, legislative, educational) to

[2166] ibid
[2167] 'RECARE' <https://www.recare-project.eu/> accessed 5 April 2019
[2168] Schwilch and others (n 163)
[2169] ibid
[2170] ibid
[2171] ibid
[2172] ibid
[2173] ibid

implement these decisions.[2174] Soil protection has a greater potential when land management follows local decisions and measures at a smaller scale, which would also ease the assessment process.

6.3.3.3. Valuation

The use of valuation is beneficial for this framework. For a long-time environmental policy and decision making has been dependent on environmental well-being and intrinsic values of nature.[2175] But, ES-based frameworks are bringing a new concept into environmental policy and decision making: money.[2176]

First, it is important to differentiate value and price. The former is what we receive, while the latter is what we pay. For example, preventing pollutants and nutrients from infiltrating into groundwater can be more costly than drinking water treatment.[2177] However, the public commonly attaches a higher value to clean groundwater resources.[2178] The distinction between value and price can be highlighted as: “The things which have the greatest value in use have frequently little or no value in exchange; on the contrary, those which have the greatest value in exchange have frequently little or no value in use. Nothing is more useful than water: but it will purchase scarcely anything; scarcely anything can be had in exchange for it. A diamond, on the contrary, has scarcely any use value; but a very great quantity of other goods may frequently be had in exchange for it.”[2179]

Valuation is practical for highlighting the situations where these actual contributions conflict with market values.[2180] If we do not measure the actual contribution of ES, these become undermined and under protected; and eventually ecosystems produce less of these vital services.[2181] Undervaluing ES, thus, can jeopardise limited natural resources and aggravate EDS.[2182]

Unlike the terminology suggests, valuation does not have to be economic. Whenever we make a decision, we value things explicitly or implicitly by putting importance in monetary terms, thus valuation is an inevitable practice.[2183] So, the value

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2174 ibid
2175 Ruhl (n 202)
2176 ibid
2177 Galler, Albert and Haaren (n 1962)
2178 ibid
2179 Adam Smith, *An Inquiry into the Nature and Causes of the Wealth of Nations – Volume I* (Cannan edn, University of Chicago Press 1977) 33
2180 H. T. Odum and E. P. Odum, ‘The Energetic Basis for Valuation of Ecosystem Services’ (2000) 3 Ecosystems 21
2181 ibid
2182 Rattan Lal, ‘Enhancing ecosystem services with no-till’ (2013) 28 Renewable Agriculture and Food Systems 102
2183 Feldman and Blaustein (n 1971)

of an ES is always being assessed even if it is only implicitly.[2184] However, when it is about making a trade-off within and institutional level decision making process (e.g., spending a certain amount of money on different areas), we need to communicate in commercial terms. Therefore, monetary valuation of soil ES can satisfy the need for estimating how much needs to be spent on soil protection. This also helps decision makers determine how much should be spent on this protection in the context of all other social and economic development needs (e.g., constructing highway or investing in health sector). This way, we can assess how much these conservation efforts will benefit us by using a common unit.

There is a clear intrinsic value of nature, which itself justifies its conservation. Valuation, in addition to this, offers a bill for conservation and when there is an obvious conflict between environmental protection and economic development, aids the process of decision making[2185] by determining which services are under risk.[2186] This practice will lead to better decision making before the protection or restoration of services becomes too costly or impossible.[2187]

When we are trying to gather information on the aggregated value of ecosystems, the question is how one can measure this in figures for indirect non-market resources which may be the greatest value of all the economic categories.[2188] Catskills is an important example. The watershed of Catskills mountains provides New York City's primary source of drinking water.[2189] Water is purified as it passes through the watershed's soil and vegetation. However, at one point, this water failed to pass the standards for drinking water.[2190] Eventually, the city faced two starkly different choices regarding obtaining large quantities of clean water.[2191] The first option was investing in physical capital by building a water purification plant with a capital cost of 4 billion USD and operating expenses.[2192] The second choice was investing in NC at a much lower cost by restoring the integrity of the Catskills watershed through land acquisition and restoration.[2193] The city chose the latter option, and eventually, the cost of restoring the service of water purification provided a payback period of five to seven years and

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[2184] James Salzman, 'Valuing Ecosystem Services' (1997) 24 Ecology Law Quarterly 887
[2185] National Research Council, *Valuing Ecosystem Services: Toward Better Environmental Decision-making* (National Academies Press 2005) 5
[2186] Daily (n 81)
[2187] National Research Council (n 2185) 5
[2188] Salzman (n 2184)
[2189] ibid
[2190] ibid
[2191] ibid
[2192] ibid
[2193] ibid

increased flood protection at no extra charge.[2194] It can be concluded that investments in NC can be more financially profitable than those in a physical capital and also the loss of a specific ES can require large sums to replace.[2195] Indeed, replacement cost provides an effective method for valuing ES, because it is possible to compare investments in natural and physical capital to determine the payback periods and overall costs.[2196]

An explicit valuation perspective incorporated into the ESF would provide another benefit: politically, understanding the role of ES justifies any policy objectives with a clear focus on the protection of NC.[2197] There is an important consideration about what people value the most. It is obvious that having access to clean water is priceless, but when it comes to a collective decision making between building an expensive water infiltration system and protecting the natural watershed, the public may go for the cheaper option. Then, it is more of a political issue in which choosing the NC option, which might be more expensive, cannot be justified as the public may start questioning this. Therefore, it is important to explicitly communicate the actual value of protecting NC and ES to the public in monetary terms.

The problem with choosing investments in NC over physical capital is that ES mostly cannot be identified easily at a local scale.[2198] There are multiple challenges incorporating ES values into decision making directly. Ecologists must comprehend the services provided by a specific ecosystem;[2199] however, the existing literature proposes hypothetical and highly complex techniques for the valuation of soil ES.[2200] This challenge creates a lack of relevant data, which adds to the complexity of the task.[2201] Although scientists must understand ES, researchers have mostly focused on understanding ecosystem processes, rather than determining ES.[2202] Besides, they mostly focus on the land rather than the soil. Indeed, disaggregating land prices into the prices of the various below and aboveground sections of land to estimate the monetary value of soils is difficult and may be inaccurate.[2203] Another issue is that cultural services are disregarded in most studies, and finally, researchers fail to monetarise some regulating and supporting services because of the lack of their manufactured substitutes.[2204]

2194 ibid
2195 ibid
2196 ibid
2197 Salzman and others (n 91)
2198 Salzman (n 2184)
2199 ibid
2200 Schwilch and others (n 163)
2201 Salzman (n 2184)
2202 ibid
2203 Baveye, Baveye and Gowdy (n 749)
2204 ibid

Another challenge occurs in determining the future stream of services in monetary terms.[2205] To ensure a full accounting of costs and benefits, the future income flow of existing services should be factored into its current value.[2206] So, further research and incorporation of local knowledge of the services should be used for recognising a site's current ecological characteristics to the future provision of ES. Even if this is achieved, that value may change all the time due to different conditions, such as land use patterns, weather and pollution. Values are affected by temporal scale of analysis, this is the period of time over which benefits, and costs are distributed.[2207] The benefits and costs from the functions and services that soils are expected to provide in the future should be considered by any CBA, along with present-day values.[2208] To make this analysis possible, it is crucial to set a date after which these ES will not be seen valuable.[2209] This analysis can be achieved by using discount rates, which is the practice of progressively decreasing the estimated, present-day value of future benefits and costs.[2210] Discount rate offers the ratio of the value of the future provision of an ES versus the value of the current provision of the same service; and the higher the discount rate, the shorter the time we believe that a given function or service will be valuable for future generations.[2211] It is then questionable whether it is ethical to offer future generations fewer benefits from the same service. This question is highly significant when the flow or quality of that service is likely to decrease. It is important to assess the economic consequences of conservation efforts by adopting different temporal scales and discount rates reflecting intergenerational equity. If there is a conservation or enhancement decision to be made, there is a need to measure the value of a service and benefits from it in longer term.[2212] Considering the continuous degradation of soil ecosystems, it is appropriate to use high discount rates in a valuation context. Thus, valuation and choosing discount rates are not purely economic practices.

It must be noted that valuation is not always straightforward or clear. Ecosystem values can be personal; therefore, while estimating the value of ecosystem changes, it is important to define who is placing value.[2213] Also, the choice of valuation methods is not simple, for example, the valuation approach that adopts a threat-based focus, i.e., costs associated with the loss of topsoil due to erosion, is still a questionable one.[2214] Among

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2205 Salzman (n 2184)
2206 ibid
2207 Feldman and Blaustein (n 1971)
2208 Baveye, Baveye and Gowdy (n 749)
2209 ibid
2210 ibid
2211 ibid
2212 Balmford and others (n 185)
2213 Feldman and Blaustein (n 1971)
2214 Bilotta, Grove and Mudd (n 624)

others, the replacement cost method is seen as the most appropriate one for a type of analysis where the benefits of conservation exceed the costs of conservation and conservation also makes economic sense.[2215] Thus, valuation is useful to understand whether compromising economic development for the sake of nature would be costly and this idea hinders the policy action to stop environmental degradation.[2216]

It is commonly argued that when economic valuation is used, it should not be intended to replace a physical ES assessment, which can provide crucial information on which area is good for providing specific services.[2217] Valuation should only complement decision making by prioritising alternatives for development where there is no clear objective for protection in legislation.[2218] This practice is not necessary or sufficient by itself, but ideal to complement other tools and efforts for conservation.[2219]

The aim of this valuation practice is to make better decisions regarding land use. Having the right institutions creates incentives and decisions made by individuals, communities, businesses and governments promote widely shared values.[2220] Hence, bringing stakeholders together with the hand of government might be a useful step.[2221] It leads people to think that the environment is not a free good, but is capital resources that would depreciate without suitable care.[2222] This practice is also significant for integration of local knowledge that shed a light on ecosystem values.

A project undertaken in Belize is an excellent example of how valuation can be used alongside other tools and how local knowledge was utilised.[2223] It proved how multiple objectives can be achieved simultaneously through multidisciplinary research, effective stakeholder participation and sufficient government support.[2224] In this project, different scenarios were developed consisting of zoning schemes to see which activities can be permitted for balancing multiple objectives.[2225] There was a mix of metrics, e.g., monetary (value of fisheries, value of property protected from storms), social metrics (number of tourists), and biophysical metrics (area of coastline protecting).[2226] The results are projected to increase protection from storms and double revenue from fisheries.[2227]

[2215] Balmford and others (n 185)
[2216] ibid
[2217] Galler, Albert and Haaren (n 1962)
[2218] ibid
[2219] Ruhl (n 202)
[2220] Daily and others (n 13)
[2221] ibid
[2222] ibid
[2223] Ruckelshaus and others (n 1984)
[2224] ibid
[2225] ibid
[2226] ibid
[2227] ibid

This project shows the vast potential of integrating information about ES into multiple real-world decision making areas (e.g. planning or ecosystem management).

Monetary valuation of ES is not straightforward and what financial markets might do with soil ES prices is not clear. Thus, non-monetary methods for integrating ES into decision making are becoming more popular.[2228] An example of this is BBN mentioned earlier, which allows the effect of parameter uncertainties to be accounted for.[2229] The most appropriate approach for ecosystem management is to evaluate the performance of alternative courses of action (e.g., management or policy options) with respect to criteria that capture the key dimensions of the decision making problem (e.g., ecological, economic, and social sustainability), involving human judgment and preferences.[2230] There is evidence that this Multi-Criteria Decision Analysis (MCDA) can be useful in decision making.[2231] A combination of both monetary quantifications of soil ES methods and deliberative decision making methods including stakeholder involvement can be the way forward.[2232]

6.3.4. Step 4: Implementation and Enforcement

As governance entails two steps, namely decision making and implementation of that decision, strong ecosystem governance requires an accurate implementation. To achieve this, the decision should be logically followed and materialised. If implementation fails, the only step would be decision making which does not realise governance. So, these processes are inseparable.[2233]

The ESF is not an extension that can be attached to the current policy and miraculously change the way ecosystems are managed. Realistically, the integration of this framework is likely to suffer from a number of inherent implementation issues. To start with, for a complete development and implementation of the ES, political, technical,

[2228] Baveye, Baveye and Gowdy (n 749)
[2229] ibid
[2230] Heli Saarikoski and others, 'Multi-criteria decision analysis (MCDA) in ecosystem service valuation' (*OpenNESS*) <http://www.openness-project.eu/sites/default/files/SP_MCDA.pdf> accessed 4 June 2020
[2231] Y. Volchko and others, 'Using soil function evaluation in multicriteria decision analysis for sustainability appraisal of remediation alternatives' (2014) 485-486 Science of the Total Environment 785; Jonne Rodenburg and others, 'Sustainable rice production in African inland valleys: Seizing regional potentials through local approaches' (2014) 123 Agricultural Systems 1; Akalu Teshome, Jan de Graaff and Leo Stroosnijder, 'Evaluation of soil and water conservation practices in the north-western Ethiopian highlands using multi-criteria analysis' (2014) 2 Front. Environ. Sci. 1
[2232] Baveye, Baveye and Gowdy (n 749)
[2233] Michael Hallsworth, Simon Parker and Jill Rutter, 'Policy Making in the Real World – Evidence and Analysis' (*Institute for Government*, April 2011) <https://www.instituteforgovernment.org.uk/sites/default/files/publications/Policy%20making%20in%20the%20real%20world.pdf> accessed 22 June 2020e

and bureaucratic resources are required.[2234] This requirement involves the need for institutional resources and capacity for developing a new framework that may alter the existing policy significantly.[2235]

The ESF, as seen above, offers a wide range of tools, facets and terminology that requires understanding to develop governance structures.[2236] Thus, time and financial resources should be spared for those administering the policy to become familiar with these aspects.[2237] The implementation may face other challenges at local levels, such as farmers experiencing adjustment issues to the new measurements and market conditions.[2238] The implementation process of the ESF should find public support for the ease of the transition process.[2239] Financial resources also may be an issue in developing a number of payment-based schemes, such as PES or procurement funds.[2240]

In the UK, one of the problems related to land management is that the government does not have sufficient information to manage lands at the local level.[2241] The ESF advocates smaller scale ecosystem management and decision making that would require major changes in the national institutions and local level governance if implemented in the UK.

Regarding the implementation of the decisions made within the ESF, it is also worth mentioning that enforcement can act as a tool that would protect ES[2242] by ensuring the full implementation of policy decisions and compliance. More effective and robust legal instruments that are enforceable is needed to realise this objective. As mentioned in previous chapters, environmental laws and regulations commonly suffer from the lack of enforcement, which is required to address environmental challenges.[2243] Additionally, ES-based frameworks to date are suffering from the clear lack of development in the legal and regulatory component.[2244] The discussion surrounding the issue has been limited to developing a typical legal framework consisting of statutory legislation and

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[2234] David Gawith and Ian Hodge, 'Envisioning a British Ecosystem Services Policy – Policy Brief on an alternative approach to rural land policy after Brexit' (May 2017) <http://www.csap.cam.ac.uk/media/uploads/files/1/besp-policy-brief---15-5-17.pdf> accessed 11 June 2020
[2235] ibid
[2236] J. Dwyer and I. Hodge, 'Governance structures for social ecological systems: Assessing institutional options against a social residual claimant' (2016) 66 Environmental Science & Policy 1
[2237] Richard Packer, 'Brexit, Agriculture and Agricultural Policy' (*Centre for Policy Studies*, 6 January 2017) <https://www.cps.org.uk/research/brexit-agriculture-and-agricultural-policy/> accessed 21 June 2020
[2238] Gawith and Hodge (n 2234)
[2239] ibid
[2240] ibid
[2241] ibid
[2242] David Markell, 'Is there a possible role for regulatory enforcement in the effort to value, protect, and restore ecosystem services?' (2007) 22 Journal of Land Use 549
[2243] UNEP, 'Environmental Rule of Law: First Global Report' (January 2019) <https://wedocs.unep.org/bitstream/handle/20.500.11822/27279/Environmental_rule_of_law.pdf?sequence=1&isAllowed=y> accessed 5 May 2020
[2244] Feldman and Blaustein (n 1971)

administrative actions.[2245] Law makers commonly fail to consider the concept of ES, quite naturally as laws are old and the concept of ES is relatively new.[2246]

The law, however, has been considering ES and functions without explicitly using the term.[2247] Whether something is seen as a service is dependent on human perception, a service for one can be a disservice to another.[2248] Also, there are conflicting interests between ecocentric functions and anthropocentric functions; the law is more restricting when it comes to the ecosystem functions.[2249] Trade-offs occur among these and they are mostly related to different pillars of sustainable development.[2250] It is argued that the law's role is important in guiding choices and decisions made about restoration or maintenance or mitigation.[2251] Restoration of past harm can be an important component of an ecosystem management programme, in this situation, it does not matter what that program goal is or whether it is maintenance, restoration or mitigation.[2252]

It is argued that the law only plays a reactive role in ES protection, for example rehabilitation of mangroves after storm damages.[2253] Laws have been failing to cover some ES or functions in a sense of preventing or enabling way, although there are natural occurrences that cannot be prevented and are beyond human control (e.g., floods or earthquakes).[2254]

The concept of ES has not played a considerable role in legal instruments, other than soft law that lacks effective implementation and enforcement.[2255] The concept is majorly found in the EU's preparatory and non-legislative documents.[2256] This suggests that EU legislators refrain from placing ES into legislation.[2257] As seen in the previous chapter, the situation is similar in the UK law.

However, ES can find many operation opportunities in law for integrating ES aspects following an enforceable approach. For example, there are studies focused on ES assessment results feeding into binding targets for erosion protection.[2258] Similarly, further legal research should keep investigating diverse and proactive approaches for

[2245] ibid
[2246] ibid
[2247] Volker Mauerhofer, 'The law, ecosystem services and ecosystem functions: An in-depth overview of coverage and interrelation' (2018) 29 Ecosystem Services 190
[2248] ibid
[2249] ibid
[2250] ibid
[2251] ibid
[2252] ibid
[2253] ibid
[2254] ibid
[2255] Volker Mauerhofer and I. Laza, 'How do ecosystem services perform in enforceable law? Potentials and pitfalls within regional and national integration' (2018) 29 Ecosystem Services 190
[2256] ibid
[2257] ibid
[2258] Frank and others (n 294)

incorporating ES for soil protection by using legal tools. Keeping this potential in mind, the ESF recommends that the concept of ES can be utilised through a number of legal tools, such as property rights, compensation as prevention schemes and PES schemes for encouraging stewardship.

6.3.4.1. Property rights

The ESF has important implications for private markets and public policy.[2259] Regarding land management, knowledge about the value of ES improves the information available to landowners in deciding what constitutes the most efficient use of the land and resources.[2260] Private landowners need a way of capturing the market value of services. For some services, this is more difficult than others, such as pollination.[2261] These are public goods that we cannot charge anyone for.[2262] So, the owner of NC cannot prevent others from obtaining benefits from the service which means these are non-excludable, and the buyer cannot prevent other people from benefiting from the service which means they are non-rivalrous.[2263] Beneficiaries do not have to pay for the service, so they do not invest in NC, thus eventually it is being depleted.[2264]

This challenge of how to integrate private land ES values into markets can be addressed by law. The law can be drafted in a way that places value on land according to traditional valuation and add the value of ES provided from that land. If the law requires a minimum sale price based on the aggregated value of the land, landowners will reconsider their land use and management.[2265] Within this approach, a challenge arises when an identified service's provision benefits individuals beyond a particular population in a particular time and location.[2266]

It is also not clear who owns some ES.[2267] The lack of incomplete, inconsistent, or unenforced property rights may generate environmental issues.[2268] The majority of European land is privately owned and farmers who have temporary use rights to soil suffer first from soil degradation.[2269] This is because farmers may have an interest in short term (i.e., maximising yield and income); however, yield losses have been masked by

[2259] Ruhl (n 202)
[2260] ibid
[2261] ibid
[2262] ibid
[2263] ibid
[2264] ibid
[2265] ibid
[2266] ibid
[2267] ibid
[2268] ibid
[2269] Louwagie and others (n 1168)

using fertilisers, proving that farmers without property rights do not always have incentives to adopt soil friendly practices.[2270]

One striking issue in property law is market failures. Market failures create incentives to convert funds of NC into marketable goods and do not assign property rights to ES benefits.[2271] The existing economic model encourages private development at the expense of public ES.[2272] It is discussed that the declining of most ES is due to the tragedy of ES, which results partly from the overconsumption of common-pool resources which have two components, namely a fund (NC), and second the flow of benefits it yields (ES).[2273] The majority of environmental injustice issues stem from this tendency. When the fund is degraded, it risks the quality and quantity of future flows of the benefits.[2274] Where there is a lack of property rights regime which establishes rules under which the community members access and use a common-pool resource, these open-access resources can be exploited to the point of collapse.[2275]

Ecosystem governance would hugely benefit from establishing property rights, valuation of environmental externalities, the use of market-based instruments for conservation, such as payments for ecosystem services (PES), which will be discussed below,[2276] as a reflection of market environmentalism, which aims at balancing economic growth and the protection of the natural environment.[2277] Thus, defining equitable baseline property rights and distributional impacts are found beneficial[2278] to determine which services are owned by landowners and which services they must deliver to society.[2279] It is argued that in some cases they must deliver a baseline level and expect compensation for provision above that level (discussed below).[2280] Without these tools being used, the owner receives no compensation for providing ES for their private lands, so no financial incentive to keep providing them; therefore, these can be underprovided.[2281]

Overall, governments should regulate private ES markets, design public PES and manage flows of services from lands to ensure distributional equity.[2282] This step would

2270 ibid
2271 C. L. Lant, J. B. Ruhl and S. E. Kraft, 'The tragedy of ecosystem services' (2008) 58 Bioscience 969
2272 ibid
2273 ibid
2274 ibid
2275 ibid
2276 ibid
2277 Gomez-Baggethun and Ruiz-Perez (n 218)
2278 Ruhl (n 202)
2279 ibid
2280 ibid
2281 Lant, Ruhl and Kraft (n 2271)
2282 Ruhl (n 202)

also eliminate environmental justice issues and minimise poverty.[2283] As mentioned earlier, it would be useful to develop ESD that promote a shift from single-purpose resource management, promote a holistic and integrated approach and different types of governance and financing mechanisms.[2284]

6.3.4.2. Payment for Ecosystem Services

There is also a positive economic relationship, i.e., protector-receiver in PES schemes. Following this logic, one party to the contract (receiver) acts in a certain way that promotes the proper functioning of ecosystems.[2285] The other party (the state or local government) who assesses and comes to the conclusion that this effort is acceptable and valuable, makes a payment for ES provision.[2286] Implementation of management options from the previous step of the ESF can be promoted through PES by a market-based approach so that direct economic incentives and performance payments can eliminate or reduce the risks of EDS and negative costs.[2287]

The underlying rationality is making the exploitation of natural resources less attractive in monetary terms than protecting them.[2288] This tool explicitly recognises the need to address trade-offs mentioned earlier by connecting landowners' and external actors' interests.[2289] Unlike polluter pays principle which underlies markets for ES, PES stems from the steward earns principle. PES, unlike polluter pays principle, highlights positive externalities.[2290] Considering soil resources, an additional benefit of this system is engaging with farmers and communities and learning from their local knowledge.[2291]

The idea is making payments for these services, so beneficiaries of ES will compensate stewards who maintain or protect them.[2292] In some cases, payments are made by the beneficiaries of the environmental services, such as water users and hydropower companies. In other cases, national or local governments pay on behalf of their citizens, who are indirect beneficiaries. As PES schemes enable the beneficiaries of ES to provide

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[2283] ibid
[2284] Lant, Ruhl and Kraft (n 2271)
[2285] Liliane Icher, 'Public Spending in the Environmental Field: the Case of Soil Protection' in Carole Hermon (ed), *Ecosystem Services and Soil Protection* (Université Toulouse 1 Capitole 2018)
[2286] ibid
[2287] Lal (n 2182)
[2288] Icher (n 2285)
[2289] Sven Wunder, 'The Efficiency of Payments for Environmental Services in Tropical Conservation' (2007) 21 Conservation Biology 48
[2290] Gomez-Baggethun and Ruiz-Perez (n 218)
[2291] Powlson and others (n 1966)
[2292] Gomez-Baggethun and Ruiz-Perez (n 218)

payments to the stewards or providers of these, they offer a new operational set of options for investment in the natural environment.[2293]

Although finding out the ES value does not necessarily mean that these must be treated as private commodities,[2294] ES and pricing are likely to result in some sort of privatisation and commodification.[2295] Especially for soils, PES is seen as a reflection of this process where landowners being able to receive payment for the amount of service provided by their land.[2296]

While large landowners would profit hugely from these conditions and could enlarge their property, this is not necessarily a positive outcome of this process from the perspective of soil protection and common benefits from soil ES.[2297] This is generally the case where an absentee landlord (who leases the property to another but does not reside in the lease property), who fails to treat soil in a considerate manner, could pave the way for further soil degradation in long-term.[2298]

One tool to enable the public interests to influence how landowners manage their lands can be Land Conservation Agreements, which are between a landowner and another party and place long-term restrictions on the use or management of a parcel of land.[2299] There are intended to be binding upon the current and future landowners.[2300] These agreements include voluntarily and partially transfer property rights, limiting the landowner's original right on the land.[2301]

In Europe, the PES approach is promoted by CAP. It can be argued that to safeguard sustainable land use, there should be changes in the CAP's PES mechanism in order to enable farmers to receive financial rewards for delivering a broader spectrum of ES.[2302] When PES scheme are rather voluntary, this generates an additional implementation and policy issue,[2303] meaning that unless the provider gives consent, these services will be under-protected.[2304] To avoid this outcome, the buyer might decrease the demands, such as shorter commitments, which might result in the decreased level of

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2293 'Fifth National Report to the United Nations Convention on Biological Diversity: United Kingdom' (April 2014) <https://www.cbd.int/doc/world/gb/gb-nr-05-en.pdf> accessed 5 May 2020
2294 Costanza and others (n 122)
2295 Baveye, Baveye and Gowdy (n 749)
2296 ibid
2297 ibid
2298 Thorstein Veblen, *Absentee Ownership: Business Enterprise in Recent Times: the Case of America* (Transaction Publishers 1938) 139
2299 Department for Environment, Food and Rural Affairs, 'Payments for Ecosystem Services: A Best Practice Guide' (May 2013) <https://www.cbd.int/financial/pes/unitedkingdom-bestpractice.pdf> accessed 13 June 2020
2300 ibid
2301 ibid
2302 Bateman and others (n 186)
2303 Icher (n 2285)
2304 ibid

protection.[2305] PES schemes, also, are majorly based on best-effort.[2306] So, it can be argued that the payment is due when the practice is achieved rather than the result.[2307] This is also valid for AEMs of the second pillar of the CAP.[2308] As mentioned in the previous chapter, PES scheme surely will benefit both buyers and sellers; however, it would not be sensible to argue that it would fully replace other conservation instruments.[2309]

Still, PES schemes have found support from governments. For example, similar measures were promoted by the United States (US) government for farmers who adopt practices against soil erosion in the 1930s.[2310] The US Clean Air Act 1990 endorsed cap and trade mechanisms for sulphur dioxide and wetland banking (allow deterioration if committed to create, restore these elsewhere). Costa Rica is the first state that set up a national PES scheme.[2311] There are also international PES schemes, such as the Clean Development mechanisms for Kyoto.[2312] In the UK, a similar outcome was achieved through emissions trading system. These initiatives demonstrate the potential of incorporating PES into the policy.

DEFRA published the PES Action Plan and Best Practice Guide for supporting these schemes.[2313] The former promotes development of these schemes and considers the actions to enable these, such as capacity building actions for the UK government, the key policy areas of opportunity for PES and the monitoring and evaluation needs of PES schemes.[2314] The latter uses instructive national and international case studies to demonstrate challenges and solutions associated with PES.[2315] Although Europe has established this approach through CAP, in the Brexit environment, it is unclear how the UK will proceed with this approach. For an ES consideration to be established, there is a need to arrange incentives promoting the provision of social value from ecosystems.[2316] PES is a useful tool for this practice where feasible. However, there may be challenges in

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2305 ibid
2306 ibid
2307 ibid
2308 ibid
2309 Wunder (n 2289)
2310 Gomez-Baggethun and Ruiz-Perez (n 218)
2311 ibid
2312 ibid
2313 Department for Environment, Food and Rural Affairs, 'Developing the Potential for Payments for Ecosystem Services: an Action Plan' (May 2013) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/200889/pb13918-pes-actionplan-20130522.pdf> accessed 5 September 2019
2314 'Fifth National Report to the United Nations Convention on Biological Diversity: United Kingdom' (n 2293)
2315 ibid
2316 Gawith and Hodge (n 2234)

practice,[2317] because a large number of ES are public goods and non-excludable.[2318] Where this is the case, it is argued that collective intervention is necessary for achieving outcomes desired by the public.[2319] Such ES with public good characteristics could be purchased by procurement funds at a national or local level.[2320]

Despite the great support that PES schemes have received, they are seen as difficult to execute and having a limited scope in practice.[2321] Also, although the case studies supported by DEFRA show some potential for implementation at larger scale, it is argued that, in reality, these might have limited opportunities.[2322] Because there is an emergence of high transaction costs in these schemes.[2323] Nonetheless, some believe that PES schemes can overcome these costs, which stem from bringing buyers and sellers together to exchange property rights.[2324] Also, there is a possible free riders threat,[2325] which occurs as public goods are available to everyone without having to pay for them and eventually too many free riders cause the natural resources to be underprovided.[2326]

As mentioned before, most ES-based initiatives are generally difficult to tackle at a national policy level.[2327] Challenges are more apparent regarding the knowledge on ES, which includes information about the direct and opportunity costs of implementing changes in land use.[2328] Therefore, local level governance would be the most suitable for such a framework, including issues about funding for locally valued ES.[2329] It is reasoned that this approach is also beneficial for complementing the function of the national procurement funds.[2330]

Ideally, as an implementation and enforcement component of an ES-based framework, PES should be built on well-defined ES. Indeed, PES scheme needs a clear framework to operate in and enforceability is required,[2331] which reflects the need for successful operation of step 1 of this framework. Also, well established and clearly

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[2317] ibid
[2318] Ruhl (n 202)
[2319] Gawith and Hodge (n 2234)
[2320] ibid
[2321] House of Commons Environmental Audit Committee, 'The Future of the Natural Environment after the EU Referendum' (6th Report of Session 2016-17) <https://www.parliament.uk/business/committees/commit tees-a-z/commons-select/environmental-auditcommittee/inquiries/parliament-2015/future-of-thenatural-environment-after-the-eu-referendum-16-17/> accessed 2 June 2020
[2322] ibid
[2323] ibid
[2324] Gabriela Scheufele and Jeff Bennett (eds), *Buying and Selling the Environment* (Academic Press 2019) 11
[2325] Gawith and Hodge (n 2234)
[2326] J. B. Ruhl, Steven E. Kraft and Christopher L. Lant, *The Law and Policy of Ecosystem Services* (Island Press 2007) 75
[2327] Bateman and others (n 186)
[2328] Gawith and Hodge (n 2234)
[2329] ibid
[2330] ibid
[2331] Department for Environment, Food and Rural Affairs, 'Developing the potential for Payments for Ecosystem Services: an Action Plan' (n 2313)

defined property rights for the land[2332] and the economic valuation of specific services is needed for establishing the benefits and payments.[2333] Community members should have a say in choosing the approach for valuation and in gathering the necessary information for valuation.[2334] The processes involved in developing and implementing PES schemes should be adaptable and open to community inputs.[2335] Implementation without a proper enforcement mechanism may end up in non-compliance. For the ESF to function properly, there must be an operational enforcement system in place that uses diverse legal and economic tools, such as the adoption of PES.

6.3.4.3. Compensation

In addition to the protector-receiver relationship in PES schemes, there is also a court-polluter relationship. It is interesting to view ES as a tool to reveal potential claims for environmental damages. It is argued that it could be useful to classify ES and relate any damage to an ecosystem to potential plaintiffs and assist them in framing the legal action and claim compensation.[2336] This approach helps with identifying the people who suffer from a specific damage.[2337]

Common law using ES can halt damaging activities through the use of injunctions and if the damage has occurred it can also recover costs.[2338] Such a system reveals the direct use, indirect use and non-use values, which shows the actual monetary impact of an activity or practice.[2339] ES help consider temporal and spatial impacts on ecosystems and can inform the law in this context. Our scientific understanding of ecological services should improve to identify injuries in specific harms.[2340]

Civil liability is responsible for actions and practices that could damage others and requires three conditions, i.e., an operative event, damage, and causation between them.[2341] The integration of ES offers a new perspective for civil liability.[2342] Legal standing, which is the right of a party to bring a lawsuit to court, comes across as an issue

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2332 Maurice A. Rawlins and Leon Westby, 'Community participation in payment for ecosystem services design and implementation: An example from Trinidad' (2013) 6 Ecosystem Services 117
2333 Wunder (n 2289)
2334 ibid
2335 Rawlins and Westby (n 2332)
2336 Mark Everard and Thomas Appleby, 'Ecosystem services and the common law: Evaluating the full scale of damages' (2009) 20 Environmental Law and Management 325
2337 ibid
2338 ibid
2339 ibid
2340 Salzman (n 2184)
2341 Séverin Jean, 'The effect of ecosystem services on civil liability law' in Carole Hermon (ed), *Ecosystem Services and Soil Protection* (Université Toulouse 1 Capitole 2018)
2342 ibid

here,[2343] because plaintiffs who wish to advance an ES-based argument must first convince the court of their stake in the litigation.[2344] This outcome can be as a result of a certain proximity of a harmful activity. However, adopting the ecosystem nexus mentioned earlier enables action where proximity is not satisfied but causation is.[2345] So, those who suffer from the consequences of an activity that is not in geographic proximity, but within the same ecosystem or merely deriving services from the affected ecosystem should be able to bring legal action.[2346] It is argued that the harm is not crucial for certain types of environmental action.[2347] This approach can be seen as a more advanced deterrent when integrated into law.

When considering some soil ES, such as carbon sequestration, it does not make any difference where this service is being provided in addressing the global threat of climate change.[2348] Under such circumstances, compensating these losses through counterbalancing their losses elsewhere can be a point of discussion.[2349] However, it can be argued that such compensation does not make sense when considering the collective soil functions and services.[2350] For example, the loss of soil biodiversity in the UK cannot be compensated simply by working towards an increased biodiversity in Latin America.[2351]

Compensation and direct payment are two feasible tools for financial institutions to profit from ES.[2352] The financial sector is increasingly affected by the notion of 'saving nature to trade it'.[2353] Thus, even a major soil loss incident can be seen as a financial opportunity in a market, which is hungry for serious events.[2354] Therefore, utmost consideration should be offered when using these legal and economic tools in a soil focused ESF. The priority should not be shifted from achieving high level environmental protection to generating financial profit.

The overarching environmental law principle for operationalising this tool is the 'polluter pays principle' or the broader 'exploiter pays principle'. These principles impose a financial liability on the ones who treat natural resources as merely instrumental

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2343 Carol Adaire Jones and Lisa DiPinto, 'The role of ecosystem services in USA natural resource liability litigation' (2018) 29 Ecosystem Services 333
2344 ibid
2345 Salzman (n 2184)
2346 ibid
2347 ibid
2348 Baveye, Baveye and Gowdy (n 749)
2349 ibid
2350 ibid
2351 ibid
2352 ibid
2353 S. Sullivan, 'Banking nature? The spectacular financialisation of environmental conservation' (2013) 45 Antipode 19
2354 M. Cooper, 'Turbulent worlds: financial markets and environmental crisis' (2010) 27 Theory Cult. Soc. 167

and to be consumed in the short term, and do not consider the ecosystem, the survivability of the resource or future generations.[2355] Proper implementation of these principles is required to hold individuals fully accountable for engaging with activities that damage ecosystems.[2356]

Without enforcement, these principles suffer from compliance issues.[2357] Enforcement can prevent harm to ecosystems by deterring violations, requiring violators to cease violations, requiring violators to fix ecosystems that they harmed or restore or remediate.[2358] The question is whether there is a role for enforcement mechanisms or reliefs for ES protection.[2359] Integration of the core notion of polluter pays should be completed through proper enforcement mechanisms.

Similarly, the concept of ES still is not being relied upon by courts as commonly as it should be. It can be argued that the enforcement of relevant laws is the best approach for the proper incorporation of ES into the law.[2360] The concept, as mentioned before, could not find a place in legislation.[2361] Another approach for promoting the concept's integration in law is through the court system.[2362] ES also were taken into account in judicial doctrine and court decisions in the global legal scene. For example, in the US, the Supreme Court deliberated about the potential degradation of a marsh's ability to filter and clean runoff, which resulted in public nuisance.[2363] In another case, the Court basically asserted that the dune's storm protection benefits would provide the homeowner with a benefit that should be taken into account when considering losses and benefits.[2364]

The situation in Europe is diverse. The European Court of Justice rulings are viewed as more focused on one dimensional environmental protection whilst leaving aside clusters of ES.[2365] In England and Wales, there were 5 cases by the time of writing in which the concept of ES was mentioned. These numbers can be a reflection of the fact that the existing courts lack focus and technical and scientific expertise in the field. Although there is an environmental tribunal in England and Wales, this tribunal only deals

[2355] Garry Nagtzaam, 'Chapter 5 Environmental exploitation: an analysis and taxonomy' in Liam Leonard and John Barry (eds) *The Transition to Sustainable Living and Practice* (Emerald Group Publishing Limited 2009)
[2356] Markell (n 2242)
[2357] ibid
[2358] ibid
[2359] ibid
[2360] Sharon and others (n 2013)
[2361] ibid
[2362] Volker Mauerhofer, 'Legal aspects of ecosystem services: An introduction and an overview' (2018) 29 Ecosystem Services 185
[2363] Ruhl (n 202)
[2364] ibid
[2365] Frederik H. Kistenkas and Irene M. Bouwma, 'Barriers for the ecosystem services concept in European water and nature conservation law' (2018) 29 Ecosystem Services 223

with appeals against fines or notices for an environmental offence.[2366] An environmental court whose jurisdiction is wider, its judges are experts in their fields and in which participation is enabled and broadened, can potentially change these trends.

Using the right arguments, these numbers of cases can be extended, especially environmental groups as claimants could assist courts in the development of ES-incorporated law.[2367] Such an approach would be influential especially in common law countries where these rulings become law, and past decisions typically serve as a binding precedent or persuasive legal authority.[2368] This practice could be of major help in mainstreaming the ES concept in the legal scene.

6.3.5. Step 5: Monitor

Monitoring comprises of two aspects. Firstly, we should monitor how the decisions or selected options for management operate in the real world and whether they remain the best options under changing circumstances. Secondly, it is crucial to continually monitor the state and provision of ES to address emerging risks at local, regional, and national levels.

Even if all the steps of the ESF are taken carefully, there is still a chance that the policy decisions made about ES may not always be the best option. Therefore, monitoring is a vital step to check whether the institutional safeguards are efficiently functioning.[2369] We should continually engage in self-evaluation and adaptive management.[2370] The actions mentioned above must be complemented with monitoring schemes that consider short- and long-term provisions of ES.[2371]

Monitoring the impacts of decisions or policies on a small scale and publishing public reports in a standardised and user-friendly format routinely would help track how decisions impact the status of ES.[2372] Such a practice would also increase accountability of ES-related decisions.[2373]

Involving a monitoring step is also important at the national policy level. Governments monitoring the outcomes of decisions about ecosystems on a regular basis would enable the public to track progress as well as decision makers to be held

[2366] 'Environmental fines or notices: appeal against a regulator' (*GOV.UK*, 17 November 2014) <https://www.gov.uk/guidance/environmental-fines-or-notices-appeal-against-a-regulator#how-to-appeal> accessed 21 October 2020
[2367] Kistenkas and Bouwma (n 2365)
[2368] Sharon and others (n 2013)
[2369] Daily (n 81)
[2370] Ruhl (n 202)
[2371] Rodríguez and others (n 2144)
[2372] Irwin and Ranganathan (n 1994)
[2373] ibid

accountable.[2374] Monitoring is also crucial for governments to keep their practices in line with access to information, public participation, and judicial review on decisions affecting ES.[2375] Government officials should work regularly with networks at all levels (including smaller policy level) to encourage effective and continuous action.[2376] At the international policy level, the compliance with the implemented international legal instruments focusing on ES should be monitored closely and dialogue among national parties should be facilitated.[2377] Several communities should have a say in international policy, making negotiations similar to regional and national policy making.[2378]

In the UK, there is insufficient data on soil health, and it is contended that more investment is needed in soil monitoring.[2379] Since 1978, the state of soils in the UK are monitored through the Countryside Survey, as mentioned in chapter four, which measures and assesses long-term change in physical, chemical and biological aspects of soils at national and regional scales.[2380] It also aids in identifying the key drivers of change, collects data on environmental issues to support policy makers and contributes to the development of an integrated assessment of the drivers and pressures of change.[2381] Finally, it helps better understand their effects on the UK countryside and their implications for ES.[2382] For the purposes of this step of the framework, similar initiatives should be in place, making data available for understanding how ES respond to different ecosystem management options.

In monitoring the state of ES, a set of economic and biophysical indicators can be used. While the former shows the economic changes in ES values by measuring and monitoring over time, the latter can help to reveal the changes in non-economic ES and their values.[2383] In the existing frameworks, monitoring is somewhat developed and widely implemented for certain ES, e.g., water quality.[2384] On the other hand, there is no or very limited monitoring for some ES, e.g., pollination and carbon sequestration.[2385] In line with this argument, it is worth discussing that some ES cannot be measured or

[2374] ibid
[2375] ibid
[2376] ibid
[2377] ibid
[2378] ibid
[2379] Environment Agency (n 752)
[2380] 'Policy and Planning' (n 870)
[2381] ibid
[2382] ibid
[2383] David K. Loomis and Shona K. Paterson, 'Human dimensions indicators of coastal ecosystem services: A hierarchical perspective' (2014) 44 Ecological Indicators 63
[2384] Daily (n 81)
[2385] ibid

monitored directly.[2386] Instead, proxies are being used in some frameworks.[2387] For example, in Costa Rica's PES scheme, landowners are paid to provide services, such as carbon sequestration, measured by proxy (the number of hectares forested).[2388]

It is clear that more research for improving direct measurement and monitoring of some ES is needed[2389] as the tools mentioned in this framework, such as the design of PES, should be based on rigorous science.[2390] Science tells us what ES are, and how to monitor and measure them.[2391] The research outcomes will feedback into the system, which is essential for including new knowledge. It can be argued that public bodies, such as Natural England, should have the role of collecting and selecting knowledge that will be incorporated into the system. Proven monitoring methods could be established widely, in conjunction with efforts to safeguard ES.[2392] Monitoring will eventually provide information on what operates well and what does not.[2393] Therefore, this practice is crucial for correcting any aspects before it generates irreversible harm to the natural environment.

This aspect supports the notion of adaptive law. Environmental law must be more dynamic than any other area of law and it requires constant evaluation, update and development through the introduction of new information. Monitoring is an essential tool for this purpose. Challenges might emerge, such as insufficient monitoring quality, inherent difficulties in the monitoring of certain environmental aspects and lack of resources. However, we must ensure that law does not play a role as a barrier in front of adaptiveness[2394] by lengthy implementation and application processes or lack of requirement for reporting and incorporating updates. Law, indeed, must accommodate and facilitate monitoring processes in order to support adaptive environmental management.[2395]

6.4. Conclusion

In this chapter, the existing policy challenges are determined and a number of ES-based recommendations for a potential legal reform are offered through the presentation of the ESF, which would address these policy challenges. These recommendations are

[2386] Fisher, Turner and Morling (n 69)
[2387] ibid
[2388] ibid
[2389] Daily (n 81)
[2390] Ruhl (n 202)
[2391] Fisher, Turner and Morling (n 69)
[2392] Daily (n 81)
[2393] ibid
[2394] Barbara A. Cosens and others, 'The role of law in adaptive governance' (2017) 22 Ecology and Society 30
[2395] ibid

not exhaustive and somewhat limited to the challenges regarding soils. Further research should be undertaken to recognise how these can be incorporated in different socio-economic contexts with different environmental issues.

In this chapter, it has been made clear that although there is a growing awareness of the multifunctionality of soils for over half a century, there is still room for development in our understanding of soils. Soil and its benefits are overlooked by the public. There is a lack of data on soil functions and ES alongside an absence of direct quantitative measurements of these which would reveal the actual state of soils.

As seen in the first step of the ESF, this issue of quantitative measuring should be addressed if ES are to be used in decision making. Significantly, the adoption of ESD is meaningful in this sense. It can enable developing and using information about the types, amounts, value, sources, uses, and beneficiaries of ES. Additionally, it can allow the public to have a voice in environmental objectives as seen in the second step of the ESF. Indeed, this approach is found to be strengthening the rights of local people to make decisions about the use and management of ES. These decisions seen in the third step have public consequences. Such information about types, amounts, and value of ES could provide the basis for modelling economic and financial incentives with ecosystem stewardship, such as PES, as seen in the fourth step. The fifth step consists of monitoring the impacts of decisions and selected options as well as the state of ES.

Decisions about ecosystems, clearly, should be informed by science. Science has a crucial role in revealing what ES are, how to monitor, measure and value these benefits. The public commonly considers short-term perspectives while assessing the objectives and making decisions about management of natural resources and development, and it fails to make appropriate long-term decisions. This outcome is because of the lack of science-based information in the public's sphere. Here, it is crucial to promote multidisciplinary research as well as the communication between scientists and the public. Indeed, there is a clear need for scientists to communicate findings to the public and decision makers. A clear understanding of ES is a vital element for effectively using the concept. Also, scientists will be informed about what is significant for the public and decision makers.

In an ideal application of the ESF, properly implemented policies are expected to set minimum environmental standards for ES protection whilst promoting the rights of local communities and achieving a fair distribution of costs and benefits. This framework proposes the integration of biophysical and social dimensions of environmental protection.

Supporting active participation of the public in decision making, MCDA is a useful approach for the ESF for enabling the consideration of scientific data and information about ES or CBA where needed. However, this approach is also flexible enough and does not require all criteria to be expressed in monetary terms. This notion is in line with the argument that economic valuation of ES is not essential but is complementary and potentially beneficial. Although a small number of studies have focused on valuing soil ES, these are interdependent and difficult to evaluate, and there are not many methods available for this task. Additionally, it is impossible to assign prices to most of the supporting and cultural, and some regulating ES of soils. It is worth mentioning that once these services have a price tag on, a CBA would control what is done with soils, which may not be the most environmentally friendly approach and could even jeopardise soil conservation efforts.

In any case, since there is demand for valuation at an institutional level, researchers have the responsibility to deliver prices. However, this perception should not divert the focus from the actual objective of soil protection, which could be actualised through a more holistic approach. Rather than mere valuation, this approach should offer actual public participation resulting in social education opportunities and reconciliation of interests and also an analysis of uncertainties and risk assessments.[2396] Therefore, MCDA offers a transparent approach for enabling precise analysis of different scenarios for different contexts, i.e., social, economic, environmental; and deal with real-world uncertainties.

Incorporating all the aspects that affect decision making about ecosystems has many advantages over a simple CBA in establishing the best possible option for society, which includes educating the public on the benefits from soils, leading to more informed and sustainable decisions. If decision makers, who are dealing with decisions regarding competing demands and interests are more informed and educated, they would consider these benefits more in their decisions. Indeed, it is argued that if the messages about the importance of soils got across to the whole of society, the threats against soils would be eliminated more easily, and we would not have to continuously advocate their value.[2397]

The ESF presented in this chapter is an intelligent, holistic, multidisciplinary approach that incorporates a systemic understanding of the interactions within ecosystems and multifaceted relationships in the socio-ecological systems. This approach that promotes incorporating multiple criteria for considering ecosystems and their

[2396] Y. E. Chee, 'An ecological perspective on the valuation of ecosystem services' (2004) 120 Biol. Conserv. 549
[2397] Baveye, Baveye and Gowdy (n 749)

management and supports the use of all appropriate tools to offer ecosystems the attention and protection they deserve.

The next and final chapter of this study will summarise the findings and provide an overall discussion on how the ESF can improve the existing framework.

CHAPTER SEVEN

Overall Discussion and Conclusion

7.1. Introduction

This final chapter will provide a summary of the findings of this research. An overall discussion on how to operationalise the ESF in a meaningful and beneficial manner for law and policy will follow the summary of the findings. This chapter will also emphasise the contribution and impact of this research and highlight the limitations of this work. This chapter aims to explain how the ESF is envisioned to function as a part of the policy and potentially improve it.

This research evaluated the need for robust soil protection by determining the importance of soils through recognising soil processes, functions and ES, which are crucial to various human needs, and by ascertaining soil threats. Then, it identified the gaps and weaknesses of the existing UK soil protection laws and policies and critically discussed whether these are effective for protecting soils and soil ES. Using the findings of this analysis, this research developed a novel understanding for soil protection through the multidisciplinary approach of ES, introduced the ESF and offered a set of recommendations in light of this analysis. This framework provides a holistic approach that suggests integrating the importance and value of ES into policy making by combining scientific, economic and societal perspectives.

As explained in chapter two, this research uses a modified version of ELM. The design of this research is in line with the fundamental requirements of these methods: It highlighted the main issues within the sphere of soil protection and presented the focus and gaps in the literature in chapter one. As seen in chapter two, it presented ELM, which requires a multidisciplinary approach and explained other methodological motivations. In chapter three, a scientific perspective was adopted to explain the importance of soils through soil processes, functions, and ES as well as how soil threats impact these aspects. ELM also requires an examination of the deficits in the current system, which were presented in chapters four and five through an in-depth analysis of the existing soil protection legislation, which revealed how these laws protect soils and soil ES. The aim of this research was to develop a novel understanding for soil protection through the multidisciplinary approach of ES and provide policy recommendations in light of this perception. This aim was achieved through the introduction of the ESF in chapter six. The next section will present a summary of the findings of this work.

7.2. Summary of the Findings

To highlight the importance of soils, this research has provided a brief explanation of soil processes, functions and ES. This explanation emphasised the importance of soils through studying the relationship among soil processes, functions and ES. Soil ES are vital for human survival and well-being as well as economic and societal needs. It was established that soil processes support the provision of some ES through maintaining healthy and functioning soils as soil functions are directly linked to ES. Indeed, these functions determine the delivery of soil ES. Chapter three further highlighted the significant need for robust soil protection that incorporates these aspects and benefits of soils by studying the important soil threats. Certainly, soil ES interact with several soil threats, namely erosion, pollution, sealing, compaction, SOM loss, salinisation and desertification. This research concluded that ecosystem functions and services are at acute risk from the soil threats due to the changes they generate on soils and their properties.

This research also made clear that soils, regardless of their importance, have not received the deserved attention in the public eye and in scientific and legal research that its importance warrants. This situation has led to a lack of regulation for the activities that can harm soil. There are several reasons for this tendency. Arguably, the fact that the benefits we obtain from soils are not obvious is a significant reason. Indeed, law makers do not put effort into protecting these benefits in practice. There are also many different soil types, which make it difficult to regulate them through an umbrella system. Unlike land, there is no price for soils. The lack of private ownership for soil is another reason for the lack of regulation in this area.

Where there are soil protection laws, these seem rather ineffective considering the continuous soil degradation around the globe as a result of abovementioned soil threats. The literature indicates that soil degradation is not addressed adequately at the international level. This problem is not only a low income country issue, as European laws are also found largely ineffective for protecting soils. This research found that the common nature of soil protection laws in the EU is either non-binding or lacking a specific focus on soils. Although there are some binding legislative instruments that provide protection for soils, the level of protection is rather basic and indirect. Besides, the present study found that some soil threats are not fully considered in these laws, i.e., sealing, compaction, salinisation. By focusing on the UK soil protection laws, including the ones which stemmed from the EU law, the present study offered a critical analysis of the relevant legal instruments. This analysis is significant as there is a clear lack of critical literature offering such a comprehensive legal analysis for soil protection laws. The findings of the present study suggest that complications caused by different pressures on soils, such as agriculture, industrial activities, waste management and development are not fully addressed in the existing legislation. Starting from this point, the present study adopted a pressure-based analysis perspective to understand how well certain elements in the legal order respond to these pressures. It concluded that, indeed, the existing legislation cannot sufficiently respond to these pressures.

The evaluation of the UK laws, including the implementation of the relevant EU legislation, demonstrated that they fail to address all soil threats adequately although these threats are in direct relationship with the pressures on soils. Also, soil threats other than pollution are usually ignored in the UK as seen in the findings of the present study. It was concluded that merely 5 threats (pollution, erosion, SOM loss, sealing and compaction) are explicitly mentioned in the analysed legal instruments, with pollution considerably more often than others. This analysis shows that the existing legislation lacks a comprehensive soil protection from a wide range of threats and associated pressures.

The legal analysis in chapter five concluded that the UK laws are focused on protecting other environmental media and provide soil protection at a basic level. It was found that only 8 legal instruments out of 20 have soil specific targets or objectives. It must be noted that only 1 law was found to be very strong from a soil protection perspective, while 6 are strong, 5 are modest, 5 are weak and 3 are very weak. These numbers demonstrate that these laws do not provide sufficiently strong protection for UK soils.

This research also contributes to the literature by analysing the extent that these legal instruments consider the crucial importance of soil ES as reflected in chapter three. From a soil science perspective, this approach can be viewed as the only logical method for analysing whether soil protection laws effectively protect the soil itself. Because mere land protection cannot be sufficient for soil protection as land can be protected while soil is losing its vital functions and capacity to provide ES due to changes in its properties as explained in chapter three. Adopting this perspective, this research found that commonly provisioning and regulating services are explicitly mentioned in these legislative instruments, whilst cultural and supporting ES are usually overlooked in the law. This point is supported by an argument that is often found in the literature, which reflects that ES other than provisioning and regulating ones are mostly ignored in law and decision making.[2398] This argument, which was provided by the literature for other environmental media, is confirmed for soil in the present study.

[2398] James Salzman, The Importance of an Ecosystems Perspective in Environmental Law, Sustainable Dev., Ecosystems & Climate Change Comm. Newsl. (American Bar Ass'n Section Env't, Energy & Resources), Apr. 2004, at 9

This present study determined in chapter five that the current UK law fails to provide adequate and deserved protection for soils as it is a fragmented system in which pertinent laws are scattered across different policy areas. These different policy areas have other main focuses, such as the protection of water. Furthermore, soil protection legislation has suffered from the lack of accurate information on soils due to limited research and incoherent administration. More comprehensive documents are seen in the form of guidance or recommendation that are non-binding and unenforceable. However, the need for a robust and enforceable soil protection legislation is still ignored. There is the fact that the UK law makers believe that there is no need to legally protect soils directly, as seen in the rationale behind the withdrawal of the EU Soil Thematic Strategy in which the UK was a blocking state. However, the present study demonstrated that this reflection from the UK government was incorrect, in fact there is a clear need for direct and robust protection for soils. Where there is a rather stronger soil protection (such as the Sewage Sludge Directive), additional issues appear, such as the weak implementation of the laws by the Member States. Looking at these challenges inherited from the EU's attitude towards soils, Brexit can be seen as a significant opportunity for the UK to walk away from this ineffective legislative system for soil protection.

The weaknesses found in these laws can be viewed as reflections of a more significant issue about how we fail to prioritise our natural sources and NC. Our current way of living leads to a policy that supports a continuous economic growth and development. NC and natural resources have upper limits, which threatens the provision of ES for the future generations. As seen in the previous chapters, the legal framework focused on sustaining provisioning services that have economic values and market prices, which is a reflection of the understanding we currently have. The ESF will respond to this challenge by eliminating the situations in which other services are threatened at the expense of production of provisioning services, in other words, the situations that support this infinite economic growth. Simply put, this issue can be eliminated by reflecting how one decision about one service affects the provision of another ES. So, ensuring that the public and decision makers are aware of these interrelations will lead to more informed decisions about natural resources.

These decisions are of crucial importance and must be made through incorporating all the information we have access to. The existing legal framework is not adequately responsive to the pressures on soils. As mentioned, these are not specifically and directly focused on these problems. The ESF will enable an understanding of the different pressures on soils and how they impact the functioning of soils. This aspect of

ES is beneficial because the holistic assessment of a piece of land will reveal what can be achieved as a result of the decisions made regarding soils. If the assessment identifies the issues in environmental, economic, and social contexts, as seen in the first step of the ESF, it will lead to a clearer understanding of how the ecosystem will respond to various decisions. So, decision making should be improved, ensuring that none of these pillars of sustainable development are undermined. For example, at a farm level, a farmer may decide to produce more barley, which would increase his income. However, there are other considerations, such as soil type or climatic conditions. He also needs to consider the amount of fertiliser used, which can mean more nitrogen fertiliser that if incorrectly applied can leach into waterbodies and impair water quality and risk biodiversity and human health. Furthermore, depending on the cultivation intensity, soil quality and structure may change. To sum, it is clear that the provision of one service will affect other services. The farmer, then, faces a decision between economic considerations and potential adverse environmental impacts. This example can be applied to a larger scale decision and law making. When there is a decision to be made about ecosystems, decision makers must consider the surrounding aspects and additional repercussions of these decisions. The ESF supports a holistic approach that incorporates these considerations.

The first step of the ESF aims to offer the necessary knowledge for incorporating these elements into decision making. Prior to the decision making stage, it is crucial to identify, measure, monitor and value the services. For this assessment, improved knowledge on soil properties, processes, functions and ES, and their relationship as briefly explained in chapter three, should be established. The findings at the end of this step should, thus, present a clear classification scheme that identifies soil processes, functions, ES and EDS. The current trends regarding these aspects should also be understood. Another consideration in this step should be analysing and deducing the main issues in law and policy that lead to weakened soil protection, which can result in an extensive legal analysis as conducted in chapter five. In a soil-based framework application, this analysis should reflect the impacts of main soil threats as discussed in chapter three, how these interact with specific soil pressures as seen in chapter five and how these impact on soils and soil ES. This step is vital for identifying the gaps in law and policy, which paves the way for integrating new information and knowledge and eventually mainstreaming ES in land use strategy and management.

The second step of the ESF presents a set of precise and operationalisable environmental objectives, which will be set through the prism of sustainable development. The consideration of this principle ensures that these objectives should not prioritise other pillars of sustainable development but these all should go hand in hand. Realistically, there will have to be trade-offs among different objectives. However, it is vital to change our approach to economic and social incentives and start incorporating environmental considerations into the priority areas for ensuring the future provision of ES and the protection of natural resources in the long term. The role of law is crucial as these objectives cannot drastically change our approach to environmental protection unless they are designed as enforceable. Laws should be drafted in a way that enables the realisation of these objectives in different priority areas.

The third step of the ESF highlights that different scenarios that reflect different management options should be developed by integrating information from Step 1 and considering the environmental objectives from Step 2. The importance of scenario development is high as this provides us with several different outcomes of different actions regarding the management of a specific ecosystem. It is unreasonable to consider the selection of an option if while one ES is enhanced as a result of it, but all other ES are decreased. Similarly, even if all ES are enhanced, there are still other considerations, such as EDS and how these affect the lives of the people who are the habitants in that ecosystem. Thus, ES protection is incredibly vital; however, realistically it can or will never become the only consideration in choosing the best management option. This step merely suggests that there must be a range of scenarios to choose from so that society can move away from the continuous economic growth and the decisions that are based on this approach. Undoubtedly, the selection to incorporate information on interrelations among different aspects of soils as seen in chapter three becomes crucial.

The fourth step of this framework requires the proper implementation of decisions. This step requires time and financial resources as this framework cannot be seen as a simple attachment to the existing laws. The ESF supports the small-scale ecosystem management, which is particularly useful for land management as different soil types in the larger spatial scale have different needs and requirements. It was found that this process can be hindered by the lack of sufficient information on local level management that governments have, as seen in the UK example. Also, at a higher policy level, the process of achieving effective protection is stalled by the lack of enforcement. To sum up, there should exist an effective and operational enforcement system established through different legal and economic tools for this framework to achieve its full potential.

The fifth step, finally, advocates a two-limb monitoring system, one is monitoring of the decisions made and two is continuous monitoring of the state of ES. This step will provide us with understanding of how our decisions about ecosystems work in real world situations in short- and long-term. This step also enables us to comprehend the complex relationships in natural ecosystems, ES and functions, and other aspects of ecosystems as discussed in chapter three and provides us with data for more sustainable future decisions.

7.3. Overall Discussion

This research introduced a new approach to soil protection, developed the ESF and presented its steps in chapter six. It is now appropriate to emphasise how this framework would respond to the challenges identified in chapters four and five, which are the lack of adequate focus on soils in environmental legislation, information deficit and insufficient research regarding soils and its multiple aspects, as well as the lack of public awareness of the benefits of soils.

To begin with, establishing the ESF-based response to a number of reasons why soil is ignored in law and policy in chapter four is crucial. The ESF is based on a holistic approach in which all ES contribute to human survival and wellbeing in one way or another. This notion conflicts with the idea of protecting provisioning services for maximisation of the economic or social contribution. Adopting an ES-based approach will inevitably overcome the irresponsible exploitation of natural resources and ecosystems, which can be simply seen in the relationship between the concept of ES and sustainable development. Indeed, the balance between the exploitation of natural resources and social and economic development and protecting ES for the current and future generations is key to sustainable development. This objective does not necessarily mean that mainstreaming ES will abandon the continuous economic growth. In fact, the concept can provide a path for sustainable economic growth by highlighting areas for economic exploitation that are currently ignored or by creating new markets for ES. Thus, it can be expected these concepts to enable each other's adoption and operationalisation in practice. The legal analysis in chapter five revealed that generally, where ES are considered, provisioning and regulating services are in the forefront of legal protection provided for soils. This situation results from the productionist approach that the past and present generations cannot elude from. For achieving sustainable development, there must be a level of economic and social development; however, this should not be in the expense of the environment. As seen in the second step of this framework, environmental objectives must be realistic and consider the economic and social pillars of sustainable development. The ESF advocates that all ES (including supporting and cultural services) must be protected by law to ensure their continuous flow to be provided for the future generations. To achieve this objective, the ESF aims to understand the interrelations amongst different services within ecosystems.

Moving onto the issue of information deficit, in the ES context, lack of sufficient research is a significant weakness. Also, there is insufficient data on soils, including data on soil ES, especially other than provisioning ones. This lack of data leads to incomplete information about these services and their value. Insufficient knowledge about the importance and interrelations of soil ES and threats against them leads to a situation where these benefits are not sufficiently protected. This weakness can be potentially overcome by adoption and an effective application of the ESF, as it advocates the proper assessment of ES and the use of up-to-date scientific data in law and decision making. Incorporating such data is crucial for realising the ESF and its several steps, i.e., identifying environmental, economic, and social issues, setting environmental objectives, and developing scenarios and choosing the best management approach. These steps suggest the vital importance of scientific data on soil (including soil processes, functions and services and how these interact with each other and with soil threats as examined in chapter three). The framework recognises that scientific data should be gathered prior to any attempt for managing or regulating natural resources. Therefore, the ESF supports more focused effort and funding into appropriate research.

The holistic approach of the ESF also aims to change the way we see different services of nature, including disservices. This integration is crucial for delivering justice in society as the costs of these EDS generate should be borne by society as a whole and benefits from ES. Also, considering EDS in an ES-based framework is vital for understanding how ecosystems function and for eliminating these negatives and enhancing the provision of benefits. As emphasised in the first step of the ESF, this framework is information and data driven, science-based and multidisciplinary in itself, which can be eventually useful for mainstreaming the idea of expert courts dealing with environmental concerns. It supports that scientific knowledge must be translated and transferred into law and policy making. These aspects demonstrate that this framework, following the similar characteristics of the concept of ES, will initiate the process that information about ecosystems and ES being put in the forefront of environmental management and protection.

Certainly, further knowledge on the importance and value of ES along with more awareness in the public eye would increase the credibility of the decisions regarding ecosystems. ES is a useful concept for changing the public's existing perception, which can appear as another reason why soils are ignored in the policy. Most functions of soils are not appreciated as there is a gap in education and awareness. Step 1 of the ESF supports public education on the matter and aims to achieve the outcome of greater public awareness and increased knowledge by reflecting what soil does for us and why its protection is crucial for our survival and wellbeing. Ideally, once public education on soils and ES increases awareness, this awareness will lead to an enhanced public participation, which is valuable for more legitimate decisions regarding ecosystems. More substantial public participation would also increase the credibility and transparency of such decisions. Including people who will be affected by the decisions, especially those individuals who depend on natural resources heavily, is crucial for ensuring environmentally just decisions. Within the current environment, it is difficult to say that the participation of these communities in environmental decision making is effectively facilitated. The participation of such communities is also important for incorporating their local knowledge of ecosystems. This argument does not necessarily mean excluding scientific work or findings. Indeed, the ESF suggests that it is extremely valuable to collect traditional knowledge of local communities and combine it with a set of scientific data in a given ecosystem for more informed decisions regarding natural resources. From a soil perspective, it is virtually certain that integration of local knowledge will produce better decisions, given that local people, such as farmers, are in direct contact with soils for long periods of time.

Another policy challenge is the fact is that soil is rather difficult to regulate because of the huge variety of soil types. Indeed, different soil types have different properties, as mentioned in chapter three, and different needs and the flow, quality or quantity of ES that are offered by them are diverse. This is similar in the context of smaller scale environmental management. Local needs and desires can be different and properly responding to these aspects in international or national policy levels is impossible. The ESF, by advocating a multiple level policy, can address these issues. This framework supports the notion that where necessary, local level management of and decision making about ecosystems must be considered as seen in the ESD argument in the first step of this framework. Also, in the third step of the framework, developing scenarios and choosing the best management approach for every land use would better reflect the actual needs of different soil types as one-size-fits-all is not an acceptable approach especially in soil management.

The lack of sufficient regulation for soils also stems from the fact that private land ownership hinders the efforts for regulating soils. The fourth step of the ESF shows that the framework introduces a new understanding in regulating and making decisions about ecosystems, which places their services in the front as these services are serving humans beyond boundaries of private ownership, a clear one being carbon sequestration. The tools that the ESF can offer include PES, in which beneficiaries of ES compensate stewards, including private owners, who maintain or protect them. This supports a fair situation, where stewards of the environment are being paid for their efforts while beneficiaries are making a payment for what they obtain. This perception can support an environmentally, socially and economically just system in which eventually a high level of environmental protection is offered for the current and future generations.

Chapter six introduced the ESF, which is generated on the basis of the previous ground-breaking works in the field. This novel framework was developed through a critical analysis of ES research, including several approaches and tools to construct it, with the aim of addressing the legal and policy gaps in this present study. This research used the issue of soil protection as a tool to highlight that such a framework has the potential to respond to the existing legal challenges. Indeed, beyond merely responding to the abovementioned policy and social challenges, the ESF has potential for addressing several issues found in the environmental law scene. As the legal analysis in chapter five proved that there is a clear need for stronger soil protection in the UK and this need has been ignored, the way laws protect soils and how the law makers view soil protection must drastically change. This research discussed that these weaknesses of the existing legislation can be overcome and the current approach to soil protection can be changed by adopting an ES-based approach, which reflects a brand-new understanding of how we manage and make decisions about soil ecosystems. Therefore, before concluding this section, it is important to explain how this framework can strengthen soil protection laws.

Soil protection laws should be drafted in a manner that incorporates the concept of ES. ES can benefit from a reform through which laws include references that enable the ESF's steps or tools to operate in a meaningful way. A pressure-based legal analysis in chapter five is the most appropriate analysis for this process. Once the key pressure is identified, which is aimed to be controlled by a law, it is then simpler to determine the priorities for protection. In this case, the ESF also strives to establish the notion that the effects of environmental protection would be limited and incomplete, unless a satisfactory level of protection is provided for ES. This objective can be achieved, again, by setting priorities and considering trade-offs, synergies and win-win outcomes among different services. For this practice, the interrelations between threats and ES, as discussed in chapter three, must be established. It is unlikely that all services from an ecosystem can be granted a high level of and equal protection at the same time. Indeed, trade-offs do and will occur amongst different desires, which reflect different pillars of sustainable development. Science has a role of informing these decisions, whilst law has a part in guiding these decisions. With the consideration of this fact, law should aim to protect these services as much as possible, which calls for an assessment to be made during the regulation process. Indeed, environmental law must be proactive in protecting ES, not reactive. This practice inevitably calls for good incorporation of scientific research and information.

As seen in Table 6.1., each separate aspect found in different steps of the ESF supports a novel approach to tackle the problematic issues in the existing environmental law and policy. For the purposes of this research, Table 7.1. presents how the ESF approach can improve the existing soil legislative instruments that are weak or very weak in the legal analysis in chapter five. This is a non-exhaustive list of the potential ESF responses to issues identified in these legal instruments and aims to illustrate that the ESF approach can strengthen the existing laws and establish the notion of making more sustainable decisions regarding our natural resources. This new approach will indicate that environmental decision making, starting from the smaller scale to national and international law making, hugely benefits from incorporating scientific research outcomes, local knowledge and effective practice of environmental democracy.

It must be noted that there are challenges. Mainstreaming the new approach to law and decision making and incorporating this into policy is not a quick or straightforward process. Also, further research should be supported, and resources should be spared for the operationalisation of the ESF. It is difficult to estimate how and when this can become a reality in a country where multiple desires and priorities clash, including political and economic agenda and the existing conservation approaches.

Although the concept has the potential for improvement in law and policy, it is not possible to argue that it will revolutionise the field of environmental law. This framework can be expected to be operationalised in areas where environmental legislation is particularly weak, such as soil protection, which requires a significant improvement to be successful. However, adopting the ESF does not necessarily mean that there must be a drastic change in environmental laws or repealing all the existing environmental legal instruments. Therefore, the existing conservation approaches currently used in several environmental media and issues, such as protected sites in nature conservation or limitations on pollutant levels in air and water, should not be negated, in fact the effectiveness of some of these tools would only be expected to increase by the adoption of the ESF. Effective environmental protection may be sufficient for its set purpose;

however, an ES-based approach to these existing policies would enhance their success by enacting more ambitious goals and emphasising that robust environmental protection can only be comprehensive, including the protection of ES. Soil is a particularly good example of this, as mentioned, its functions and ES can be hugely impacted while it is still fertile as soil issues can be concealed for a long time. To sum, this framework should be considered as a tool for changing our current approach to making decisions about natural resources into a more holistic, inclusive and considerate perspective. This understanding must be communicated at all levels of society and mainstreamed as a concept, which will eventually find legislative underpinning.

When or if this concept is mainstreamed, there is always a risk of being undermined as in the case of sustainable development. Indeed, such concepts have the potential to be distorted when reflected in law and policy, which explains why they cannot be operationalised in a meaningful way. Their effects tend to be limited to a modest level of behavioural change in society and ineffective in law making due to a clear dilution in their meaning. Lessons we have learned from the development of international environmental law should be incorporated for a proper and effective use of the concept of ES as a novel tool for law and decision making.

Table 7.1. The Ecosystem Services Framework response.

This table presents a non-exhaustive list of examples on how the ESF can respond to the weaknesses identified in legal instruments which were found weak or very weak as a result of the legal analysis in chapter five.

Pressure	Legal Instrument	Main Weaknesses	The ESF Response
Agriculture	Agriculture Act	The aim of maximising production intensified agricultural practices in the expense of environmental damage and there is no specific protection provided for soils from these pressures.	Step 3 of the ESF requires an approach of preventing environmental degradation for provision of certain ES, which are likely to have more economic benefits. Trade-offs and synergies between different ES should always be assessed. Accordingly, maximisation of one service should not be supported by law in the expense of degradation of another service. Mentioning cultural services in the text of the legal instrument cannot go beyond a mere tick box exercise, unless there are proactive measures in law to protect these services.
Agriculture	Direct Payments Regulation	Payments, other than greening payments which are only 30% of total direct payments, do not focus on environmental protection. Also, farmers receive BPS according to the amount of land they own.	Greening payments and BPS can benefit from an approach similar to the PES schemes mentioned in Step 4 of this framework. This would help placing a broader spectrum of ES (including regulating, cultural and supporting services) in the forefront of environmentally friendly practices and prevent unnecessary food production.

Agriculture	Animal Feed Directive	Once an animal is fed, animal waste is disposed in manures and slurries into the soil. Although limiting arsenic, lead, mercury, cadmium at the Directive's levels limit toxicity to mammals to low levels, these levels can be extremely toxic to soil microbes and other organisms.	The ESF advocates a multidisciplinary approach to law making. Incorporating the results from scientific studies (e.g., assessing the impacts of these elements on all soil organisms prior to setting limits) is crucial for complete environmental protection. Also, reflecting the importance of soil through a biodiversity perspective by viewing this as a soil ES, has the potential for taking soil protection to a different level.
Agriculture	Water Framework Directive	1- There is limited consideration of sediment release into waterbodies from soil related pressures and threats. 2- The implementation of the public information and consultation provision is weak and some Member States (including England) fail to facilitate active engagement at national level.	1- The ESF provides an approach, which focuses on objectives and decisions based on interrelations between pressures and threats to ecosystems and their functions. The use of scientific research is crucial for incorporating these aspects in law and policy. This legal instrument can be strengthened from a soil perspective by encompassing different pressures and threats, such as soil sealing and the impacts of sealed soil on pollutant input in waterbodies. This approach would provide indirect, but more holistic environmental protection. 2- The ESF reflects that environmentally, economically and socially just decisions can only be made through a meaningful engagement from different stakeholders. The idea of enabling interest groups and local people to offer their knowledge and their voice in the decision making is supported. This way, decision makers and the public build trust and achieve cooperation which reinforce environmental democracy and ease the process of adopting strict environmental measures.
Agriculture	Groundwater Directive	The Directive does not have soil related objectives or targets, which reflect the partial links between water and soil protection.	The fact that most groundwater enters waterbodies through soils makes soil and groundwater protection highly interrelated. Drafting water and soil laws must be informed by risks and opportunities, which are established through combined assessments that support the notion of holistic approach that the ESF introduces.
Agriculture	Pesticides Directive	Effectiveness is hindered by implementation failures of IPMs which reduce the adverse impacts of certain plant protection methods and require a justification of their use.	This framework adopts the precautionary principle which in this context requires compliance with IPM measures. Here, the enforcement element is crucial and the ESF supports the notion that specific measures in place for environmental protection must be enforceable to ensure effectiveness.
Industry and Waste Management	Part IIA of EPA	1- This regime is found unfair as the payment might be made by the next owner of the land although it might have been contaminated before the purchase. 2- Remediation activities can cause more damage to the soil and soil functions.	1- The ESF supports the polluter pays principle, or more broadly, the exploiter pays principle which imposes a financial liability on the exploiter who treat natural resources as merely instrumental, to be consumed in the short term, without consideration for the survivability of the resource, the overall ecosystem, or future generations. This framework suggests

			that when determining the monetary value of damages, ES should be taken into consideration which reflects the actual harm that has been done. 2- By offering an approach which puts scientific evidence at the forefront of environmental decision making, the ESF aims to prevent situations in which remediation or compensation activities do not produce further harm to ecological systems. Decisions regarding natural resources must be made following effective incorporation of scientific evidence and careful consideration. Also, continuous monitoring, as seen in Step 5, ensures that the short- and long-term impacts of these decisions are not overlooked.
Industry and Waste Management	Waste Framework Directive	Although waste management activities should consider risks to soils, there is no soil protection objectives or targets, which undermines the importance of this statement in the legal text.	The ESF offers a holistic approach, which supports taking into account the impacts of legal instruments on different aspects of the environment. Therefore, as seen in Step 2, laws regulating activities that have relevance to soil protection, such as waste management, must reflect associated concerns and contain inclusive objectives in order to achieve better protection for different aspects of the environment.

7.4. Limitations

Since there is limited multidisciplinary research on soil ES, we cannot be sure that this framework will provide robust soil protection in practice. This research merely achieved the aim of introducing a novel framework and demonstrating how it could respond to numerous challenges faced by soils and the policy. Developing the ESF further and then placing it into operation requires input from a multidisciplinary research team. More research and work on the development of the ESF will also help understand how the framework could be operationalised to achieve different ecosystem management priorities and objectives, e.g., nature conservation or agricultural intensification. Additionally, further multidisciplinary research is vital for applying the ESF to different ecosystems, e.g., terrestrial or marine ecosystems. Therefore, the findings in this research are restricted to initial conclusions from a legal and policy point of view, but these cannot be taken as hard evidence of the applicability of the ESF from other disciplines' perspectives. Thus, these findings do not imply that the ESF is the only guaranteed way for better soil protection. Eventually, it is not possible to transform the field of environmental law through a limited study. However, this research can be viewed as a foundation for future research.

There are issues regarding the methods stemming from the lack of a research team. Although it was suggested that systematic review would offer a significant benefit for this kind of research, this remained as a rather insufficient attempt for this study and is only used to improve the quality of research through systematised review. The nature of this research did not allow the researcher to seek assistance from others or work in a research group. Also, due to the language barriers, there was no possibility for the researcher to review the whole existing literature, thus only literature written in English language is included in this review. Finally, the timeline of this research did not allow the researcher to spend more than a specific period of time on the review of the literature. Thus, the most appropriate method for reviewing the literature was systematised review for this study.

It must be made clear that the legal analysis found in chapter five is only focused on the legal instruments with high relevance to soil protection; therefore, a number of legal instruments with minimal relevance are not included in this research. This legal analysis also was intentionally focused on preventative laws and excluded reactive laws, such as the Regulation Enforcement and Sanctions Act 2008. Although EPA has a reactive nature, it is one of the most important legal instruments in the UK soil protection legislation; thus, it was included in this legal analysis.

7.5. Contribution and Impact

Considering these limitations, this research suggests some directions for future research in environmental law to operationalise the ESF in complex real-world situations. Besides, this study has made two significant contributions to the literature.

Firstly, the legal analysis found in chapter five is a significant contribution to the literature as there is an evident lack of critical literature offering such an analysis concentrating on the effectiveness of soil protection legislation in the UK. This analysis also adopted a pressure-based approach, which reveals how these pressures impact soils, their functions, ES and interrelate with several soil threats and how the law responds to them.

Secondly, the number of studies presenting framework recommendations, which integrate soil ES into legislation is scarce. As mentioned earlier, the main reason is that soil is a component that is generally overlooked in ES research. By considering soil ES within the legal analysis and demonstrating how this concept can enable development in the law, this research supports the notion of mainstreaming ES in law and policy through further research.

Future research based on the findings of the present study can enable the theoretical and practical implications of this research to generate a positive impact on our current approach in managing ecosystems and regulating environmental problems. As researchers, we have a responsibility to work towards an improved understanding of soils, help public to appreciate the benefits that soils offer for our survival and wellbeing, and inform policy makers about what we can do to protect these benefits. This study has strived for a step towards this objective.

7.6. Conclusion

We only appreciate clean drinking water when we are thirsty or realise how pleasant it is to go out and enjoy a piece of nature and clean air, when we are not able to. As most of the time these benefits are already available to us, we do not contemplate the processes that provide our access to these benefits. Before we started enjoying the luxuries of modern life, such as water filtration or air conditioning systems, only nature offered these valuable assets. However, we should not forget that we do not have manufactured substitutes for all of nature's services. Being disconnected from nature has blurred our vision about how our and future generations' survival and well-being are dependent on nature, which eventually led to a situation in which we fail to protect these benefits of nature.

To provide legal protection for these benefits, the concept of ES should be mainstreamed to inform public, including decision and policy makers. Throughout history, the values of society, desires and priorities have changed drastically. Law must continuously evolve to be capable of reflecting these values. Owing to scientific advancements, today we live in a world where the global society has been prioritising environmental values as much as economic and social considerations. Now, we are aware that we have reached a point where we cannot afford to keep degrading our natural resources. The existing laws must follow the same direction and respond to these concerns through a holistic approach and brand-new understanding developed through the incorporation of science that allows us to comprehend the importance of nature and its services.

This research used soil as a case study to reflect how this new approach can become reality in law and policy. In chapter three, to justify the need for strong soil protection, this research highlighted the importance of soils through identifying soil processes, functions and ES, which are crucial to humans' economic and societal needs and ascertaining threats to soils. This highly complex, variable and non-renewable natural resource is crucial for human life, well-being and economy through the flow of most terrestrial ES, which are food production, water storage, platform, biomass and raw materials, biodiversity, gene pool and genetic resources, refugia or refuge, water quality regulation, water supply regulation, gas and climate regulation, carbon sequestration, erosion control and sediment retention, recreation, cognitive, heritage, primary production, nutrient cycling (Table 3.1.). The importance of this natural resource shows the need for comprehensive and effective protection to be offered to soils.

This research also presented a pressure-based legal analysis of the effectiveness of the UK law for protecting soils and their services. It can be concluded that considering the importance of soils as reflected in chapter three, the legal analysis in chapter five showed that the existing law does not address the threats and pressures against soils adequately and fails to provide sufficient consideration for soil ES in legislation. Indeed, the finding of this study demonstrate that, out of 20, only 1 law was found to provide very strong soil protection (Sewage Sludge Directive, which has a very limited application), while 6 are strong, 5 are modest, 5 are weak and 3 are very weak.

Using the weaknesses found in the legal analysis in chapter five, this research presented a novel framework for improving soil protection in chapter six. Different methods for integrating the importance and value of soil ES into policy making were critically appraised and how the ESF, which offers a holistic approach combining scientific, economic and societal insights, can respond to the challenges are discussed.

This research helped developing a new understanding of soil protection through the multidisciplinary approach of ES and provide policy recommendations in light of this concept. It concluded that this approach has a substantial potential for reshaping the current legal approach to soil protection in a way that it effectively protects the valuable benefits we obtain from soils. It must be noted that this research does not conclude that we should abandon the existing and established strategies for environmental protection. The ESF should be seen as an additional tool for a better response to critical environmental issues. The perception that the ESF offers should be complementary to other tools and methods. This approach offers a new perspective for soil protection, which focuses on soil functions that provide the benefits that we obtain from soils, rather than trying to protect them because it is simply the right thing to do. The ongoing global soil degradation is a proof that the latter approach has failed for a long time. Today, we are aware that we must use all the tools we have for direct and robust soil protection before it becomes too late.

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Appendix I

Research Results

Search Term	Database										
	Lexis Library	HeinOnline	Westlaw	Google Scholar	JSTOR	ScienceDirect	Academic Search Complete	Emerald Insight	The ENDS Report	Environment Complete	GreenFILE
Soil	206 (in journals)	70,105 (2000 to date)	~9,500 (2000 to date)	~1,440,000 (2000 to date)	93,369 (2000 to date)	499,415 (2000 to date)	332,256 (2000 to date)	9,070 (in articles/chapter)	2,306	294,427 (2000 to date)	81,719 (2000 to date)
Soil protection	354 (in journals)	56,881 (2000 to date)	~6,000 (2000 to date)	~1,180,000 (2000 to date)	25,077 (2000 to date)	128,718 (2000 to date)	2,386 (2000 to date)	5,066 (in articles/chapter)	845	4,527 (2000 to date)	709 (2000 to date)
Soil legislation	385 (in journals)	33,228 (2000 to date)	~6,700 (2000 to date)	~309,000 (2000 to date)	4,669 (2000 to date)	24,598 (2000 to date)	101 (2000 to date)	1,981 (in articles/chapter)	471	109 (2000 to date)	61 (2000 to date)
Soil law	254 (in journals)	61,764 (2000 to date)	~7,300 (2000 to date)	~1,620,000 (2000 to date)	16,874 (2000 to date)	76,263 (2000 to date)	314 (2000 to date)	3,792 (in articles/chapter)	526	216 (2000 to date)	66 (2000 to date)
Soil conservation	598 (in journals)	29,544 (2000 to date)	1,936 (2000 to date)	~1,540,000 (2000 to date)	34,769 (2000 to date)	85,609 (2000 to date)	9,324 (2000 to date)	1,978 (in articles/chapter)	348	10,762 (2000 to date)	3,757 (2000 to date)
International soil legislation	572 (in journals)	25,691 (2000 to date)	2,975 (2000 to date)	~265,400 (2000 to date)	3,457 (2000 to date)	14,480 (2000 to date)	N/A	1,423 (in articles/chapter)	84	1 (2000 to date)	N/A
European soil legislation	544 (in journals)	15,796 (2000 to date)	~4,900 (2000 to date)	~122,000 (2000 to date)	2,958 (2000 to date)	16,914 (2000 to date)	N/A	1,277 (in articles/chapter)	199	8 (2000 to date)	5 (2000 to date)
UK soil legislation	566 (in journals)	9,476 (2000 to date)	~6,700 (2000 to date)	~101,000 (2000 to date)	1,566 (2000 to date)	7,539 (2000 to date)	N/A	825 (in articles/chapter)	290	N/A	N/A
Soil policy	423 (in journals)	54,070 (2000 to date)	~4,700 (2000 to date)	~1,370,000 (2000 to date)	23,520 (2000 to date)	74,521 (2000 to date)	372 (2000 to date)	5,681 (in articles/chapter)	636	501 (2000 to date)	246 (2000 to date)
Ecosystem services	869 (in journals)	23,021 (2000 to date)	2,360 (2000 to date)	~1,370,000 (2000 to date)	16,011 (2000 to date)	85,362 (2000 to date)	11,793 (2000 to date)	5,853 (in articles/chapter)	381	15,329 (2000 to date)	6,832 (2000 to date)
Ecosystem disservices	6 (in journals)	16 (2000 to date)	1 (2000 to date)	~15,500 (2000 to date)	76 (2000 to date)	683 (2000 to date)	77 (2000 to date)	22 (in articles/chapter)	N/A	119 (2000 to date)	60 (2000 to date)
Soil ecosystem services	306 (in journals)	7,287 (2000 to date)	851 (2000 to date)	~16,300 (2000 to date)	7,722 (2000 to date)	42,953 (2000 to date)	488 (2000 to date)	940 (in articles/chapter)	66	543 (2000 to date)	203 (2000 to date)
Soil functions	332 (in journals)	28,202 (2000 to date)	1,855 (2000 to date)	~1,580,000 (2000 to date)	24,457 (2000 to date)	287,649 (2000 to date)	4,405 (2000 to date)	5,021 (in articles/chapter)	106	4,604 (2000 to date)	1,046 (2000 to date)
Soil processes	324 (in journals)	27,772 (2000 to date)	2,564 (2000 to date)	~1,210,000 (2000 to date)	46,299 (2000 to date)	405,940 (2000 to date)	10,015 (2000 to date)	7,601 (in articles/chapter)	668	10,098 (2000 to date)	2,532 (2000 to date)

Search Term	Lexis Library	HeinOnline	Westlaw	Google Scholar	JSTOR	ScienceDirect	Academic Search Complete	Emerald Insight	The ENDS Report	Environment Complete	GreenFILE
	Database										
Soil properties	198 (in journals)	18,878 (2000 to date)	1,985 (2000 to date)	~1,080,000 (2000 to date)	26,873 (2000 to date)	262,741 (2000 to date)	21,520 (2000 to date)	4,553 (in articles/chapter)	243	21,297 (2000 to date)	4,773 (2000 to date)
Ecosystem services approach	879 (in journals)	15,470 (2000 to date)	2,015 (2000 to date)	~1,100,000 (2000 to date)	10,894 (2000 to date)	66,883 (2000 to date)	431 (2000 to date)	5,449 (in articles/chapter)	156	612 (2000 to date)	291 (2000 to date)
Ecosystem approach	884 (in journals)	22,110 (2000 to date)	2,782 (2000 to date)	~1,650,000 (2000 to date)	37,961 (2000 to date)	171,156 (2000 to date)	2,833 (2000 to date)	6,814 (in articles/chapter)	350	3,665 (2000 to date)	1,351 (2000 to date)
Ecosystem management	884 (in journals)	32,971 (2000 to date)	3,023 (2000 to date)	~1,570,000 (2000 to date)	39,361 (2000 to date)	140,373 (2000 to date)	23,208 (2000 to date)	6,984 (in articles/chapter)	423	34,792 (2000 to date)	13,419 (2000 to date)
Soil threats	517 (in journals)	18,715 (2000 to date)	949 (2000 to date)	~272,000 (2000 to date)	8,187 (2000 to date)	51,798 (2000 to date)	473 (2000 to date)	2,206 (in articles/chapter)	171	544 (2000 to date)	190 (2000 to date)
Soil erosion	249 (in journals)	16,408 (2000 to date)	993 (2000 to date)	~1,450,000 (2000 to date)	12,220 (2000 to date)	80,541 (2000 to date)	12,155 (2000 to date)	1,494 (in articles/chapter)	122	14,251 (2000 to date)	3,342 (2000 to date)
Soil contamination	491 (in journals)	13,765 (2000 to date)	1,427 (2000 to date)	~1,420,000 (2000 to date)	7,530 (2000 to date)	109,168 (2000 to date)	12,935 (2000 to date)	1,802 (in articles/chapter)	1,056	16,333 (2000 to date)	7,822 (2000 to date)
Soil pollution	545 (in journals)	23,788 (2000 to date)	2,672 (2000 to date)	~1,320,000 (2000 to date)	10,357 (2000 to date)	106,346 (2000 to date)	11,816 (2000 to date)	2,422 (in articles/chapter)	1,387	21,816 (2000 to date)	13,644 (2000 to date)
Soil sealing	191 (in journals)	4,103 (2000 to date)	390 (2000 to date)	~57,600 (2000 to date)	1,057 (2000 to date)	11,170 (2000 to date)	914 (2000 to date)	1,120 (in articles/chapter)	55	819 (2000 to date)	109 (2000 to date)
Soil compaction	21 (in journals)	1,745 (2000 to date)	213 (2000 to date)	~174,000 (2000 to date)	1,870 (2000 to date)	51,408 (2000 to date)	2,896 (2000 to date)	837 (in articles/chapter)	34	2,155 (2000 to date)	391 (2000 to date)
Soil organic matter loss	156 (in journals)	8,345 (2000 to date)	779 (2000 to date)	~440,000 (2000 to date)	10,582 (2000 to date)	79,447 (2000 to date)	229 (2000 to date)	977 (in articles/chapter)	33	259 (2000 to date)	88 (2000 to date)
Soil salinization	14 (in journals)	285 (2000 to date)	15 (2000 to date)	~22,400 (2000 to date)	551 (2000 to date)	66,653 (2000 to date)	902 (2000 to date)	82 (in articles/chapter)	8	835 (2000 to date)	199 (2000 to date)
Desertification	156 (in journals)	6,183 (2000 to date)	564 (2000 to date)	~86,800 (2000 to date)	2,398 (2000 to date)	9,938 (2000 to date)	3,318 (2000 to date)	454 (in articles/chapter)	20	3,157 (2000 to date)	947 (2000 to date)

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Appendix II

Recent Policy Developments

Since the completion of this thesis, there has been a few changes in the UK soil policy. This appendix will provide an overview of these relevant policy developments.

Following Brexit, the critical need for an improved agricultural policy led the policy makers to take initiatives for progressing with the Agricultural Bill. In November 2020, the Bill received Royal Assent and became the Agricultural Act 2020. The most relevant provisions are related to payments. The Act outlines the departure from BPS under CAP to payments of public money for the provision of public goods,[2399] including air and water quality, soil health, wildlife conservation, measures to reduce flooding and impacts of climate change. These payments will be made to support farmers and land managers.[2400] Other soil focused provisions include the Secretary of State's authority to give financial assistance for or in connection with a number of purposes including protecting or improving the quality of soil.[2401] The inclusion of soil quality appears as a political signal that soil is slowly becoming a priority for the government.[2402] Although it is too soon to discuss its effectiveness, these measures and provisions demonstrate the Act's potential for reforming British farming and contributing to the UK's environmental objectives,[2403] such as its commitment to reach net-zero carbon emissions by 2050.

In February 2021, a report of the Independent Review on the Economics of Biodiversity led by Professor Sir Partha Dasgupta was published. The Dasgupta Review[2404] focuses on the economics of nature and is important in terms of soil protection and ES for several reasons. It has a large number of references to soil, soil ES and soil biodiversity,[2405] reporting the need for placing soil related issues in the environmental policy. In line with the previously mentioned arguments in this thesis, it reflects on the fact that our livelihoods and wellbeing depend on nature and our demands have been

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[2399] Agriculture Act 2020, s 7
[2400] ibid, s 14
[2401] ibid, s 1 (1)(j)
[2402] Tom Lancaster, 'Agriculture Bill 2020: Do good things come to those who wait?' (*Wildlife and Countryside Link*, January 2021) <https://www.wcl.org.uk/agriculture-bill-2020-do-good-things-come-to-those-who-wait.asp> accessed 2 July 2021
[2403] ibid
[2404] P. Dasgupta, 'The Economics of Biodiversity: The Dasgupta Review' (2021) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/962785/The_Economics_of_Biodiversity_The_Dasgupta_Review_Full_Report.pdf> accessed 4 February 2021
[2405] ibid

exceeding the capacity of nature to provide goods and services.[2406] According to the Report, this current situation is placing the prosperity of future generations at stake.[2407] The issue allowing these existing conditions lies within the market and institutional failures as some benefits we obtain from nature do not have market prices and governments allow economic activities at the expense of environmental benefits.[2408] It continues by emphasising the urgent need for a drastic change in our mindset and actions in relation to sustainability.[2409] The Dasgupta Report is a comprehensive and remarkable document that highlights the fact that our decisions are driven by economics and biodiversity should be placed at the core of this discipline.[2410] It must be noted that this Report has no binding effect or enforceability; however, it can become a significant driver for the future changes in the UK government's environmental policy.

In May 2021, the UK government published the England Peat Action Plan.[2411] Aligned with the 25 Year Environment Plan, this document emphasises that the government's ambitious objectives for peat restoration in England.[2412] It advocates that it will help to achieve net-zero commitments and contribute to wider environmental goals by restoring lowland peat, or where it is not appropriate, developing new responsible management measures to ensure that the topsoil is retained for as long as possible and GHG are reduced.[2413] The government outlines a set of realistic measures and substantial objectives in the England Peat Action Plan, such as secure peatlands' carbon store so they meet their contribution to net-zero commitment by 2050, delivering natural flood management and improve water quality, and protecting the historic environment of peatlands.[2414] These objectives show that the government has adopted a profound nature-based response to address our existing problems and support the delivery of a wide range of ES from peatlands. This document is not legally binding and remains as a guidance rather than providing concrete solutions for issues that peatlands face.

Nature-based solutions can be defined as "actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity

[2406] ibid
[2407] ibid
[2408] ibid
[2409] ibid
[2410] ibid
[2411] UK Government, 'England Peat Action Plan' (May 2021) <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/987859/england-peat-action-plan.pdf> accessed 30 June 2021
[2412] ibid
[2413] ibid
[2414] ibid

benefits".[2415] The adoption of similar solutions support the notion of the continuous delivery and flow of a wide range of ES and investing in NC to obtain diverse benefits from the same ecosystem by eliminating trade-offs, as discussed throughout this thesis. In recent months, nature-based solutions have drawn attention from several organisations as well as the UK government. In May 2021, the British Ecological Society has published 'Nature-Based Solutions for Climate Change in the UK'.[2416] Similar to the arguments reported in this thesis, this document promotes supporting the ability of natural habitats to offer nature-based solutions for addressing environmental issues by providing diverse benefits.[2417] The authors also advocate that these solutions should be seen as complementary to other conservation efforts, not as a replacement.[2418] Similarly, in May 2021, the World Wide Fund for Nature in its report titled 'Systemic Nature-Based Solutions' pointed out that the UK government must use their leadership role by putting land use, agriculture and nature-based solutions at the forefront of global plans to address emissions and tackle the climate and nature crisis.[2419] Although these reports have a specific focus on addressing climate change, they appear as promising examples of the broad interest in the adoption of ES in the form of nature-based solutions to address environmental challenges.

[2415] 'Nature-based Solutions' (*Commission on Ecosystem Management*) <https://www.iucn.org/commissions/commission-ecosystem-management/our-work/nature-based-solutions> accessed 2 July 2021
[2416] R. Stafford and others, 'Nature-based Solutions for Climate Change in the UK: A Report by the British Ecological Society' (May 2021) <https://www.britishecologicalsociety.org//wp-content/uploads/2021/05/NbS-Report-Final-Designed.pdf> accessed 25 May 2021
[2417] ibid
[2418] ibid
[2419] World Wide Fund for Nature, 'Systemic Nature-Based Solutions: Making Nature a Climate Hero' (May 2021) <https://www.wwf.org.uk/sites/default/files/2021-05/Systemic%20Nature%20Based%20Solutions%20Briefing.pdf> accessed 2 July 2021