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The ecosystem services provided by soil and the importance of its protection: the essential role of organic waste

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1. *One underestimated environmental matrix*

The 1987 UN report Our Common Future (the Brundtland Report) proposed looking at the Planet from a different perspective: «from space, we see a small and fragile ball dominated not by human activity and edifice but by a pattern of clouds, oceans, greenery and soils».

Despite the fact that our planet is made up of two-thirds oceans and only about one-third of soils[1], the latter are so important that our planet has been referred to as "Earth" since antiquity: the words of St. Francis' Canticle of Canticles, which gave its name to the 2015 encyclical «Laudato si', mi' signore, per sora nostra matre Terra, la quale ne sustenta et governa, et produce diversi fructi con coloriti flori et herba»[2], are well known.

Although Soil (deliberately capitalised) is cited as the primary environmental matrix in the same encyclical[3], in the public debate it is very often[4]

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[1] M. CHERLET, C. HUTCHINSON, J. REYNOLDS, J. HILL, S. SOMMER, G. VON MALTITZ (eds.), *World Atlas of Desertification*, Publication Office of the European Union, Luxembourg, 2018.

[2] Canticle of the Creatures: Franciscan Sources (FF) 263. In English: «Be praised, my Lord, through Sister Earth, our Mother, / Who sustains and maintains us / and produces manifold fruits and colored flowers and herbs» (Siglind Bruhn Saints in the Limelight: Representations of the Religious Quest on the Post-1945 Operatic Stage, Pendragon Press, 2003, 341).

[3] «The violence in the wounded human heart is also manifested in the symptoms of sickness we feel in the soil, water, air and living beings» (para. 2). References to the soil are also found in para. 10 («soil acidification»); in paras. 23 and 38 («deforestation»); in para. 89 («soil desertification is like a disease for everyone») and in para. 140 («soil composition»).

[4] There are, of course, no shortage of exceptions: meritorious, on a national level, is the work being done in this regard by the Re Soil Foundation (www.resoilfoundation.org), which is continuously raising awareness in this regard. Also worth mentioning is the international '4 per 1000' initiative launched by France on 1 December 2015 during COP21, which aims to demonstrate that agriculture

if not ignored at least obscured by the consideration of other matrices, also obviously essential (the marine environment or air, atmosphere, habitats, fauna and flora)[5]. In recent years, fortunately, there has been a timid hint of a trend reversal[6].

Perhaps because soil is known in English as "dirt", or perhaps because we walk on it, or maybe because "land" is a privately owned resource unlike air and water, the fact is that, with a few exceptions[7], we do not focus on soil with due attention. When we do, we consider it in a perspective that, as we shall see, appears reductive because it does not fully emphasise its fundamental role as environmental infrastructure.

In general, soil is still predominantly considered as a source of possible damage to man (landslides, floods, avalanches, hydrogeological instability) and, therefore, fundamentally as a resource to be preserved in order to protect public safety or to be preserved from drought and not as a provider *par excellence* of ecosystem services[8] or natural capital.

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and agricultural soils in particular can play a crucial role in food security and climate change (www.4p1000.org).

[5] N. A. FROMHERZ in his paper *Case For a Global Treaty on Soil Conservation, Sustainable Farming, and the Preservation of Agrarian Culture*, in *Ecology Law Quarterly*, 2021, vol. 39 no. 1, 57-122 states: «Soil must surely rank as the most underappreciated natural resource. We marvel at oceans, write odes to our rivers (...) At the best, we view soil as little more than a vehicle for crop production. In so doing, we fail to appreciate one of the world's true natural treasures».

[6] Take, for example, the FAO's establishment in 2014 of a "World Soil Day" (on 5 December) aimed at raising public awareness of the importance of healthy soil.

[7] Scientists who have been talking about soil as a resource capable of generating ecosystem services for years include P. M. HAYGARTH, K. RITZ, *The future of soils and land use in the UK: Soil system for the provision of land-based ecosystem services,* in *Land Use Policy,* vol. 26, Supplement 1, Elsevier, 2009, pp. 187 ff.; R. LAL, *Soil carbon sequestration to mitigate climate change*, in *Geoderma,* 123, Elsevier, 2004, pp. 1-22.

[8] It is only recently in European law that we find an express legal definition of "ecosystem services" as «direct and indirect contributions of ecosystems to the economic, social, cultural and other benefits that people derive from those ecosystems (Art. 2(14) of Regulation 2020/852, the so-called Taxonomy Regulation). With this notion, there has been a shift from a conception of the environment as a container to a conception of the same as a service provider, and at the legal level, questions are beginning to be asked on how to "protect" this service provision also through economic instruments (see at the national level, art. 70 law no. 22/2015 and art. 7, co. 8 legislative decree 34/2018 and, at the European level, art. 28 of EU reg. 1305/2013 on agro-climatic-environmental payments). In scholarship, the concept of ecosystem services emerged in the late 1980s: H.A. MOONEY - P.R. EHRLICH, *Ecosystem services: a fragmentary history,* in G.C. DAILY (ed.), *Nature Services: Societal Dependence on Natural Ecosystem,* Island Press, Washington DC, USA, 1997, 11-19; R. DE GROOT, *Functions of Nature: Evaluation of Nature in Environmental Planning Management and Decision Making,* Wolters-Noordhoff, Groningen, 1992.

At the European legislative level, despite the fact that «there was unanimous agreement on the need to guarantee the same degree of protection for soil as for other environmental matrices such as air and water, because the functions it performs are crucial for the survival of people and ecosystems»[9] and despite the fact that soil loss and declining fertility has been identified as the main threat to sustainable development[10], a specific directive on soil is still lacking in 2022[11].

In international law, the consideration of soil takes place on a broader scale: as early as 1992 at the Rio conference, the problem was addressed and the foundations were laid for the Convention on Desertification (henceforth "UNCCD" for short), which was adopted in 1994[12] and came into force in 1996,

More recently for an analysis of the concept see F. FRACCHIA, *Environmental Law: Principles, Definitions and Protection Models,* Naples, 2018; A. LALLI, *Ecosystem services and natural capital: a legal-institutional perspective*, in *Studi parlamentari e di politica costituzionale,* 2017, vol. 50, no. 195/196, pp. 39 ff; M. MONTEDURO, *Environmental Law and Agroecology. Transdisciplinary Approach to Public Ecosystem Services as a New Challenge for Environmental Legal Doctrine*, in *European Environmental Law Review*, 2013, (1)22, p. 2; M. MONTEDURO, A. DE NUCCIO, *Servicios agroecosistémicos y patrimonio rural material e inmaterial,* in D. SANTIAGO IGLESIAS - L. MÍGUEZ MACHO - A.J. FERREIRA FERNÁNDEZ (Dir.), *Instrumentos jurídicos para la lucha contra la despoblación rural*, Cizur Menor (Navarra), 2021, pp. 449 ff.; A. SOLAZZO, *Payments for ecosystem services: issues and perspectives*, in *Rivista giuridica dell'ambiente*, 2016, no. 3-4, pp. 585 ff.

[9] Proposal for a Directive establishing a framework for the protection of soil and amending Directive 2004/35 of 22 September 2006 COM (2006)232 final (hereinafter referred to briefly as "2006 Soil Directive Proposal").

[10] COM (2001) 264.

[11] A European soil law was announced in the European Soil Strategy 2030 presented in November 2021 and is expected in the second quarter of 2023.

[12] The *United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, particularly in Africa* was adopted on 17 June 1994 in Paris by the Intergovernmental Committee established ad hoc on 22 December 1992 by General Assembly resolution 47/188. The Convention, which is of unlimited duration, was open for signature from 14 October 1994 to 13 October 1995; during this time it was signed by 115 countries - Italy among them, on 14 October 1994 - which subsequently ratified it (our country with law no. 170 of 4 June 1997). The Convention, which is of unlimited duration, has been in force internationally since 26 December 1996. To date, all members of the United Nations are parties to the Convention, as non-signatory countries have also exercised their option to accede to the covenant instrument. The European Union has been a party to the Convention since 26 March 1998. The UNCCD is the only legally binding international agreement linking environment and development to sustainable land management. In 2007, UNCDD adopted a 10-year strategy (covering the period 2008-2018) in which the parties to the Convention further specified their objectives to «create a global partnership to prevent desertification/land degradation and mitigate the effects of drought in affected areas in order to support poverty reduction and environmental sustainability». The UNCCD envisages the preparation of National Action Plans (NAPs) aimed at

and which, however, limited itself to highlighting the problem of soil loss caused by drought.

Soil is now considered in various goals and targets of the UN 2030 Agenda[13].

Soil specifically constitutes Goal 15 of the 2030 Agenda, which is to «protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss»; Target 15.3 proposes «by 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world» and soil protection is also referred to in target 2.4 on sustainable agriculture where we aim to «by 2030, ensure sustainable food production systems and implement 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».

2. *The definition of soil*

In the first part of this contribution, we will try to answer several questions: what soil is; why it is so important to us; what its characteristics are; whether or not it is a renewable resource; how it is composed; and what critical issues are currently encountered in relation to it on a global, European and national level. All this in order to verify whether the existing legal regulations sufficiently recognise the environmental infrastructure value of soil itself or not.

We will then go on to examine whether the existing legal categories are sufficient to guarantee their protection in relation to environmental functions; what role the improved protection of organic waste can play in this regard; what the drivers of innovation and new technologies can provide in this regard; and

sustainable development with the objective of reducing soil productivity losses caused by climate change and human activities. The Italian NAP was prepared in accordance with the guidelines approved on 22 July 1999 by the former CNLD (National Committee for Combating Drought and Desertification) and was adopted with CIPE resolution no. 229 of 21 December 1999.

[13] Resolution 70/1 "Transforming our world: the 2030 Agenda for Sustainable Development" (henceforth referred to briefly as the "2030 Agenda") was adopted by the United Nations General Assembly on 25 September 2015 and sets out 17 Sustainable Development Goals (SDGs) and 169 targets that substantiate them.

what legal instruments, in short, can be worked on to improve the situation of this matrix from a more strictly environmental point of view.

Well, starting to answer the first question on what is meant by soil, we can say that we are referring to the upper layer of the earth's crust[14] i.e. that thin layer that extends beneath our feet and overlaps the better known 'subsoil', which is rock.

Soil is a kind of envelope that covers the emerged part of the Planet's surface and which is equal to about one third of the entire surface, consisting of a small layer of a few tens of centimetres, a small trifle compared to the size of the Planet but in which a multitude of things take place that make it the undoubtedly most complex system on Earth: it is no coincidence that even in official European documents, such as the recently proposed Soil Strategy[15], generally stingy with non-legal terms, the fanciful term 'magic carpet' has been used for soil.

It is, in fact, perhaps the most delicate and complex environmental matrix, secret and extraordinary, powerful and subtle, living and not dead, inhabited and not desolate[16], sometimes even fragrant, on which the very existence of the human species and other living species depends[17]. As an ancient Chinese proverb puts it, in short, 'we all depend on the thin layer of earth and the fact that it rains'.

Its health, its good condition is therefore important to us, not only because a poorly maintained soil encourages phenomena such as landslides, mudslides and instabilities that can threaten our safety, but also (and above all) because it silently performs a series of services that are indispensable for life.

3. *Soil specificities and its "ecosystem services"*

[14] Par. 3 of the Communication from the Commission to the Council and the European Parliament, the Economic and Social Committee and the Committee of the Regions "Towards a Thematic Strategy for Soil Protection", 16 April 2002 COM (2002) 179 (henceforth briefly "Communication COM (2002)179").

[15] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions "EU Soil Strategy for 2030". Reaping the benefits of healthy soils for people, food, nature and climate".

[16] The FAO reminds us that «there are more organisms in one gram of healthy soil than there are people on Earth» (Campaign Report, World Soil Day, 5 December 2020).

[17] In this sense, the 1994 UNCCD Convention defines «land» as «the earth's bio-productive system comprising soil, plants, other living things and the ecological and hydrological phenomena occurring within this system» (Art. 1(e)).

There are three main characteristics of soil: non-renewability; limitedness and strategicity[18].

Soil is a non-renewable resource[19] characterised by a very rapid degradation rate and extremely slow formation and regeneration processes[20]: suffice it to say that it takes 500 years to form a 2.5 centimetre soil, that 10 centimetres of soil are formed in 2000 years and that it takes 20,000 years to form a metre deep soil[21]. And the same metre of soil can be taken away by a tractor in a few minutes.

It is a limited resource since, as mentioned earlier, only one-third of the planet is covered by the thin layer we call soil and only two-thirds of this part consists of fertile soil[22].

Not only is fertile soil thus limited in an absolute sense, but unfortunately it is also subject to a continuous process of loss: the rate at which fertile soil is being lost worldwide is staggering if we consider that around 23 hectares of soil are lost every minute[23].

Soil is a strategic resource for the services it performs: from it, as we shall see, we obtain food and water for humans as well as for other living species, and it performs a fundamental climate change mitigation action.

As the world's population continues to grow (from around 1 billion in the early 19th century to around 8 billion today), it can certainly be defined as a resource that is now scarce and needs to be preserved as it is essential for life.

The fundamental components of the soil, as stated in the 2002 communication, are four: minerals or inorganic substances (these are sand, clay,

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[18] See A. MCBRATNEY, D. J. FIELD, A. KOCH, *The dimensions of soil security,* in *Geoderma,* 213 (2013), 203-213.

[19] Para. 1 of the 2006 Soil Directive Proposal.

[20] Communication COM (2002)179 par. 2.3.

[21] See P. M. LACY, *Our Sedimentation Boxes Runneth Over: Public Lands Soil Law as the Missing Link in Holistic Natural Resource Protection,* in *Environmental Law*, 2008, vol. 31, 433-475; see also A. M. WYATT, *The Dirt on International Environmental Law Regarding Soils: Is the Existing Regime Adequate?*, in *Duke Environmental Law & Policy Forum,* 2008, 165-208: «Formation of soil is slow and complex. An inch of soil can take centuries or even millennia to form, depending on the location and conditions».

[22] According to FAO, 33% of the world's soils would be moderately or severely degraded.

[23] The EU Joint Research Centre claims that 20 per cent of the EU's surface area is subject to erosion: among the areas most impacted by desertification are Cyprus (99 per cent), Spain (74 per cent), Italy (59 per cent), Portugal (50 per cent) and Romania (30 per cent). A joint study by CNR, ISPRA and ENEA in 2015 found that about 5% of the Italian territory is already desertified, another 5% is undergoing a desertification process and 20% is at risk of desertification.

silt, which make up 45% of the soil)[24]; the component or organic matter (which accounts for about 5% but which, as we are about to see, is fundamental to the soil's role as environmental infrastructure)[25]; water (which accounts for about 25%); and air (which is worth about 25%).

Thanks to these components, soil forms the interface between the Earth (geosphere), air (the atmosphere) and water (the hydrosphere)[26] and performs a variety of functions or ecosystem services.

Recital 7 of the 2006 proposal for a Soil Directive stated that «Soil should be used in a sustainable manner which preserves its capacity to deliver ecological, economic and social services, while maintaining its functions so that future generations can meet their needs».

The 2006 draft directive identified seven fundamental functions that correspond to the so-called "ecosystem services" of soil.

Firstly, soil provides 95 per cent of food[27] and therefore appears to be the first resource for food production: agriculture and forestry are largely dependent on it in the sense that they need soil to supply water and to fix their roots.

Second, it has a balancing function both in the water cycle because it allows the storage, filtration and transformation of nutrients and water, guaranteeing its potability[28] and from the point of view of contaminant absorption (the soil plays an effective role since the microorganisms present in it help regenerate it by destroying contaminants deposited in it over time).

Third, soil is a veritable reservoir of biodiversity, providing a habitat for an enormous number of organisms living beneath its surface. An impressive fact is that about a quarter of all the Planet's biodiversity lives in it[29].

Fourth, soil constitutes the physical and cultural environment for people. It is widely known that it is the platform of human activity as well as an element

[24] Communication COM (2002)179 par. 2.3.
[25] Soil organic matter, largely composed of carbon, participates in four main ecosystem services: soil fertility for plants, soil water retention, soil resistance to erosion and soil biodiversity. Even small changes in carbon stocks can have important effects on both agricultural productivity and the global greenhouse gas cycle. Source: International 4 per 1000 Initiative "Soils for Food Security and Climate".
[26] Communication COM (2002)179 par. 2.1.
[27] FAO, Campaign Report, World Soil Day, 5 December 2020.
[28] By 2050, this fragile layer is expected to feed and filter potable, ready-to-drink water for a population of about 10 billion people.
[29] FAO (2020), State of knowledge of soil biodiversity - Status, challenges and potentialities and Campaign Report, World Soil Day, 5 december 2020.

of landscape and cultural heritage. And this is perhaps one of the most immediately perceptible and best defended of soil functions to date.

Fifth, soil appears to be the largest carbon store on the planet: it is the so-called "buffering power" of soil (*carbon sink*), i.e. its ability to capture carbon from the atmosphere. Just citing a few numbers[30] one can understand how healthy soil appears to be decisive in combating climate change as a true "sponge" for CO_2.

Sixth, soil is a source of raw materials: think for example of biomass such as wood. Moreover, as highlighted in FAO reports, soil constitutes a kind of huge, natural pharmacy, if one considers that most antibiotics are made through microorganisms found within it[31].

Seventh, soil constitutes an archive of geological, geomorphological and archaeological heritage.

The services that are performed by the soil, which are far superior to those usually taken into account in e.g. urban plans, have been well summarised in four basic families[32]: support services[33], supply services[34], regulatory services[35] and social and cultural services[36].

In summary, soil is not only what needs to be defended to avoid disruption or contamination, but because of its provision of ecosystem services (it is estimated that cultivated land and pastures in the EU alone produce

[30] Carbon in the atmosphere is estimated at 850 billion tonnes, carbon in forests at 360 billion tonnes, and carbon in soils at 4000 billion tonnes. Being by far the largest store of carbon on the Planet, its protection appears essential for combating climate change (according to FAO data, cultivated soils on our Planet have lost between 25% and 75% of carbon released into the atmosphere in the form of CO2). If the level of carbon stored by soils in the first 30 to 40 centimetres increased by 4%, the annual increase of carbon dioxide in the atmosphere would be significantly reduced.
[31] FAO, Campaign Report, World Soil Day, 5 December 2020.
[32] P. M. HAYGARTH, K. RITZ, *The future of soils and land use in the UK: Soil system for the provision of land-based ecosystem services,* cit., 187 ff.
[33] The soil as the seat of important primary bio-geochemical reactions makes possible the carbon cycle but also those of nitrogen, phosphorus and many other nutrients.
[34] Soil makes possible water supply, water storage, the formation and maintenance of habitats, biodiversity and the production of genetic heritage, the generation of organic matter and biomass as well as the storage of important raw materials.
[35] Soil provides water filtration and purification, internal biological control, control of the concentration of greenhouse gases in the atmosphere thus influencing the climate, and erosion control.
[36] These include identity, landscape, historical and archaeological heritage, recreation, health and well-being.

ecosystem services quantifiable at 76 billion euro per year) it appears to be the most important environmental infrastructure to be defended for the balance of the Planet[37].

4. *The biggest threats to soil*

Soil is a natural resource that is coming under increasing environmental pressure, as is clear from the World Atlas on Desertification, now in its third edition in 2018[38].

Suffice it to say that dry land, which, as mentioned above, constitutes about one third of the planet's surface area, is only two thirds fertile, and that it is predicted that if the current trend of degradation continues, 90 per cent of it will be compromised by 2050[39]: these are impressive numbers.

It is important to make it clear from the outset that when soil loses its ability to perform its functions we speak of desertification[40] which, we might say, constitutes death, the opposite of soil protection: the 1994 UNCCD convention refers to it as «land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities» and is assessed through three sub-indicators: soil productivity; the presence of organic carbon in the soil; and land cover and changes in land level.

The 2002 European Communication summarises soil problems in eight basic points: 1) erosion, 2) decrease in organic matter, 3) contamination, 4) salinisation, 5) compaction, 6) decrease in biodiversity, 7) sealing and 8) landslides.

The first problem is erosion: soil on a global scale is degrading faster and faster. As much as 24 billion tonnes of fertile soils each year disappear due to wind, flowing water, ice and gravity. That is 3 tonnes per inhabitant per year. Erosion also tends to sweep away the best part of the soil, the so-called topsoil[41], which is the most important part for agricultural crops. This is a natural phenomenon that is, however, greatly accelerated by human activity (e.g.

[37] J. F. PONGE, *The soil as an ecosystem*, in *Biology and Fertility of Soils*, Springer Verlag, 2015, 51 (6), 645-648.
[38] https://wad.jrc.ec.europa.eu/download.
[39] FAO, Campaign Report, World Soil Day, 5 December 2020.
[40] Communication COM (2002)179 par. 4.
[41] Topsoil is defined as follows: «surface soil usually including the organic layer in which plants have most of their roots and which the farmer turns over in plowing» Merriam-Webster's Collegiate Dictionary (1998).

removing a forest or woodland not only makes the place where it stood erodible, but also means that a windbreak for neighbouring soils is lost).

The second problem is the depletion of organic matter. It is absolutely necessary to keep carbon in the soil because in its absence the soil not only becomes unusable for agriculture but also threatens the conditions of existence of the microorganisms that live there. The cause of this second problem is above all anthropogenic and has to do with deforestation, conversion of agricultural areas to grassland, fires, and ploughing too deep. Most of the degradation processes have in common the decline in soil organic matter content, which is associated with a loss of fertility and plant productivity but also with a decrease in soil resilience.

The third problem is contamination. One of the key properties of soils is their porosity, which allows them to absorb water and air that are indispensable for the functioning of the complex system that soils contain. This strength also represents its weakness because it allows the easy absorption of harmful liquids such as hydrocarbons, oils, ammonia, pesticides, acid rain and sludge. This threat finds its cause in man.

The fourth problem is salinisation. Salt tends to kill the soil by inhibiting its metabolic processes and irreversibly damaging its ecosystems. Salt can enter the soil through irrigation and the misuse of fertilisers in agriculture and poses a threat to fertility and thus to food production.

The fifth problem is compaction. Soils breathe thanks to the diffuse porosity that ensures exchanges between inside and outside. If the surface densifies by reducing porosity, resulting in the progressive hardening of the surface layer due to repeated compression of the upper layers (e.g. rolling of tyres), the soil can no longer breathe and dies. This is why soils are ploughed, to make them breathe, and why compacted soils decrease their yield by up to 35%.

The sixth problem is the loss of biodiversity. The biotic communities that have the soil as their habitat are mutually dependent. If foreign and toxic substances eliminate one of the biotic communities, the others also fail, breaking the balance.

The seventh problem is soil sealing, which occurs when soil is consumed for building. When urbanisation takes place, the soil layer is completely removed and the soil's ability to retain water is compromised forever. Soil is a giant, pore-rich sponge capable of retaining 10 to 25 per cent of its volume of water and then

releasing it partially over a deferred period of time. Once a soil is covered it stops absorbing water forever.

The eighth problem is landslides, disruption or hydrogeological risk. Every flood, every landslide takes away fertile soil.

Soil degradation phenomena also have a significant impact on other areas of European interest such as surface water protection, human health, climate change, nature and biodiversity protection and food safety.

If one considers that, as mentioned above, 23 hectares of soil are lost every minute in the world, one understands the urgency of providing for this: in Europe, for example, it is already estimated that between 60 and 70 per cent of soils are not in good health[42].

In particular, the risk of desertification is very serious throughout southern Europe. As the World Atlas of Desertification shows, the areas where soils are most affected are in fact southern Portugal, parts of Spain and southern Italy, south-eastern Greece, Malta, Cyprus and the areas of Bulgaria and Romania bordering the Black Sea[43].

A study by the European Environment Agency showed that in less than a decade (2008-2017), desertified areas in Europe have increased by an area roughly equivalent to Greece and Slovakia[44]. The phenomenon of desertification affects 73% of the cultivated dry land in Africa. Overseas, the situation is also not rosy: in the United States, fertile soil is being lost at a rate of about five tonnes per acre per year[45].

Finally, poor land management will produce political and social problems such as migration and wars: according to the Secretariat of the UNCCD «within ten years 67 million desperate people from North Africa and 145 from the Sahel, 212 in all, will be marching to survive» and according to David Sekler, Director General of the UN International Water Management Institute «within the next few years armed conflicts over water supplies may break out between different countries and even between different regions of the same country».

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[42] European Soil Strategy, 2021.
[43] European Court of Auditors Special Report 2018, p. 7.
[44] European Court of Auditors Special Report 2018, p. 11.
[45] USDA Nat. Res. Conservation Serv., Summary Report August 2015. For a discussion of the US context see N. D. HAMILTON, *Needed: A New Commitment to Soil Conservation - Can Addressing Soil Health and Climate Change Re-Energize This Work?* , in *University of the Pacific Law Review*, 2021, vol. 52, no. 3, 599-622.

5. *An overview of international and European law on the ecosystem functions of soil*

At the level of international law, soil protection has at first appeared timidly and then increasingly in the form of environmental infrastructure.

Thus, in the first general declaration, the Stockholm Declaration of 1972, which although refers to our Planet as the "Earth"[46], soil is not mentioned directly[47] .

A first important soil protection document is the FAO World Soil Charter approved in 1981[48] and updated in 2015[49].

A specific consideration of soil (also from an ecosystem perspective) is also found in both the 1982 World Charter for Nature[50] and the World Soils Policy approved in the same year by UNEP.

It was at the Rio Conference in 1992 that soil began to firmly establish itself as an object of environmental protection: Principle 7 of the Rio Declaration refers to the need to «conserve, protect and restore the health and integrity of the Earth's ecosystem».

As is well known, two very important conventions were signed at the Rio conference in 1992, the convention on biodiversity and the convention on climate change; less well known is that, again in Rio, the foundations were laid for the drafting and signing of what is considered to be the third Rio convention, the convention against desertification[51].

In the same year, 1992, a World Atlas of Desertification was published for the first time by the United Nations, later updated in 1997 and 2018, to which

[46] See Articles 2, 3, 5 and 8. In Article 3, for example, it was written that «the Earth's capacity to produce renewable natural resources shall be maintained and, where practicable, restored and improved».
[47] Article 2 of this declaration indicated the need to safeguard «The natural resources of the earth, including the air, water, land, flora and fauna…» but without mentioning soil even though it was implicitly included in the concept of "natural ecological system" mentioned below.
[48] FAO Resolution 8/81.
[49] Approved by the FAO Conference in June 2015.
[50] Article 10 (b) states that «the productivity of soils shall be maintained or improved by measures that preserve their long-term fertility and organic decomposition processes and prevent erosion as well as any other form of degradation». In this case there is alongside water an express mention of soil.
[51] To date, this convention appears to be the most important instrument of international law with regard to soil protection and states that the parties intend to work together to improve and restore soil productivity. It should be noted that each of the countries has taken on the obligation to define and implement National Action Programmes (NAPs) to combat desertification.

data has been referred to in the previous paragraphs in order to become aware of the difficult global situation.

Several articles of the Rio + 20 Declaration of 2012, starting with paragraph 205, are dedicated to soil protection, and in 2015 the United Nations adopted the 2030 Agenda for Sustainable Development: in it, as mentioned above, one of the goals, goal 15, is precisely about the soil matrix.

The Treaty refers to them as resources (thus, for example, Article 21(f) refers to the need to «preserve and improve the quality of the environment and the sustainable management of global natural resources, in order to ensure sustainable development» and Article 191(1) speaks generically of «natural resources»)[52]. The only resources specifically mentioned on several occasions in the Treaties are the biological resources of the sea.

While practically all other environmental matrices are covered by secondary legislation (numerous directives on air; water; biodiversity; habitats; birds, etc.), soil, as mentioned above, does not yet have an *ad hoc* directive.

As a special report by the European Court of Auditors in 2018[53] strongly pointed out, there is no specific soil protection policy at European level even though soil protection provisions can be found integrated in other directives on water, waste, chemicals, pesticides, prevention of industrial pollution and nature protection[54].

Yet European law at the beginning of the 2000s[55] had focused clearly on the issue of soil protection as an ecosystem service: the Sixth Environmental

[52] See on this point Z. TOTH, *Soil protection in the EU: The Most Important Soil-Related EU Policies and Legal Sourges*, in *Journal of Agricultural and Environmental Law* 2017, vol. 12, no. 22, 202-223; A. TURBÈ, A. DE TONI, P. BENITO, PATRICK LAVELLE, PERRINE LAVELLE, N. RUIZ, W.H. VAN DER PUTTEN, E. LABOUZE, S. MUDGAL, *Soil biodiversity: functions, threats and tools for policy makers*. Bio Intelligence Service, IRD and NIOO, *Report for the European Commission's DG Environment*, 2010.

[53] «There is no EU-level strategy on desertification and land degradation»: European Court of Auditors, Special Report "Combating desertification in the EU: a growing threat in need of more action", 2018, point V. Also for that report, «In 2015, the EU and Member States committed to achieving land degradation neutrality in the EU by 2030. However, there has not been a full assessment of land degradation at EU level, and no methodology has been agreed on how to do so»: point VII.

[54] See I. L. HEUSER, *Milestones of Soil Protection in EU Environmental Law*, in *Journal for European Environmental & Planning Law*, 3(3), 190-203, 2006.

[55] Among the first European documents on soil, however, is the European Soil Charter approved by the Council of Europe in Strasbourg in 1972.

Action Programme of 2002[56] referred in several places to the need to address soil protection[57] and the proposal made in the same year by the Commission[58] clearly highlighted, for example, the link between soil, greenhouse gases and climate change[59].

Following the Communication of the same year "Thematic Strategy for Soil Protection"[60] in September 2006, the Commission adopted a Thematic Strategy for Soil Protection[61] and as a result the Soil Protection Framework Directive was proposed[62].

Since a minority bloc of five Member States (Germany, France, the Netherlands, Austria and the United Kingdom) voted against the proposal in the Environment Council in 2007, although all the other 22 Member States voted in favour, a full eight years after its presentation, on 30 April 2014, the Commission decided to withdraw its proposal.

In the following years, there have been various programmatic interventions related to soil.

[56] Decision No 1600/2002/EC of the European Parliament and of the Council of 22 July 2002 laying down the Sixth Community Environment Action Programme.
[57] Cf. recital 22 («Soil is a finite resource that is under environmental pressure»); Art. 6 para. 1, which mentions among the objectives and priority areas for action for the environment and biological diversity that of «promoting sustainable use of soil, with particular attention to the prevention of erosion, deterioration, contamination and desertification» with «the development of a thematic strategy on soil protection (...)», para. 2c.
[58] Communication "Environment 2010: Our Future, Our Choice – 6th EU Environment Action Programme", COM (2001) 0031 final of 24 January 2001.
[59] According to the abovementioned Communication: «The greenhouse gases of concern are carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), as well as so called fluorinated gases [13]. The major driving force behind the increases in emissions of greenhouse gases is the burning of fossil fuels, in cars, trucks, aeroplanes, power plants, domestic heaters, etc. Other sources of greenhouse gases include methane emissions from cattle, nitrous oxides from agricultural soils, methane emissions from waste in landfills as well as the emission of the fluorinated gases from manufacturing processes. Deforestation and changes in land use are an important contributor to the release of CO2 to the atmosphere. Conversely, it is possible to reduce the concentration of CO2 in the atmosphere by geological sequestration and by locking-up carbon in biomass (forests) and soils by changing land use patterns and practices».
[60] COM (2002) 179.
[61] COM (2006) 231 final.
[62] This was the Communication of 22 September 2006 in which the Commission proposed a proposal for a framework directive for soil protection that would amend Directive 2004/35.

In the European Commission's communication "Roadmap to a Resource Efficient Europe"[63] a specific chapter is dedicated to land (Land) and soil (Soil) by setting the goal of zero net land consumption by 2050[64].

In April 2013, the Commission, in adopting an EU strategy for adapting to climate change, highlighted the irreplaceable role of soil as a carbon sink, and in November of the same year, in its 7th Environmental Action Programme to 2020 "Living well within the limits of our Planet", it highlighted the goal of a world free of soil degradation[65].

Also in 2013, the EU adopted its forestry strategy highlighting that forests are important not only for rural development but also to combat soil degradation and desertification.

The EU Regulation 1307/2013 on support schemes for farmers for the CAP also stipulates as a condition of such support that actions to prevent erosion, maintain soil organic matter levels, etc. must be put in place (funds are also provided for this in the LIFE instrument, which is a financial instrument for the environment).

Important references to soil protection can also be found in the Land Use, Land Use Change and Forestry Regulation No. 841 of 30 May 2018.

Recently, on 17 November 2021, as part of the initiatives following the Green Deal (which also refers to soil protection in several places), through the EU Soil Strategy 2030[66], the Commission announced its intention to adopt a real European soil protection law by 2023.

6. *Organic waste as a means of soil regeneration*

[63] COM (2011) 571.

[64] It should be noted that zero net consumption does not mean freezing the urban infrastructure by absolutely preventing the occupation of new land, but on the contrary, occupying free space on the condition that areas of equal size that were previously urbanised and sealed are de-sealed or restored to agricultural or semi-natural use.

[65] Recital 19 of Decision No. 1386/2013/EU of the European Parliament and of the Council of 20 November 2013 on a Union Environment Action Programme to 2020 "Living well within the limits of our Planet" (see also points 6, 8, 12, 17, 20, 22, 23, 24, 25, 28, 42, 46, 100 of the annexed programme).

[66] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions of 17 November 2021 "Healthy Soils for the Benefit of People, Food, Nature and the Climate", COM (2021) 699 final, which envisages a strategy to have restored, resilient and adequately protected soils by 2050 (zero net land take).

As mentioned above, in order to be able to perform its ecosystem functions, including, for example, carbon sequestration, soil must be endowed with organic matter: where this is lacking, one should no longer speak of soil but of inorganic material or "dead" soil, or even "desert".

Well, as mentioned, unfortunately the data speak for themselves that soil, especially in Europe, is losing more and more organic matter and is therefore turning, in an increasing number of areas, into dead, lifeless soil. The EU Joint Research Centre claims that 20 per cent of the EU's surface area is subject to erosion: among the areas most impacted by desertification are Cyprus (99 per cent), Spain (74 per cent), Italy (59 per cent), Portugal (50 per cent) and Romania (30 per cent).

At the same time, the European continent is one of those which, due to its wealth conditions and consumption patterns, produces considerable volumes of organic waste[67] and especially that particular type of organic waste which is the so-called "food waste" consisting of all household food waste (the classic banana skin for example) which is one of the fundamental categories of organic waste alongside the so-called green waste, i.e. "pruning or garden waste"[68].

This organic *food* waste is rich in organic material, a veritable mine of nutrients and vitamins essential for the life (or regeneration) of the soil[69].

This wealth of nutrients present in *food waste* can be re-transferred to the soil following industrial treatment in which a stabilisation process is actually accelerated faster that nature itself would have carried out, albeit over a much longer period of time (known as composting).

The material obtained from such treatment, a true medicine for weakened soils, is called "compost" and is none other than fertiliser whose function is precisely to restore to the soil the organic substance it had lost, thus improving and reviving soil[70].

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[67] Organic waste constitutes the bulk of municipal waste in terms of quantity.

[68] In the classification of waste according to Commission Decision 2000/532/EC of 3 May 2000, organic waste is included in municipal waste (chapter 20: «household and similar waste from commercial and industrial activities and institutions including separately collected waste») and falls if "food waste" under EWC code 20 01 08 biodegradable kitchen and canteen waste or if "green waste" (maintenance of green areas, prunings, lawn cleaning, hedges) under code 20 02 01 "biodegradable waste".

[69] *Food waste* contains the so-called "trinity" of macro-nutrients that underpin the needs of crops and which is composed of nitrogen, phosphorus and potassium.

[70] Compost can be obtained from a traditional aerobic digestion process (a composting plant where the input is organic waste or other waste with an organic matrix and the main output is compost) or

The proper management of organic waste represents the case of circular economy *par excellence* because the nutrients that originate in the soil (the soil produces the banana) then return to the soil through a waste management process (the banana skin becomes fertiliser) that mimics nature by simply speeding up the process through industrial treatment and a system that requires the collaboration of a number of actors (the citizen first and foremost, but also institutions, businesses, and the world of research and innovation)[71].

In any case, the paradox is that in our continent we have soils that are dying because they lack nutrients and at the same time a great mine of nutrients contained in *food waste* that we nevertheless use to a minimal extent.

Nutrients are wasted for various reasons: either because the *food waste is* simply sent to landfill as it was not collected separately (and is therefore lost with high external costs and negative environmental impacts) (lack of separate collection)[72]; or because the *food waste* is carelessly collected and therefore contaminated (usually by plastics) and can no longer be used (non-quality separate collection); or because the *food waste* is wholly or partly 'burnt' for fuel (use of *food waste for* energy recovery)[73].

The destination of *food waste* that appears most useful for the protection of the soil matrix is, therefore, undoubtedly that of organic recycling.

The phases of organic waste management aimed at returning nutrients to the soil can therefore be summarised as: separate collection of organic waste made in such a way as to obtain clean or quality organic waste (without other

from an anaerobic digestion process supplemented by a composting plant (in which case the plant outputs are biomethane and compost).

[71] See M. EDEN, H. H. GERKE, S. HOUOT, *Organic waste recycling in agriculture and related effects on soil water retention and plant available water: a review*, in *Agron. Sustain. Dev.*, 37, 11, 2017; C. G. COGGER, *Potential Compost Benefits for Restoration Of Soils Disturbed by Urban Development*, in *Compost Science & Utilization*, 13:4, 243-251,2005; R. KHALEEL, K. R. REDDY, M. R. OVERCASH, *Changes in Soil Physical Properties Due to Organic Waste Applications: A Review*, in *Journal Of Environmental Quality*, 10, 2, 133-141, April-June 1981.

72 Today, almost 70 per cent of organic waste in the European Union, as well as most sewage sludge from municipal wastewater treatment, is still sent to landfill.

[73] The idea of using organic waste to produce energy certainly appears meritorious, but nevertheless in the waste hierarchy it appears one step below aerobic digestion or composting, which is the form of organic recycling par excellence. In other words, in the hierarchy of actions, the recycling of organic or assimilated waste from which compost is derived should be given priority over recycling that produces energy or that produces secondary raw materials, which, of course, in a cascade system, can be considered intermediate steps compared to the final "return" to the soil.

contaminants); organic recycling carried out in treatment plants; and the production of fertiliser (compost).

This all comes full circle with the return of the compost to the soil, which is then revived and "saved" from desertification and can therefore continue to provide its ecosystem services.

Separate collection of organic waste and organic recycling are, therefore, some of the easiest ways to 'save' soils: suffice it to say that in Europe organic waste accounts for about 40% of all municipal waste[74].

Although it is a simple recipe, it is still not put into practice: only 18% of organic waste on average is turned into compost in Europe[75] with wide differences between nations.

Steps forward can fortunately be found in positive legislation even if they are still perhaps too timid: there is now finally a definition of organic waste[76] even if among the various categories of waste organic waste has been the last to be "regulated".

There is now a European-wide obligation to collect organic waste separately[77]: the organic fraction was therefore the last to be collected separately.

There is now an obligation to submit organic waste for recycling to ensure a high level of environmental protection as well as output waste that meets the relevant quality standards[78].

The fulfilment of these obligations is considered to be of such importance that Member States are required to report on municipal waste and bio-waste, including the material and territorial coverage of separate collection[79].

The 2008 waste directive also includes a deadline for the Commission to ask European standardisation organisations to set European standards for organic

[74] In Europe, the total municipal waste generation in the 27 member countries is about 220 million tonnes. The average amount of municipal waste per inhabitant in Europe is 484 kg. Of this about 88 million tonnes is organic. EEA Report, No 4/2020, *Bio-waste in Europe - Turning challenges into opportunities*.

[75] Eurostat data referring to 2019. Italy is a positive exception, managing to collect and compost 23% of the organic waste collected. This is a very high percentage both at European and global level (only South Korea achieves better results).

[76] The European legislator in the Circular Economy package has given a new definition that innovates the previous one from 2008: Art. 3 point 4 Waste Directive 851/2018.

[77] Art. 22 of the Waste Directive.

[78] Recital 57 waste directive and Art. 22(2)(*a)* waste directive.

[79] Art. 10 Waste Directive.

waste fed into organic recycling processes, for compost and for digestate, based on best available practice.

Obviously, it also follows from these obligations to collect and recycle organic waste that biodegradable municipal waste cannot be landfilled[80].

The good management of organic waste, according to the circular economy model[81], is in fact not the end but a means to regenerate the environment and in particular soil. And this function of bio-waste appears even more important in the first place in the current geopolitical crisis, which has seen important fertiliser exports from Russia and Ukraine effectively disappear[82], with

[80] Directive 1999/31/EC on landfills already provided in Art. 5 on waste and treatment not permissible in a landfill that the amount of biodegradable municipal waste should be progressively reduced to 35%. This principle can be found in recital 7 of the Landfill Directive. Art. 2(*m)* of Dir. 1999/31/EC (landfills) contains a broader definition of biodegradable waste than that contained in Art. 3(4) of Dir. 2008/98/EU (waste).

[81] See H. HOTELLING, *The Economics of Exhaustible Resources*, in *Journal of Political Economy*, XXXIX, No. 2, 1931, 137ss.; J. KORHONEN - A. HONKASALO - J. SEPPÄLÄ, *Circular Economy: The Concept and its Limitations*, *Ecological Economics*, Amsterdam; F. BONCIU, *The European Economy: From a Linear to a Circular Economy*, in *Romanian J. Eur. Aff.,* 78°, 2014; J. KORHONEN - C. NUUR - A. FELDMANN - S. ESHETU BIRKIE, *Circular economy as an essentially contested concept*, in *J. Clean. Prod*., 2018; R. MERLI - M. PREZIOSI - A. ACAMPORA, *How do scholars approach the circular economy? A systematic literature review*, in *J. Clean. Prod.,* 2018, 703; M. SCHMID - S. PADEL - L. LEVIDOW, *The Bio-Economy Concept and Knowledge Base in a Public Goods and Farmer Perspective*, in *Bio-based and Applied Economics*, 2012, 47ss.; K. WEBSTER, *The Circular Economy: A Wealth of Flows, Cowes* (UK), 2017; J. ZOTTI - A. BIGANO, *Write circular economy, read economy's circularity. How to avoid going in circles*, Econ. Pol., 2019, 1 ss.

[82] According to the Information Note "The Importance of Ukraine and the Russian Federation to Global Agricultural Markets and the Risks Associated with the Current Conflict" published by the FAO on 25 March 2022, «The Russian Federation and Ukraine are among the most important producers of agricultural commodities in the world». «In 2021 (…) the Russian Federation also stood as the world's top exporter of nitrogen fertilizers, the second leading supplier of potassium fertilizers and the third largest exporter of phosphorous fertilizers». «In Ukraine, the escalation of the conflict raises concerns on whether crops will be harvested and products exported. The war has already led to port closures, the suspension of oilseed crushing operations and the introduction of export licensing requirements for some products. All of these could take a toll on the country's exports of grains and vegetable oils in the months ahead. Much uncertainty also surrounds Russian export prospects, given sales difficulties that may arise as a result of economic sanctions imposed on the country». «With prices for fertilizers and other energy-intensive products expected to rise as a consequence of the conflict, overall input prices are expected to experience a considerable boost, resulting in lower affordability for farmers and ultimately lower use levels, in theory contingent on the level of output prices. For instance, the recent price increases for fertilizers were so pronounced that they exceeded the price increases for outputs by a considerable margin. The result was a sharp decline in the affordability of fertilizers, which was particularly pronounced for agricultural products that have so far been spared by the otherwise widespread price increases. This was particularly the case for rice and sugar (Figure 32 to 35), where sharply higher fertilizer prices

immediate repercussions also on the production system of individual Member States. Secondly, the function of organic waste as a means of soil regeneration appears crucial in the current climate crisis that Europe is experiencing, characterised by extremely high temperatures and long periods of drought.

7. *A tool for soil protection: compostable materials*

The organic circular economy, on the soil protection side, is therefore first and foremost about the best possible management of existing organic waste.

This is where research and technological innovation comes to the rescue: considering that one of the problems that have always arisen for the better management of organic waste has been plastic containers (think of the old black polyethylene bags used to collect rubbish, but also the old plastic bags, also technically made of polyethylene, which created quite a few problems for the management of organic waste by making the process of nutrient extraction more difficult) a new material had to be "invented", which is called bioplastic, but which plastic in fact is not because it has a completely different end-of-life from other types of plastic, i.e. that of organic waste.

Just as a tree, a plant or an animal at the end of its cycle returns to being an added value for the soil or ecosystems in general, the idea was to design and produce goods that at the end of their cycle not only put as little pressure as possible on the environment, but can even contribute to improving it, for example by allowing organic waste to be managed without the problem of separating it from the traditional plastic in which it was collected.

Compostable materials are in fact polymers that are designed not to "bother" wet waste at the end of its life, but rather to facilitate its management. They are also produced using renewable raw materials (such as starches and sugars) and have the same end-of-life as organic waste.

With such materials (also called "bioplastics"), for example, compostable shopping bags are made (the ones we find in supermarkets and which are softer to the touch than plastic ones) that have the same end-of-life as wet waste, which

resulted in a precipitous decline in affordability levels. Lower levels of affordability in turn will almost inevitably result in lower input use and, as a consequence, lower yields and compromised qualities in the next cropping season (e.g., lower protein levels in milling wheat)».

can/should be reused for the collection of wet food waste[83]. Compostable materials are also used for agricultural films in fruit and vegetable production[84].

Quite rightly, therefore, Article 22 of the Waste Directive states that «Member States may allow waste with similar biodegradability and compostability properties which complies with relevant European standards or any equivalent national standards for packaging recoverable through composting and biodegradation, to be collected together with bio-waste».

This is the regulatory recognition of those materials that constitute one of the outputs of the so-called circular bio-economy, i.e. that are designed to behave in their end-of-life like the organic waste whose management they facilitate (turning into compost, fertiliser or soil nutrients in the same way as "natural" organic waste does without affecting its quality)[85] .

The circular bio-economy thus emerges as a strategic tool to aim for regeneration starting from the maintenance and enhancement of soil fertility, the restoration of organic matter, the construction of a new relationship between cities and agriculture, and the development of appropriate plant engineering and sustainable products that do not accumulate on the environment[86].

The issue of restoring organic substance to the soil, with the help of compostable materials, is particularly pressing in a country like Italy, which excels in food production, which should also be self-sufficient in the production of raw materials, and which more than others is affected by natural phenomena of desertification.

Obviously, in order to make use of compostable materials as a support for implementing the collection of organic waste, it is necessary to have an adequate system for treating organic waste together with compostable materials.

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[83] In essence, a pile of banana skins collected from a compostable bag allows perfect handling in a composting plant because it does not require separation processes and above all because it does not contaminate the organic waste.

[84] S. GUERRINI, G. BORREANI, H. VOOJIS, *Biodegradable Materials in Agriculture: Case Histories and Perspectives*, in M. MALINCONICO (eds.), *Soil Degradable Bioplastics for a Sustainable Modern Agriculture. Green Chemistry and Sustainable Technology*, Springer, Berlin, Heidelberg (2017).

[85] A specific definition of biodegradable plastic can be found in Art. 3 no. 16 of Dir. 904/2019 (Single Use Plastic), while that of biodegradable packaging can be found in Annex II, no. 3 (*d)* of Dir. 94/62/EC.

[86] *A sustainable Bioeconomy for Europe: Strengthening the connection between economy, society and the environment*: COM(2018) 673 final.

Italy excels in organic waste management also thanks to the use of tools such as the new compostable materials and a treatment system capable of composting and anaerobically digesting organic waste together with compostable materials.

8. *Conclusions*

In the preceding pages, it has been shown that, although not immediately perceptible to the uninitiated, there is an inseparable link between soil, agriculture, organic waste management and new technologies, and that this link becomes apparent when focusing on the ecosystem functions and services that soil provides.

Unfortunately, there is still a lack of systemic vision even in the European Commission which, although it has acknowledged on several points that organic matter must be returned to the soil in order to regenerate it, still acts with little determination on the management of organic waste in the various European countries (in many cases allowing it to be "recovered" in the form of energy), thus proving to be still too anchored to schemes and logics of the past and insufficiently aware of the strategic role of compostable materials.

The terrible geopolitical and climate crises, which we all hope can be resolved as soon as possible, force us to reflect, even more urgently, not only on the concept of global interdependence, especially in the sense of energy self-sufficiency and energy saving, but also on that of food production and consequently on soil, an essential but too often underestimated environmental matrix, to which these few pages have attempted to restore the fundamental role that it is rightfully due. To conclude, we consider it useful to quote a statement by F.D. Roosevelt that we hope will lead to serious reflection on the subject: «The nation that destroys its soil, destroys itself»[87].

[87] F. D. ROOSEVELT, *Letter from President to State Governors* (Feb. 26, 1937).

ABSTRACT

Francesco De Leonardis – *The ecosystem services provided by soil and the importance of its protection: the essential role of organic waste*

Soil is a key environmental matrix that is often forgotten (there is still no European directive specifically dedicated to it), even though it performs fundamental ecosystem services. In some European countries soil is particularly desertified (e.g. Italy and Spain). In order to solve the problem of desertification and deal with the other threats attacking the soil, it is urgent to return organic substance to the soil. One immediate and logical solution seems to be the utilisation of organic substance from organic waste to the soil. To achieve this goal particularly efficient management of organic waste is required. Compostable materials are innovative materials having the same end-of-life as organic waste. These materials can be crucial in order to maximise the collection of organic waste and the production of compost, a precious ally for soil regeneration.

KEYWORDS: *Soil; Ecosystem functions; Organic Waste; Compostable materials; Bioplastics.*