<20

Paper: Without soil

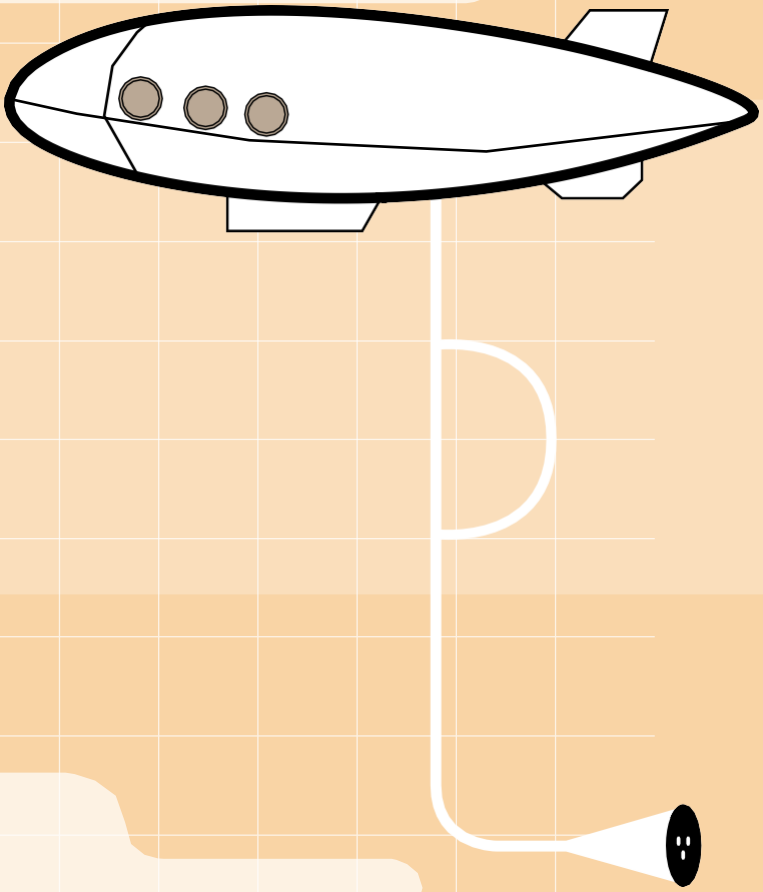
The catastrophic effects of overbuilding, fires and ground-based photovoltaics

Authors
Piermichele La Sala,
Riccardo Fargione,
Giuseppe Pachino,
Dario Vivani

Illustrations Matilde
Masi

Contacts
info@divulgastudi.it

Issue Month June 2024

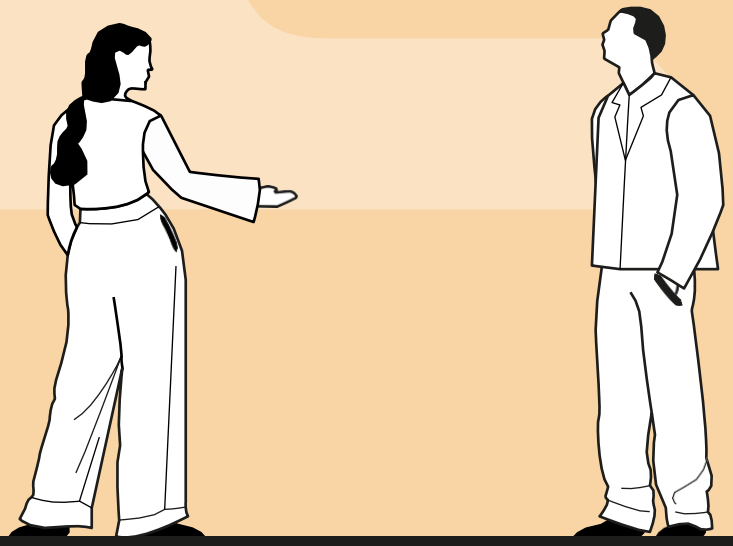


Soil degradation is becoming more and more relevant. We most definitely need a change of pace. Uncontrolled overbuilding, along with fires and ground-based photovoltaics, are creating significant problems for the entire planet.

Yet, let's try to understand more using data, facts and possible strategies.

I

Soil is a crucial resource that should be protected, and instead... But what is happening?



Abstract

- Soil is a fundamental part of the natural capital which is essential for our economy, society and environment as it supports over 95% of food production, hosts over 90% of biodiversity and is the most important resource for carbon stocks. It supports a plurality of ecosystem services of high economic and social value, primarily food and water supply services, but it also has important climate regulation effects.

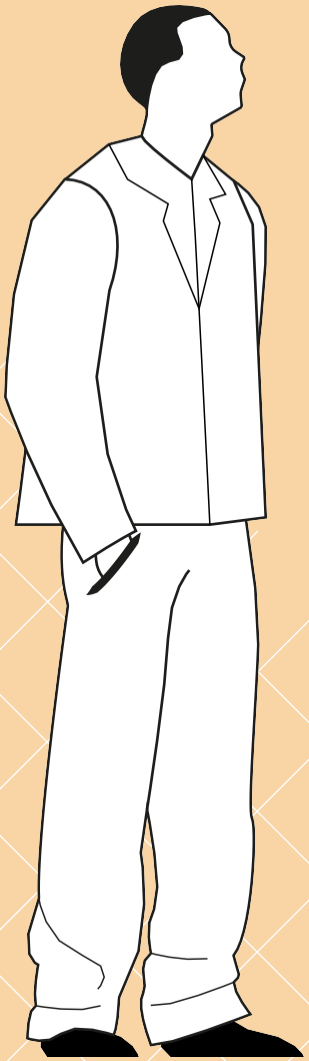
- Soil is often considered a renewable resource, yet actually its regeneration takes a long time, consequently making it a non-renewable resource, considering that it takes 100 to 1,000 years for the formation of just one centimetre of fertile soil.

- Uncontrolled urban expansion, water and wind erosion, fires and the installation of photovoltaic systems on land are substantially contributing to damage this crucial resource for both our present and future. The degradation of this resource leads to an annual loss of arable areas that costs roughly 400 billion dollars a year in lost agricultural production globally. Every hour, roughly 1,000 hectares of land are lost worldwide, equal to an area that corresponds to 1,500 football fields.

- In Italy, if the rate of consumption were to remain constant, by 2050 another 198.1 thousand hectares would be needed, equal to an area larger than entire provinces such as Milan and Trieste combined. This could entail an overall environmental cost, linked to the loss of ecosystem services provided by soil, of 100 billion euros over the period 2012-2030.

- Agriculture today is often blamed today, yet it is often forgotten that it represents a key factor for sustainable soil management, since the fruits of agriculture depend on the health of the land. A loyalty pact, therefore, which is embodied in the adoption and dissemination of good agricultural practices, such as hydraulic-agricultural arrangements, tillage, grassing with leguminous cover crops, green manure and crop rotations.

i



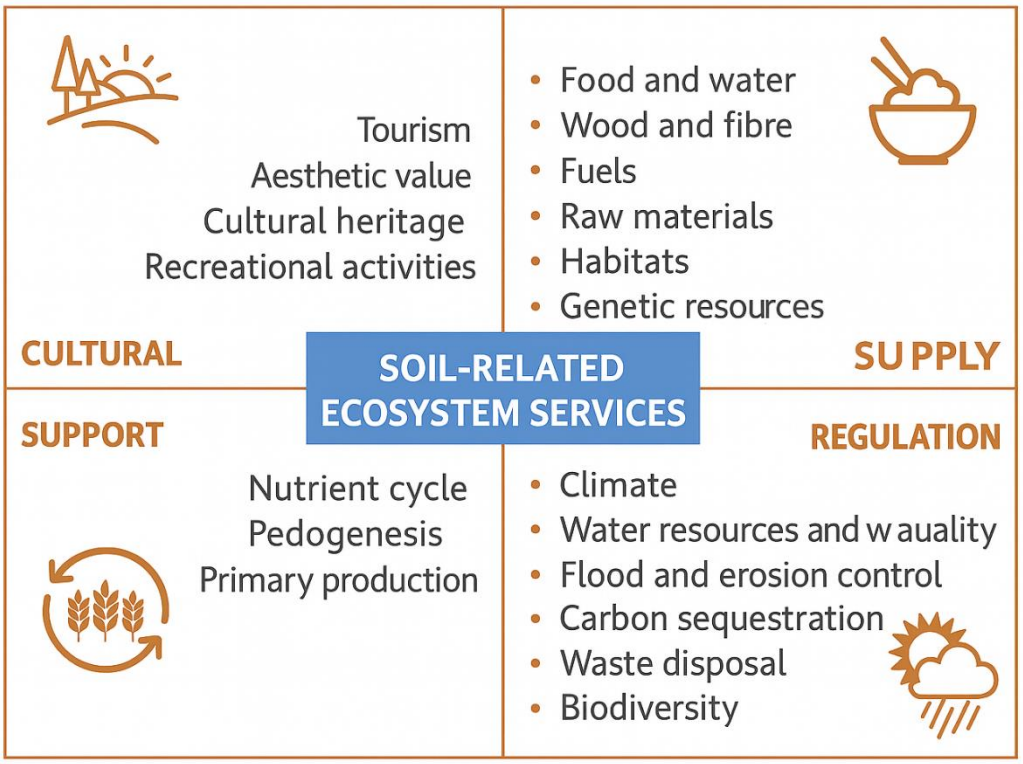
Contents

1.

1 Soil: A Precious and Limited Resource

Soil, consisting of inorganic and organic components of the surface layer of land, is a fundamental part of the natural capital that is essential for our economy, society and environment. In fact, soil supports more than 95% of food production, is home to more than 90% of biodiversity and is a key player for carbon stocks. Suffice it to say that agricultural soils have a carbon content equal to three times that of the atmosphere [1], helping to increase resilience to climate change and extreme weather events, such as droughts and floods. As a result, all terrestrial life, including ours, is supported by a few centimetres of soil [2]. Soil also supports a plurality of ecosystem services (Figure 1 . 1) , i.e. indirect benefits for the well-being of people and of society as a whole, of high economic and social value. These include: provisioning services such as food, water, timber, and fibre; regulating services that influence climate, flooding, disease, waste, and water quality; cultural services that provide recreational, aesthetic, and spiritual benefits; and supporting services such as the formation of organic matter and humus, photosynthesis, and nutrient cycling [3]. These services vary in quantitative and qualitative terms due to the remarkable spatial and temporal diversity that characterizes soil and its use. Soil is often considered a renewable resource, but in reality its regeneration takes a long time, making it a non-renewable resource. Suffice it to say that it takes 100 to 1,000 years for the formation of one centimetre of fertile soil [4].

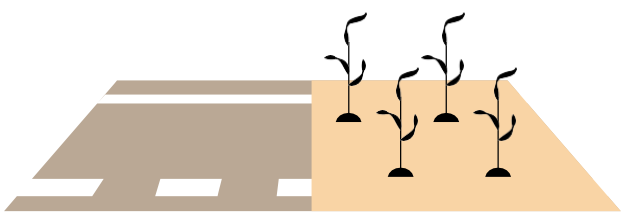
Figure 1.1: Soil-related ecosystem services



Source: Elaboration by Centro Studi Divulga

Due to a series of phenomena including uncontrolled overbuilding, fires, erosion and climate change, soil is subjected to increasing pressures that alter its properties and functions leading to its degradation and consumption. Overbuilding, in particular, leads to soil sealing, causing ecosystems to become less resilient due to landscape fragmentation, habitat destruction, decreased carbon sequestration, and reduced flood protection [5]. In Europe, 60%-70% of soils are in a state of degradation [6], while globally this percentage stands at 52% [7]. The intense rate of exploitation, which is faster than the regeneration of resources, makes the current use of the land unsustainable, foreshadowing an uncertain and unreassuring future with around 90% of the land in a state of degradation by 2050 globally. This would lead to an increased risk of food and water insecurity, higher prices for many goods and greater difficulty in accessing land and water [8], as well as aggravating the climate change framework and vulnerability to extreme events with relevant repercussions on people's safety. The United Nations has recognized the urgency of halting the exploitation of this resource by, directly or indirectly, setting several goals of the sustainable development strategy on soil. Among these, the main aim is to “Combat desertification, restore degraded lands, including those affected by desertification, drought and floods, and strive for a world free of soil degradation” (Sustainable Development Goals 15.3). Minimizing or eliminating soil degradation is substantially more cost-effective than restoring soils after degradation has occurred [9]. Many soil functions can be prevented from further degradation, while others can be improved by implementing appropriate practices to preserve and/or enhance soil health, defined as "the capacity of a soil to function within ecosystems and land-use constraints to support biological productivity, maintain environmental quality, and promote plant and animal health" [10]. The main objective is to ensure healthy soils for future generations through sustainable resource management that supports food production, conserves and supplies biodiversity, sequesters carbon and increases resilience in a context of profound climate change [11].

2.



2 Advancing soil consumption: causes and evolution in Europe and Italy

The causes of land consumption are to be found in uncontrolled urban expansion, in the resulting soil sealing, in water and wind erosion, which lead to the loss of the most fertile topsoil, fires that threaten forests in particular and degrade the soil, and the installation of ground-mounted photovoltaic systems that take land away from agri-food production, exacerbating the difficulties of accessing the planet's food. Monitoring the state of the soil is essential because it allows us to understand the state of the environment. In fact, variations in soil quality and functionality are reflected in the state of other

environmental sectors, i.e. air and water, threatening the balance of ecosystems and human health, in addition to causing significant economic losses. Indeed, limiting the advance of land consumption would make it possible to stem the considerable economic damage associated with the loss of ecosystem services, estimated by ISPRA at around 8.6 billion euros per year for Italy alone, in the period 2006-2022 [15]. Of these, most are associated with the loss of the hydrological regime regulation service (increase in surface water runoff) added to which is a share linked to the loss of agricultural production. In particular, between 2012 and 2021, a total potential loss is estimated in Italy, due to new land consumption, of about 4.15 million quintals of agricultural products [12] for an average value of 364 million euros per year [15]. The largest reductions affected arable crops with 2.8 million quintals lost, followed by forage crops (-899,000 quintals), orchards (-193,000), vineyards (-156,000) and olive groves (-126,000).

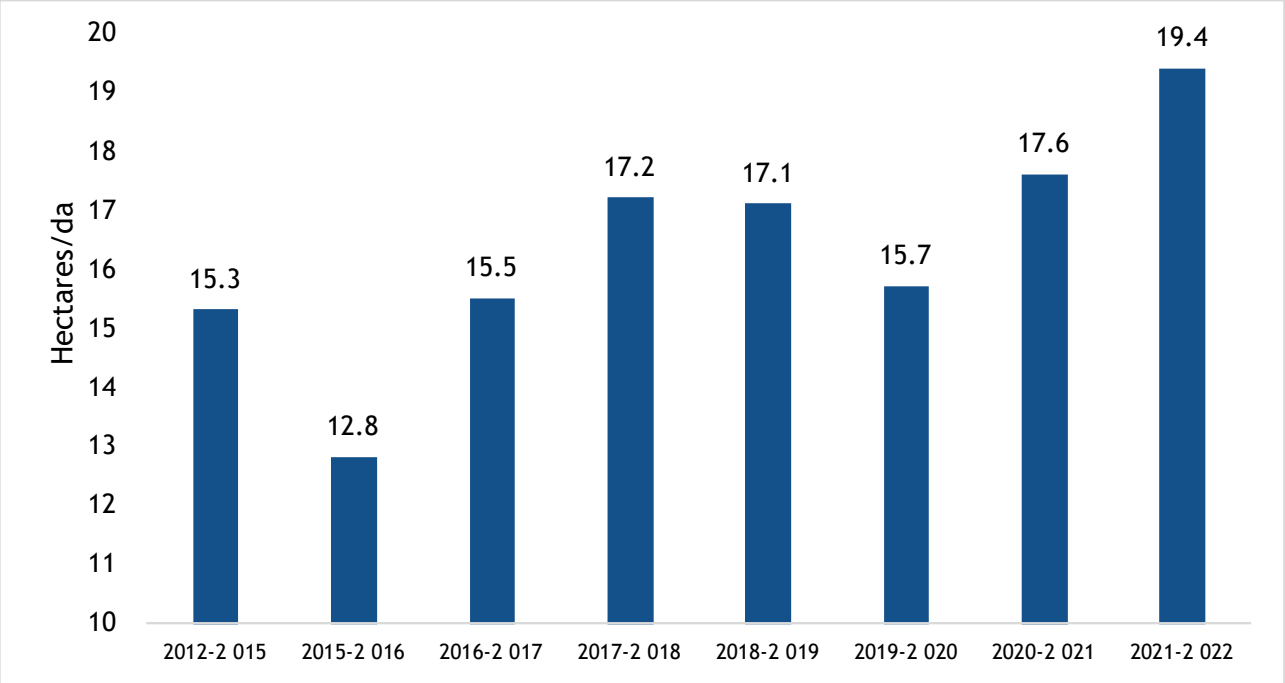
2 - 1 Overbuilding and sealing

Overbuilding, or the construction of new infrastructure and buildings, involves the covering and destruction of soil and is the most intense form of land consumption. This phenomenon is often accompanied by sealing, an irreversible process that inhibits the exchange of air and water between the atmosphere and the soil, profoundly altering its physical structure and biochemical activity. This results in the loss of soil resources, their functions, and the biodiversity it preserves, generating "hidden" costs and indirect effects even in areas adjacent to those covered in concrete. The increase in artificial surfaces, to the detriment of agricultural and natural surfaces, has generated an actual "erosion" and fragmentation of the natural landscape. This phenomenon mainly affects urban areas, which represent 23% of the territory of the EU-27 and the United Kingdom, but are home to 75% of the population [5]. The same phenomenon, albeit to a much lesser extent, also affects rural areas. Recent data shows that overbuilding mainly concerns high productivity soils along the coast, plains and valleys. In Europe, the loss of agricultural, forest, and natural land to artificial use is monitored through the Copernicus Land Monitoring Service's Corine Land Cover (CLC) data, which shows an annual soil loss of approximately 500 sq.m. since the beginning of the century, corresponding to the total area of two Italian cities: Parma and

Genoa [13]. More specifically, between 2012 and 2018, land consumption stood at 5,39 sq.m./year and sealing increased by
1,467 sq.m., mainly at the expense of cultivated land (35% of the sealed surface), of which a fifth had high productivity potential and almost two-thirds had medium potential. In 2022, however, land consumption reached rates not seen in Italy for over a decade. According to the latest ISPRA report of 2023, the new artificial coverings affected a total of 76.8 sq.m., partly offset by the restoration of 6.0 sq.m. of natural areas (conversion from consumed to non-consumed land).

Therefore, net land consumption reached 70.8 km2, recording the highest net transformation rate since 2012, equal to approximately 19.4 hectares per day, equivalent to 27 soccer fields per day (up 10.2% compared to 2021). Moreover, more than 89% concern portions of land suitable for various uses and high-quality soils. Ultimately, with 2.2 sq.m. of soil lost every second, our country is far from achieving the goal of zero land consumption set for 2030 by the national soil strategy (see Chapter 5), also due to the lack of consistent and effective regulatory intervention at the national level.

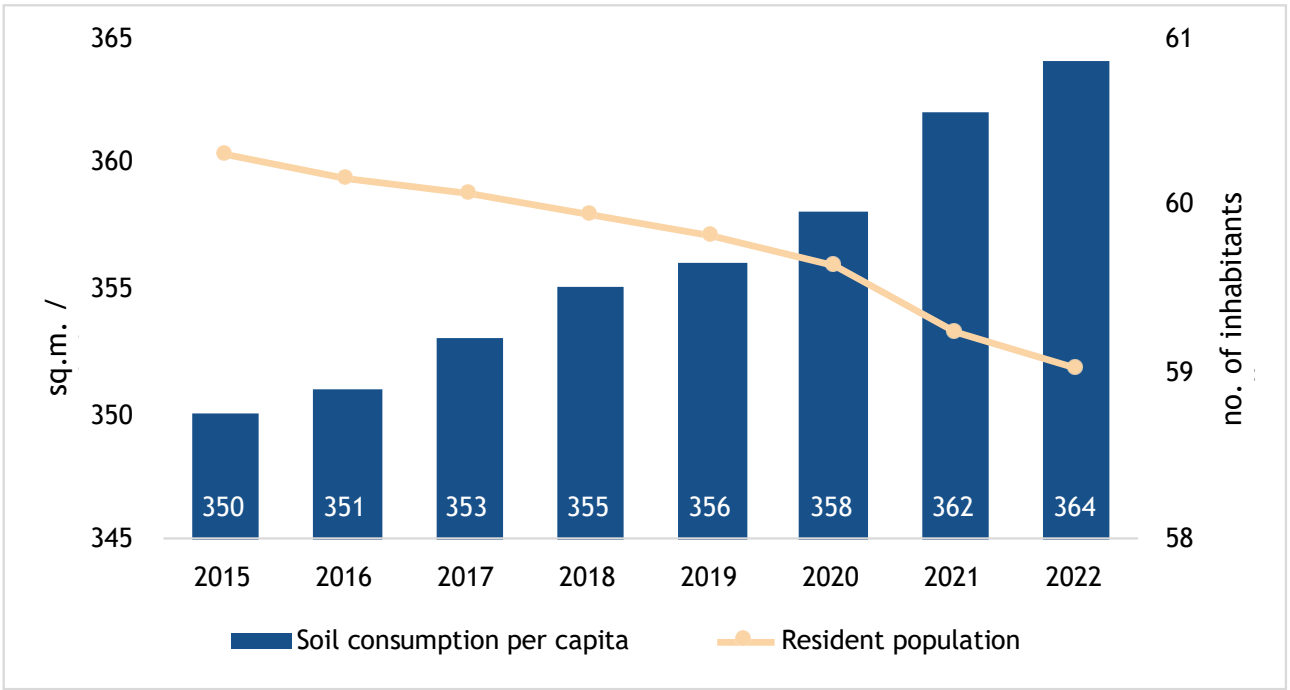
Graph 2.1.1: Net land consumption in Italy (hectares/day)



Source: Elaboration by Centro Studi Divulga based on Ispra-Snpa data

At the national level, the artificial land cover can be estimated at over 21,500 sq.m. [15], equal to approximately the area of the entire Emilia-Romagna Region and 7.14% of the national area. This value, which has been growing over the last decade, is not justified in terms of demographic growth, since Italy is experiencing a decline in population. This contraction and the simultaneous increase in land consumption translate into an increase in land consumption per capita, which reached, in 2022, a maximum of 364 sq.m. per Italian citizen (+6 sq.m/inhabitant compared to 2020 - the year of the lockdown - and +14 sq.m./inhabitant compared to 2015). If there is no reversal in this tendency in the coming years, this growing trend could jeopardize the implementation of the sustainable development goal 11.3 "Inclusive and sustainable urbanization", with particular reference to the target "Ensure that land use does not exceed population growth". Consequentially, the urgent need for a reflection on urban regeneration interventions to prevent further land use emerges. This need is reinforced by a total of 249 sq.m. of unused buildings [15], equal to the size of Turin and Naples combined.

Graph 2.1.2: Land consumption per capita (2017-2022) in relation to the population



Source: Elaboration by Centro Studi Divulga basd on Ispra-Snpa and Istat data

2.2 Erosion

Other particularly widespread forms of soil consumption include erosion, i.e. the loss of surface layers of soil following the detachment and displacement of soil particles by water or wind. Water erosion mainly affects sloping in areas subject to intense rainfall. This phenomenon leads to the loss of soil nutrients, resulting in reduced crop yields, and promotes landslides, contributing to hydrogeological instability in the affected areas. On the other hand, wind erosion mainly affects soils lacking adequate vegetation cover in arid and semi-arid areas, where it favours desertification. In addition to the action of water and wind, the rapid growth of the world's population, fires and deforestation contribute to the acceleration of erosion. Since soil erosion is a natural phenomenon that cannot be completely eliminated, it is necessary to define tolerance thresholds [4]. The European Environment Agency has defined tolerable soil loss rates, generally less than 2 t/ha per year for shallow soils (< 70 cm deep) and 4 t/ha per year for deeper soils [13]. Below these thresholds, in fact, the lost soil is compensated by newly formed soil, allowing its thickness and fertility to be preserved,

Thus benefiting soil ecosystem services indefinitely. Conversely, if erosion rates exceed those of soil formation, erosion leads to the thinning of the surface layer of soil, rich in organic and mineral nutrients, the irreversible loss of arable land due to shallow soil, and the qualitative deterioration of resources. These effects compromise the soil's functioning, jeopardizing its food supply, carbon sequestration, water filtration, and the protection of biodiversity, as well as resulting in reduced soil stability that could lead to landslides and subsidence. Every year the consumption of soil due to erosion generates crop losses equal to an average of 4% per 10 cm of soil lost [16] or 8% in case of severe erosion (greater than 10 t/ha/ year) [17]. 35% of the EU territory is losing soil due to erosion [2], more specifically,

Roughly 25% of European soils show erosion rates above the tolerance threshold of 2 t/ha per year [18]. With regard to water erosion, in particular, an average rate of soil loss on the across European has been estimated at 2.46 t/ha, equal to 970 million tons of soil lost every year [19], generating a reduction in annual agricultural production estimated at 1.25 billion euros [20]. Future projections do not look encouraging. In the face of climate change, rainfall erosion is expected to increase by an average of 18% in the European Union by 2050 [18] and will lead to an increase in soil loss of between 16% and 26% [13]. Italy, with an average of 8.77 t/ha per year [21], has the highest erosion rate among the member countries, due to the orographic nature of the territory that favours the erosive phenomena, accentuated by non-homogeneous rainfall in terms of quantity and intensity.

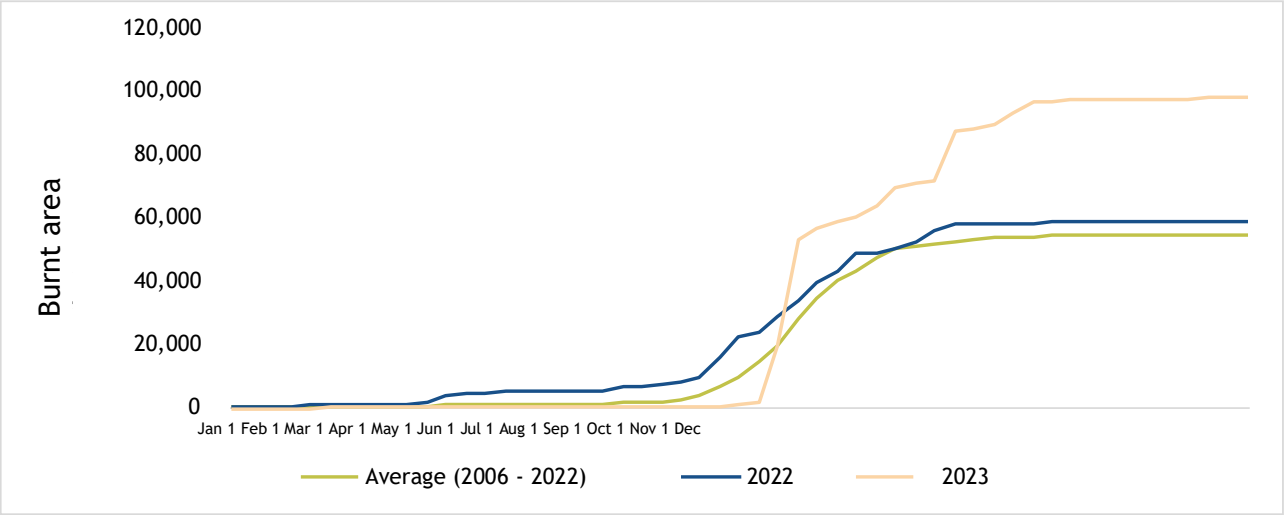
2.3 Fires

Fires are a key aspect of the current environmental crisis and threaten all the earth's ecosystems, especially the forest heritage, leading to soil degradation. The triggering of fires is mainly due to human action (around 96% of forest fires in the EU) and the lack of active management of land and forests. Where fire is a natural event, it is necessary to consider implementing measures to minimize subsequent soil erosion and to promote regrowth after the fire [11]. The phenomenon of fires is exacerbated by climate changes that contribute to increasing their frequency and intensity due to high air temperatures for prolonged periods, the disruption of rain cycles, the increase in periods of drought, low relative humidity in the soil and increasingly strong winds [22]. The result is not only the expansion of the affected areas, but also the longer duration of the fire season [23] which makes the phenomenon difficult to control, thus increasing its destructive capacity while reducing the effectiveness of prevention and contrast actions. In 2023, fires affected a total of 500,000 hectares in the European Union [25], with a reduction in the area burned of approximately 44.4% compared to 2022, also thanks to the doubling of the European firefighting air fleet during the summer of 2023. According to EFFIS estimates, the countries mainly involved were those in the Mediterranean area, namely Greece (175,000 ha); Italy (98,000 ha) Spain (91,000 ha) and

Portugal (37,000 ha). Taking into account the average area involved per single fire, there is a worsening for Greece and Italy compared to the previous year. In fact, in 2023, the average area burned per single fire was estimated at 3,121 ha for Greece (+816% compared to 2022) and 184 ha for Italy (+51%). The areas burned in our country are estimated at around 59,000 hectares in 2022 and 98,000 in 2023, showing a worsening compared to the average for the period 2006-2022 - roughly 54,000 hectares. During the "fire season" 2023 - period from 15 June to 15 September – almost 39% of the areas covered by fire are agricultural land and 14% are forest ecosystems [27]. The most affected regions were Sicily - 51.4 thousand hectares equal to 68.6% of the area burned nationwide - and Calabria – 13.7 thousand hectares equal to 18.3%.

Historically, the Southern regions have recorded the most significant damage in terms of burned surface area due to climatic conditions favorable to fires (high temperatures, strong winds, and prolonged drought), which make extinguishing operations more difficult.

Graph 2.3.1: Areas burned in Italy in 2022 and 2023 compared to the 2006-2022 average



Source: Elaboration by Centro Studi Divulga based on EFFIS data

2.4 Photovoltaic systems on the ground

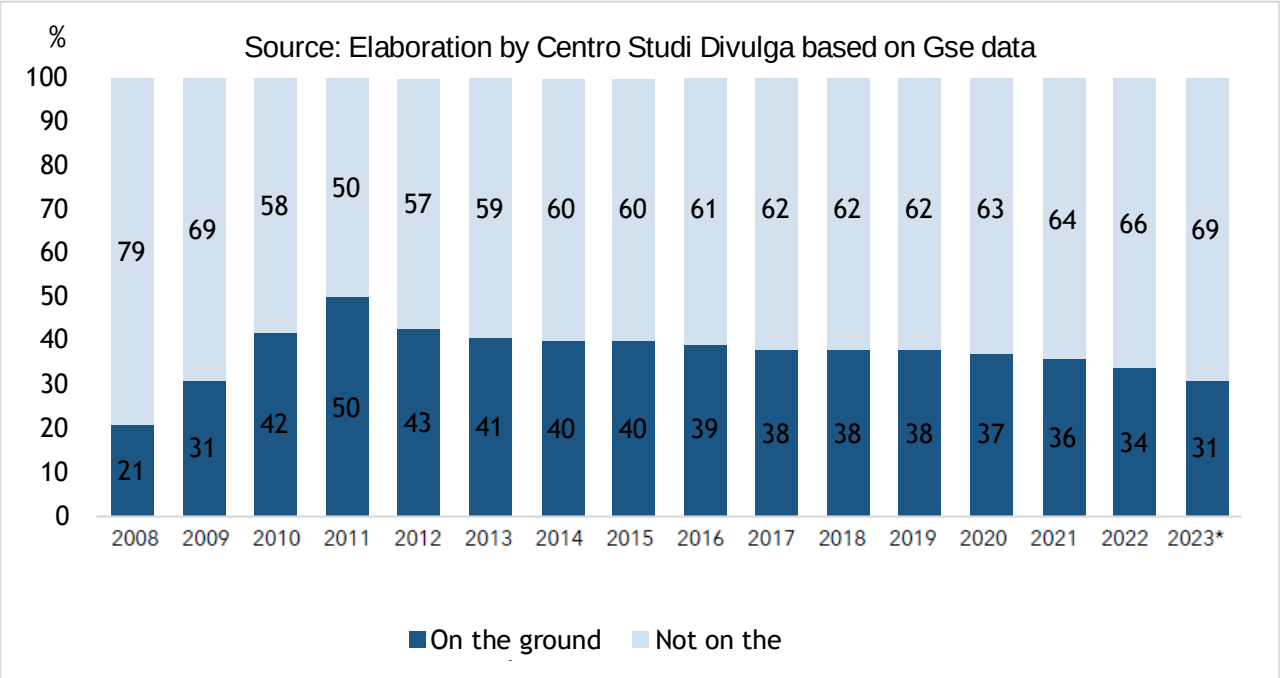
In recent years, the installation of ground-based photovoltaic systems has become increasingly widespread, a practice that contributes to the consumption of soil often destined for alternative uses. With a view to reducing dependence on fossil fuels, an increase in the use of photovoltaics for the production of clean, safe and economically accessible electricity is envisaged in the future. The Ecological Transition Plan (ETP), in fact, envisages that 72% of electricity production will come from renewable sources by 2030, rising to 95-100% by 2050. However, the installation of ground-based panels removes surface area from agricultural production, which is fundamental for the achievement of goal 2 of the 2030 Agenda, namely to end hunger and achieve food security for a growing world population. In Italy, according to the "Solar Photovoltaic" statistical reports of the Energy Services Manager (GSE), ground-mounted photovoltaic systems occupied, at the end of 2022, a surface area of 15,700 hectares, recording an increase

490 hectares compared to 2021 and 590 hectares compared to 2020 [28]. The latest updates for 2023 show that the total area occupied by ground-mounted systems is estimated at around 16,400 hectares [29], 700 hectares more than in 2022. The regions with the greatest land area occupation are Puglia (4,244 hectares), Sicily (1,681 hectares), and Lazio (1,527 hectares), which together represent 45.4% of the total national area occupied by ground-mounted systems. From 2008 to 2013, the installation of photovoltaic systems recorded a considerable increase thanks to the support of economic incentives. Subsequently, there was a consolidation phase characterized by a more gradual development. In 2023, the total power in Italy amounted to approximately 30.3 GW [29]. Until 2011, there was a growth in the percentage of power deriving from ground-mounted systems, after which non-ground installations prevailed. At the end of 2023, ground-mounted photovoltaic power amounted to 9.2 GW (31% of the total national figure), while that coming from non-ground-mounted systems was 21 GW (69%). The current trend of designing new systems with dimensions compatible with non-ground-mounted locations is undoubtedly a positive aspect to highlight, with a view to exploiting the roofs of buildings and large structures [12], as also envisaged by the

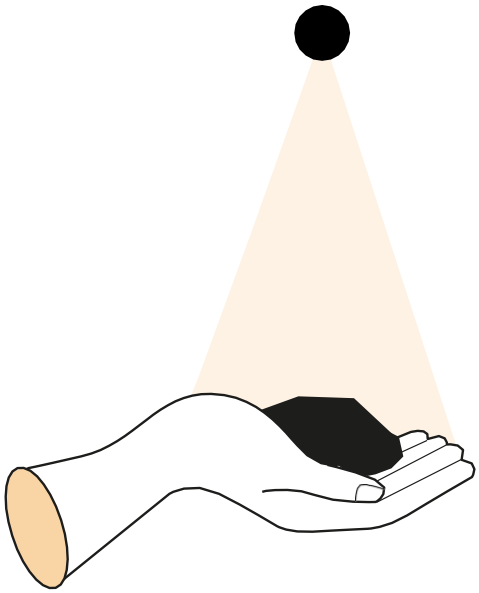
National Recovery and Resilience Plan (see chapter 5). These coverings, according to estimates in the 2022 Soil Consumption Map, represent a potentially available surface area for new plants that reaches close to 989 square kilometres

for photovoltaic power ranging between 70 and 92 GW [15], allowing the objectives of the Ecological Transition Plan for 2030 to be met.

Figure 2.4.1: Evolution of the % distribution of photovoltaic systems by location (2008-2023)



3.



3. The impacts

Land consumption and the consequent loss of ecosystem services contribute to exacerbating land degradation, as well as slowing down the achievement of the objectives of the United Nations Global Agenda for Sustainable Development. According to FAO estimates, roughly 95% of food production depends on soil and its degradation entails an economic damage of circa 400 billion dollars per year of agricultural production lost globally [11]. In other words, approximately 1,000 hectares of soil are lost every hour worldwide, equivalent to an area equivalent to 1,500 football fields. This situation is exacerbated by the extremely limited availability of land for agricultural activity in developed countries. All of this contributes to severely limiting the global biocapacity for food production, thus exposing the world's population to food insecurity. In 2022, approximately 2.4 billion people worldwide were food insecure, of which 11.3% (900 million) faced severe food insecurity [30]. Another consequence of soil consumption is the considerable loss of biodiversity; consider that 90% of living organisms reside in soil, influencing its properties, processes and functions. In particular, microorganisms that regulate the bioavailability of nutrients, and therefore soil fertility, live in the first 5 cm of soil. As a result, the loss of even the very first layers of soil means almost irreversibly compromising food production [31]. Food security is also linked to soil organic carbon levels; in fact, levels below 2% are often associated with degradation phenomena that reduce soil fertility and stability, and compromise productivity. In addition, soils contribute to the sequestration

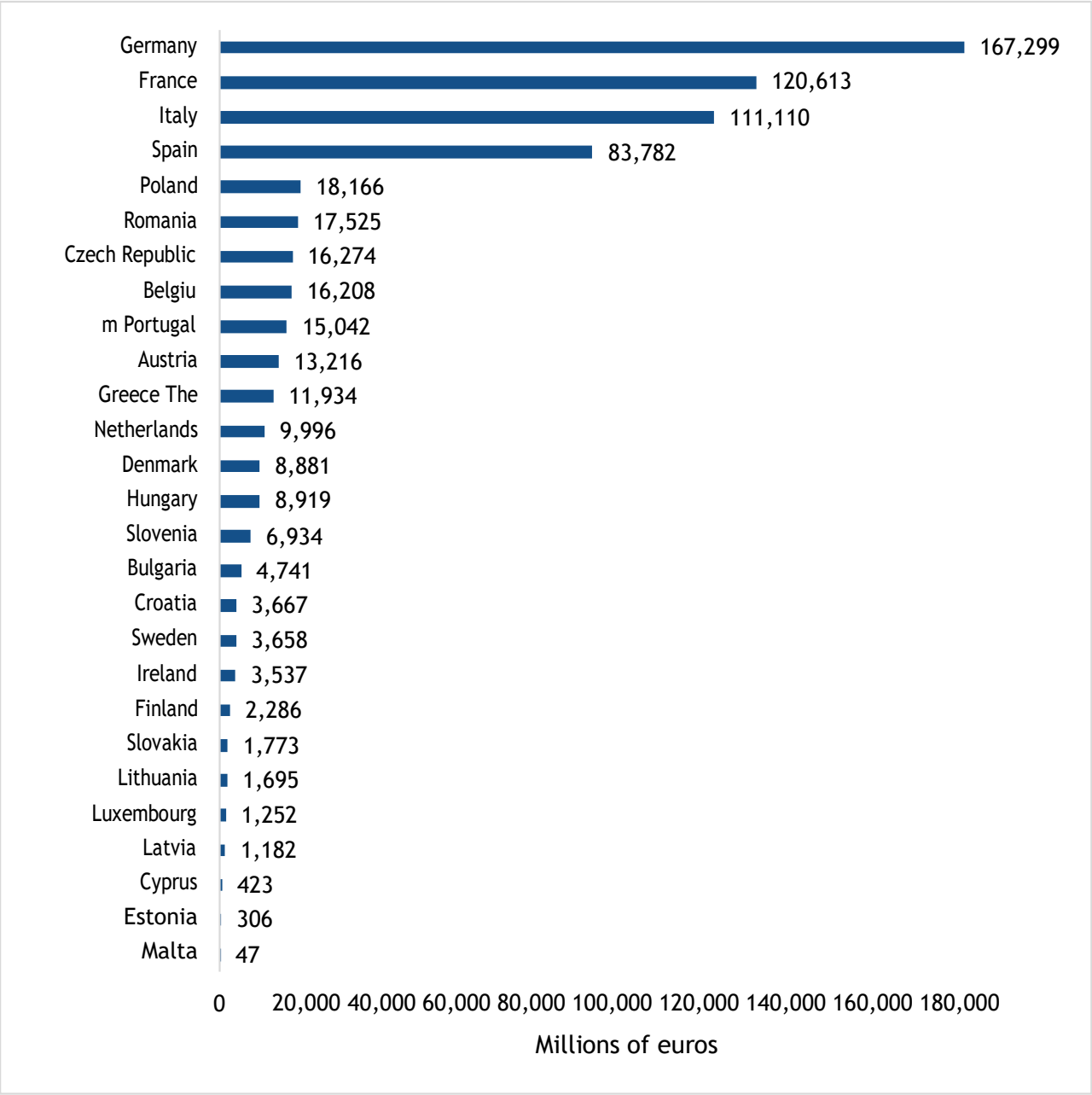
of carbon from the atmosphere, contributing to the mitigation of climate change [32]. However, this capacity is diminished as a result of the sealing of the soil. In European urban areas (EU27 and the United Kingdom), in fact, the sealing of roughly 1,467 square kilometres has resulted in a reduction in the potential for soil carbon sequestration of circa 4.2 million tonnes [5], equal to 4 tonnes per hectare of surface area. With particular reference to the entire Italian territory, over the last 10 years, a loss of approximately 3.2 million tonnes of carbon stored in the soil has been estimated, corresponding to an economic loss of 235 million euros. In general, soils store more carbon than the atmosphere and terrestrial vegetation combined [9] and their management influences the biological processes that lead soils to lose or gain carbon [33] thus influencing climate regulation. When soil degradation phenomena occur, the soil is no longer able to retain part of the carbon (labile fraction) that it will release into the atmosphere. The increase in carbon concentration in the atmosphere favours the rise in average temperatures, exacerbating vulnerability to climate change. As a result, extreme climatic events will occur more frequently, such as droughts and floods, which will result in further soil loss, generating a perverse and vicious circle. Soil degradation entails a heavy economic impact, with a cost for the European Union alone of

over 50 billion euros per year [20]. With particular reference to Italy, the SDG 15.3.1 indicator estimates a percentage of degraded territory of 17.2%, net of water bodies, with particularly high regional values in Sardinia (28.5%) and Emilia-Romagna (23.9%) [34]. From a social perspective, soil quality is intrinsically linked to the livelihood of people living in extreme poverty, which affects approximately 690 million individuals worldwide, 75% of whom come from rural areas where agriculture is their main occupation [2]. Therefore, if the consumption and degradation of the soil resources does not stop, the number of people in conditions of absolute poverty will only increase.

3.1 Soil and natural disasters

Land consumption leads to a reduction in resilience to climate change.. The alternation of prolonged periods of drought punctuated by extreme rainfall, in turn, act as catalysts for the processes of land consumption and degradation, predisposing various areas to natural disasters. In particular, soil consumption, influencing the stability of the soil, favours landslides and landslides following intense rainfall, while sealing, redesigning the hydrological characteristics of the basins, determinal problema dello disposal of rainwater and the risk of flooding and hydrogeological instability in the event of extreme rainfall. In these circumstances, floods affect cities and fields near rivers, causing enormous economic losses, biodiversity destruction and loss of human lives. With reference to cities, the overbuilding processes that have often taken place in an uncontrolled manner over the last century, the systematic sealing of the soil and the artificial state of waterways, associated in many cases with inadequate drainage systems, have contributed to increasing the risk of hydrogeological instability in urban areas [21]. The EU is increasingly vulnerable to natural disasters due, as well, to the increase in land consumption. For example, the 146.7 thousand hectares of sealed areas between 2012 - 2018 caused a potential loss of water retention capacity of 672 million m3 [5]. With reference to urban areas, sealing rates are recorded ranging on average from 10% in commuting areas (a) to 36% in cities [35], making them susceptible to the risk of flooding. From 1980 to 2022, the EU-27 countries suffered economic losses from extreme events estimated at 650 billion euros, of which 43% were linked to floods and approximately 8% to droughts and fires. At €59.4 billion and €62.3 billion, 2021 and 2022 represent the highest annual values of the entire time series [36]. Among EU countries, the largest economic losses in the period 1980-2022 were measured in Germany (167 billion euros; 2,065 euros per capita), followed by France (121 billion; 1,947), Italy (111 billion;
1,918) and Spain (84 billion; 1,977).

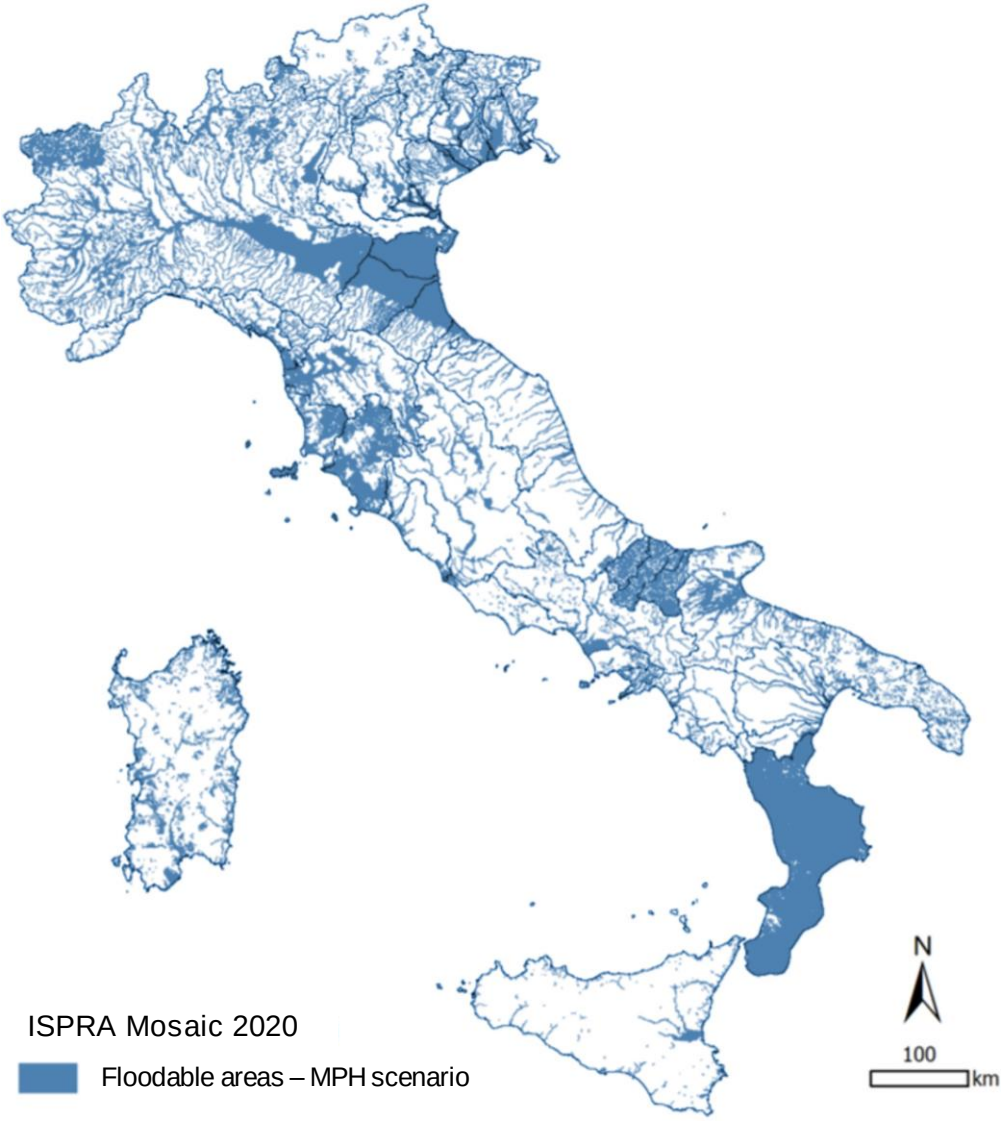
Graph 3.1: Economic losses caused by extreme weather events, 1980-2022



Source: Elaboration by Centro Studi Divulga based on European Environment Agency data

Mediterranean areas are among the most susceptible to natural hazards given the long history of erosion that has affected soils. In particular, climate change and the fragility of the Italian territory, accentuated by land consumption, have led to increasingly widespread and frequent phenomena of instability (floods, landslides, erosion and subsidence) causing victims and damage to movable and immovable property, infrastructures, services, the economic and productive fabric as well as the environment. According to ISPRA estimates, from 2012 to 2021, Italian soils have suffered a loss of water infiltration capacity estimated at around 360 million cubic metres (equal to approximately 14.4 million tanker trucks) due to land consumption; this phenomenon has not stopped even in areas already exposed to hydraulic hazards, exacerbating the risk conditions. The continuous transformations of the territory contribute to increasing the risk of hydrogeological instability in an already fragile context. In Italy, in fact, 7,423 municipalities (93.9% of the total) are at risk of landslides, floods and/or coastal erosion; 18.4% (55,609 sq. km) of the territory is classified as being more dangerous due to landslides and floods; 1.3 million inhabitants live in areas at risk of landslides and 6.8 million inhabitants in areas at risk of floods [37]. In particular, the risk of flooding threatens more than half of the population of Emilia-Romagna (62.5%) and a quarter of Tuscany (25.5%) due to the considerable extent of floodable areas [14]. And the news events of recent years only confirm this picture of vulnerability and concern.

Graph 3.2: Flood areas by medium flood hazard scenarios



Source: ISPRA Report on the hydrogeological instability in Italy (2021)

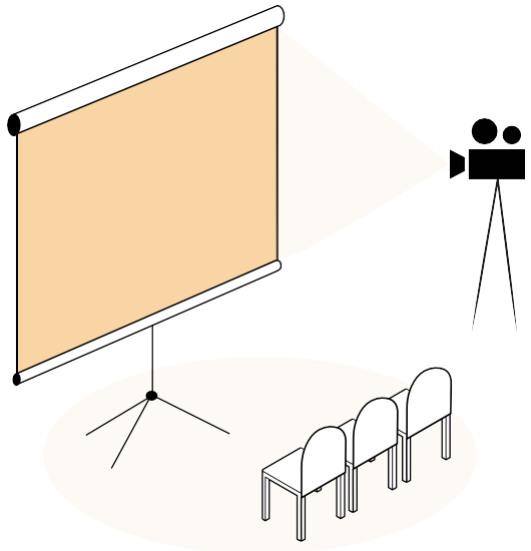
Among the countless catastrophic events that have occurred in Italy in the last two years, those that have affected Ischia, Marche, Emilia-Romagna and Tuscany are worth mentioning. Between 15 and 17 September 2022, a wave of bad weather led to intense rainfall in the provinces of Ancona, Pesaro and Urbino with maximum intensities of 400 mm in six hours and peaks of 90 mm in one hour [38], triggering numerous landslides, flash floods and flooding of the Metauro and Misa rivers with disastrous consequences and the loss of 12 lives. After roughly 2 months, on November 26, 2022, a thunderstorm hit the island of Ischia, recording 126 mm of rain in six hours. The effects of the event, amplified by the fragility of the territory due to uncontrolled overbuilding caused numerous surface landslides and a series of mudslides and debris flows, as well as considerable economic damage and 12 deaths. Between the 2nd and 3rd of May 2023, the eastern area of Emilia-Romagna was affected by abundant rainfall reaching almost 210 mm in twenty-four hours. This event led to serious consequences in the provinces of Ravenna, Forlì-Cesena and Bologna, including 2 deaths, due to the overflow of the banks of the Sillaro, Lamone and Senio rivers and the resulting flooding of vast areas, as well as numerous landslides in various locations in the provinces concerned. A few days later, between May 16 and 17, abundant and persistent rainfall further aggravated the situation, leading to the overflowing of 23 rivers and hundreds of landslides. The toll was disastrous: 15 deaths; initially 36,000 displaced; almost 21,000 agricultural businesses affected, for a total of 80,000 hectares of crops and 41,000 workers in the sector [39]; overall economic losses reached almost 10 billion euros according to initial estimates. Another disaster that affected Italy in recent years is storm Ciaràn which reached the peninsula between the 1st and 2nd of November 2023, with strong gusts of wind and intense rains. In particular, the thunderstorm remained stationary for roughly 5 hours over Tuscany registering up to 200 mm of rain [40], which caused the overflowing of numerous waterways, flooding and 8 deaths. In total, 36 deaths, 20 injuries and 41,687 evacuees and homeless people were recorded in 2023 due to landslides and floods [41]. These figures are significantly worse than those of 2022, when 24 deaths, 1 missing person, 26 injured and 1,384 evacuees and homeless people were recorded [42].

Table 3.1: Consequences of landslides and floods in Italy in 2022 and 2023

	Deaths	Missing	Injured	Evacuees and Homeless
Landslides	13	---	23	934
Flooding	11	1	3	450
2022 Total	24	1	26	1,384
Landslides	10	---	18	1,694
Flooding	26	---	2	39,993
2023 Total	36	---	20	41,687

Source: Elaborated by Centro Studi Divulga based on CNR-IRPI data

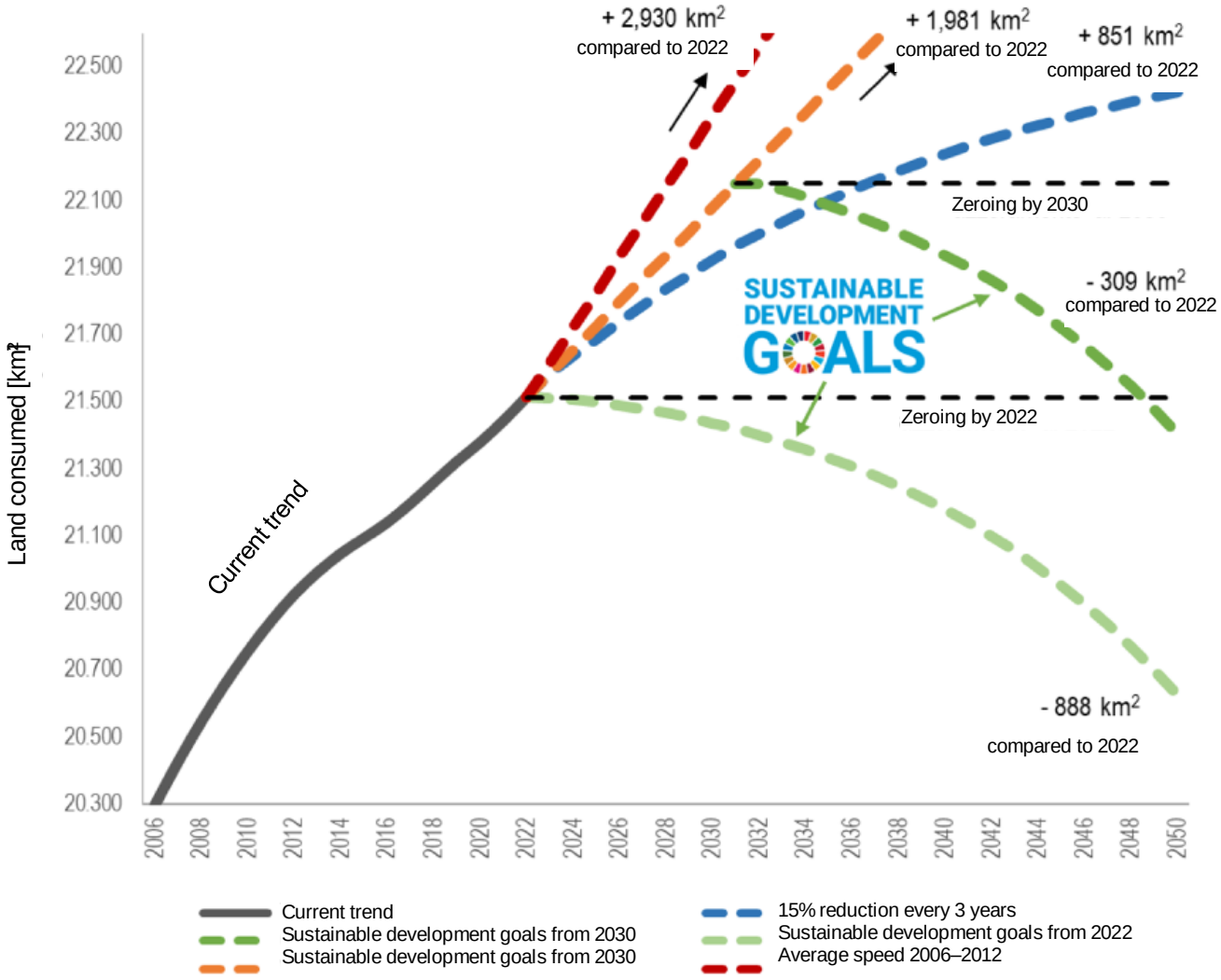
4.



4. Future scenarios

The transformation scenarios of Italy's territory for the coming years paint a less than reassuring picture in the absence of genuine rethinking of land consumption patterns. If the rate of consumption were to remain constant, by 2050 another 198.1 thousand hectares of land will be lost in Italy (an area greater than entire provinces such as Milan and Trieste combined). A return to the levels recorded in the period 2006-2012, however, would further worsen the situation, reaching 293 thousand hectares of land consumed. Conversely, in the best of prospects, assuming a reduction in consumption intensity of 15% every three years were to take place, consumption would amount to 85.1 thousand hectares before reaching zero land consumption by 2050. Reducing land consumption to zero by 2030, as envisioned by the United Nations Agenda, will likely be difficult to achieve, given the values outlined above. This will entail an overall environmental cost, linked to the loss of ecosystem services provided by soil, which could be close to 98.7 billion euros in the period 2012-2030.

Graph 4.1: Soil consumption scenarios in Italy by 2050



Source: ISPRA-SNPA report on soil consumption

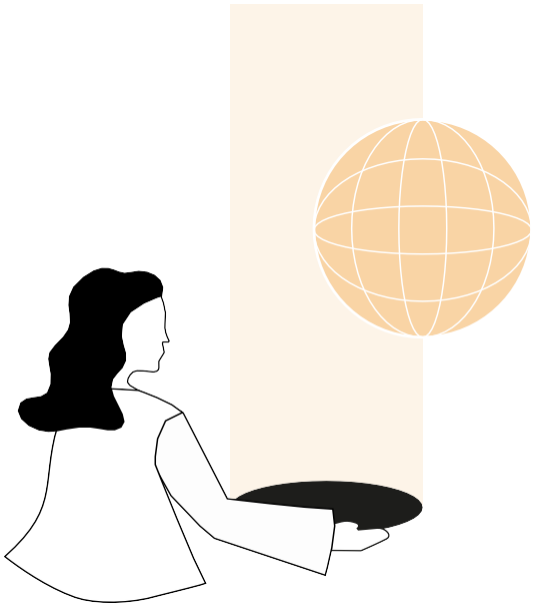
Floodable areas – MPH scenario ate of soil consumption, up to 2030, equal to the average rate for the period 2012-2022

BOX 1. AGRICULTURE, NOT THE PROBLEM BUT THE SOLUTION

Agriculture has always paid particular attention to sustainable soil management, playing a fundamental role in maintaining its health. Moreover, soil is a crucial resource for agriculture and therefore must be preserved and protected. Soil consumption has been mitigated through the adoption and dissemination of good agricultural practices, such as hydraulic and agricultural management, tillage, grassing with legume cover crops, green manure, and crop rotations. In order to further address drought, among the causes of soil degradation, it is useful to mention the central role and importance of rainwater storage basins, which represent an important solution in reducing the difficulties that come with storing water resources. Among the agricultural practices cited for soil enhancement, hydraulic and agricultural systems allow for water management by promoting infiltration and storage, as well as allowing for the drainage of excess water, reducing erosion rates and the risk of landslides and mudslides. In particular, on sloping terrain, soil tillage that follows contour lines reduces the speed of the stream [43] in the event of heavy rainfall, limiting its erosive action and the consequential soil loss. Grassing helps mitigate the impact of rainfall as well as retain soil particles through the root systems of cover crops, making the soil less susceptible to erosion. Furthermore, together with green manure and crop rotations, grassing contributes to carbon sequestration, immobilizing it in the soil in an organic form. The average values of carbon stock in the first 30 cm of depth are equal to: 51.0±16.7 for arable crops; 41.9±15.9 for vineyards; 51.5±19.8 for olive groves; 44.1±12.1 for orchards; 63.3±27.9 for rice fields and 48.9±16.1 for mixed meadows and agroforestry [1]. Organic carbon content allows to maintain soil health while improving its structure by increasing its porosity and, as a result, its water retention capacity. This reduces irrigation requirements and crop water stress, thus preserving yields. The latter aspect is fundamental to guaranteeing food security, especially in the current European scenario characterised by long periods of drought.

Moreover, soil with a good organic carbon content and that is well-structured is less vulnerable to erosion. Sustainable agronomic soil management, therefore, contributes significantly in mitigating climate change, combating desertification and maintaining and improving biodiversity. Hence, agronomic management is particularly important in the context of several United Nations Framework Conventions: Climate Change (UNFCCC); Combating Desertification (UNCCD) and Biological Diversity (UNCBD). We must not forget, therefore, the central role played by farmers in maintaining and preserving the territory. The progressive abandonment of agricultural activities in hilly and mountainous areas, on the contrary, triggers the expansion of shrubby vegetation, a decrease in soil fertility and an increase in the risk of fire, especially when associated with an increase in the frequency of drought events. These concomitant phenomena contribute significantly to situations of extreme degradation [21]. Furthermore, the abandonment of cultivated slopes in mountainous and hilly areas, and the resulting lack of maintenance, have repercussions on the entire downstream hydraulic system, where metropolitan areas are generally concentrated, causing significant hydrogeological damage. The maintenance of internal areas by farmers is therefore also fundamental for the safety of urbanised areas. As a result, the framework being outlined here highlights the need to maintain and strengthen the support offered to agriculture, through appropriate public interventions, given the agricultural sector’s strategic role in environmental and social terms.

5.



5 Political strategies to preserve soil

Soil health plays a crucial role in re-establishing an ecological balance and restoring the environment for future generations, by influencing natural biogeochemical cycles. Supporting a more efficient use of land is possible, however appropriate policy instruments and incentives must be established to protect and conserve soils which, as previously mentioned, contribute to supporting biodiversity, carbon sequestration and the ability to retain water. Soil consumption and degradation are globally recognised threats. The United Nations has dedicated two specific Sustainable Development Goals (SDGs) of the 2030 Agenda to these issues. Goal 11.3 aims to avoid uncontrolled urban expansion and limit land use in line with population growth;

Goal15.3 aims to halt and reverse land degradation in order to achieve neutrality by 2030. With the new soil strategy for 2030, published in 2021, the European Union recognised the seriousness of the impact of soil consumption on the environment and, consequently, on the climate and biodiversity objectives of the European Green Deal. Hence, the Union called on Member States to set consumption targets by 2030 in order to contribute to the ambitious EU objectives of zero soil consumption and healthy and more resilient soils by 2050. Healthy soil can be crucial in contributing to tackling the major challenges of achieving climate neutrality and resilience to climate change, through the development of a clean and circular (bio)economy,

reversing biodiversity loss, safeguarding human health, halting desertification, and reversing land degradation [44]. This will only be possible through profound changes during the current decade and the adoption of strategies aimed at increasing efficiency in the use of soil resources. With this in mind, in July 2023, the European Commission adopted the “Soil Monitoring and Resilience Law” [45], a proposed directive that sets three main objectives: the development of a homogeneous system for monitoring and assessing soil quality across the Union's territories; sustainable soil management; and the management of contaminated sites. Other aspects of soil management and protection are incorporated into other European policies, such as the European Green Deal, the CAP 2023-2027 and the LULUCF Regulation.

a. The European Green Deal aims to achieve climate neutrality by 2050. This objective can only be achieved by preserving the health of soils and their ability to sequester carbon through the 2030 biodiversity strategy and the farm-to-fork strategy. The first aims to preserve and restore ecosystems and biodiversity by increasing resilience to natural threats such as the impacts of climate change, forest fires and food insecurity. The second aims to increase the utilised agricultural area cultivated via the organic method to 25% by 2030, indirectly contributing to preserving soil health. In order to achieve its objectives, the Green Deal can count on a total budget of 1.8 trillion euros.

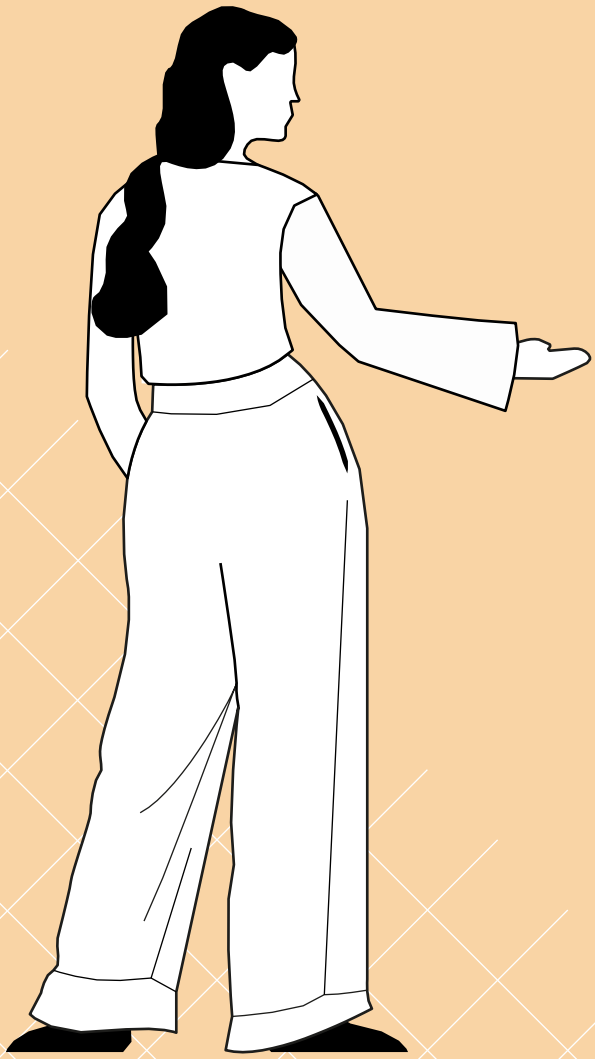
b. The Common Agricultural Policy 2023-2027, given its increased environmental ambition, introduces enhanced conditionality for direct payments by establishing new rules for maintaining land in good agricultural and environmental condition (GAEC). The three GAECs that directly relate to soil protection and quality are: "Management of tillage aimed at reducing the risks of soil degradation and erosion, also taking into account the gradient of the slope" (GAEC 5); "Minimum soil cover to avoid leaving the soil bare during the most sensitive periods" (GAEC 6); “Crop rotation on arable land, with the exception of submerged crops” (GAEC 7) [46]. Added to these are eco-schemes, i.e. additional payments to encourage the voluntary adoption of agricultural practices that benefit the climate and the environment, defined at national/regional level, which go beyond strengthened conditionality. Member States must dedicate 25% of their direct payment allocations to these eco-schemes. In terms of commitments at constant 2018 prices, the total allocation of the CAP for the entire period 2021-2027 is 386 billion euros [47], one third of the budget of the European Union [48] . Part of this funding will support the implementation of the European Green Deal.

c. The 2018 LULUCF regulation, in line with the Paris Agreement, highlights the central role of land use in pursuing long-term objectives for climate mitigation, establishing the principle of "no net debt" for the period 2021-2030. Based on

this principle, Member States are required to ensure that accounted greenhouse gas emissions from land use are fully offset by equivalent CO2 removals through land management practices that increase carbon stocks. This principle is currently only applied to forests but will be extended to all land uses by 2026.

At the national level, regarding the implementation of the 2030 Agenda and European policies, the national strategy for sustainable development, the national strategy for biodiversity by 2030 and the plan for ecological transition, have been defined. The latter, in particular, sets the goal of zero land consumption by 2030 as envisaged by the 2030 Agenda, that is, 20 years earlier than the European target. The 2023 budget law establishes, in Article 127, the "Fund for combating land consumption" with a total allocation of 160 million euros for the years 2023-2027, so as to enable the planning and financing interventions for the re-naturalisation of degraded or deteriorating soils in urban and suburban areas [49]. Finally, the National Recovery and Resilience Plan (NRRP), among the interventions aimed at relaunching the country in the post-pandemic period, provides for the approval of a national law on soil consumption given the worsening of the climate crisis and the particular fragile conditions of the Italian territory. Other important measures of the NRRP include investments in "Agro-voltaic development" and "Agri-solar Parks". The first aims to implement hybrid systems with dual production functions—agriculture and energy—without compromising land use. The second encourages the use of roofs on buildings for productive use in the primary sector; installing photovoltaic panels for renewable energy production, thus preserving the soil from further consumption.

b



.

Bibliography

[1] C R E A , 2 0 2 3 . Annuario dell’agricoltura italiana 2022, Volume LXXVI, Consiglio per la ricerca in agricoltura e l’analisi dell’economia agrarian – Centro di Ricerca Politiche e Bioeconomia

[2] Conscious Planet Inc., 2022. Soil revitalization – Global Policy Draft & Solutions Handbook – Europe

[3] Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: Synthesis, Island Press

[4] C R E A , 2 0 2 2 . Annuario dell’agricoltura Italiana 2021, Volume LXXV, Consiglio per la ricerca in agricoltura e l’analisi dell’economia agraria – Centro di Ricerca Politiche e Bio-economia

[5] EEA 2022. Land take and land degradation in functional urban areas, EEA Report no. 17/2021, European Environment Agency

[6] European Commission , Directorate-General for Research and Innovation, Veerman, C., Pinto Correia, T.,Bastioli, C. et al., Caring for soil is caring for life – Ensure 75% of soils are healthy by 2030 for healthy food, people, nature and climate, 2020

[7] European Parliamentary Research Service, Rachele Rossi, Desertification and agriculture, 2020

[8] United Nations office for Disaster Risk Reduction, definition "Soil Erosion"

[9] FAO e ITPS, 2015. Status of the world's soil resources (SWSR), Food and Agriculture Organization of the United Nations and Intergovernmental Technical Panel on Soils, Rome

[10] Bünemann E. K., et al., 2018. Soil quality — a critical review, Soil Biology and Biochemistry, Volume 120, page 105-125

[11] FAO and CREA, 2019. Voluntary guidelines for sustainable soil management, Food and Agriculture Organization of the United Nations and Council for Research in Agriculture and the Analysis of Agricultural Economics, Rome

[12] SNPA, 2022. Soil consumption, territorial dynamics and ecosystem services, SNPA 32/22 Report, National System for the Protection of the Environment

[13] EEA, 2023. Soil monitoring in Europe – Indicators and thresholds for soil health assessments, EEA Report no. 08/2022, European Environment Agency

[14] ISTAT, 2022. SDGs Report 2022 – Statistical information for the 2030 Agenda in Italy, National Institute of Statistics, Rome

[15] SNPA, 2023. Soil consumption, territorial dynamics and ecosystem services, SNPA 37/23 Report, National System for the Protection of the Environment

[16] Bakker M.M., et al., 2004. The crop-productivity-erosion relationship: an analysis based on experimental works, Catena, Volume 57, page 55-76.

[17] Panagos P., et al., 2018. Cost of agricultural productivity loss due to soil erosion in the European Union: from direct cost evaluation approaches to the use of macro economic models, Land Degradation and Development, Volume 29, page 471-484.

[18] Panagos P., et al., 2020. A soil erosion indicator for supporting agricultural, environmental and climate policies in the European Union, Remote Sensing

[19] Panagos P., et al., 2015. The new assessment of soil loss by water erosion in Europe, Environmental Science & Police

[20] European Commission, 2021. Questions and Answers on the EU Soil Strategy.

[21] MASE, 2023. National climate change adaptation plan (NCCAP), Ministry of the Environment and Energy Security, Rome

[22] UNEP, 2022. Spreading like wild fire: the rising threat of extraordinary landscape fire, United Nations Environment Programme.

[23] JRC, 2022. Forest Fires in Europe, Middle East and North Africa 2021, Joint Research Centre Technical Report, Publications Office of the European Union

[24] JRC, 2023. Advance report on Forest Fires in Europe, Middle East and North Africa 2022, Joint Research Centre Technical Report, Publications Office of the European Union

[25] European Commission, 2023. A changing climate signal: 2022 was the second year with the most damage caused by forest fires

[26] Copernicus - European Union's Earth Observation Programme. 2023. European State of the Climate 2022

[27] ISPRA, 2023. Forest fires in Italy: fire season 2023, Forest fire report, ISPRA Environmental Surveillance Operations Centre

[28] GSE, 2023. Photovoltaic solar statistical report 2022, Gestore dei Servizi Energetici S.p.A.

[29] GSE, 2024. Photovoltaic solar statistical report 2023, Gestore dei Servizi Energetici S.p.A.

[30] FAO, IFAD, UNICEF, WFP, WHO, 2023. The State of Food Security and Nutrition in the World 2023. Urbanization, agrifood systems transformation and healthy diets across the rural-urban continuum, Food and Agriculture Organization of the United Nations, Rome

[31] Gaudio C., 2021. Soil, a precious, non-renewable resource, must be protected to ensure the preservation of life, in: Soil: natural capital, Creates future no.2, page 3-6

[32] IPCC, 2019. 2019 Refinement to the 2006 IPCC guidelines for national greenhouse gas inventories, Intergovernmental Panel on Climate Change

[33] EEA, 2022. Soil carbon, European Environment Agency (last accessed 10 February 2024)

[34] ISTAT, 2023. SDGs Report 2023 – Statistical information for the 2030 Agenda in Italy, National Institute of Statistics, Rome

[35] Naumann S., et al., 2018. Land take and soil sealing — drivers, trends and policy (legal) instruments: insights from European cities, in: International yearbook on soil law and policy, Springer

[36] EEA, 2023. Economic losses from weather- and climate-related extremes in Europe, European Environment Agency (last accessed 10 February 2024)

[3 7] ISPRA, 2021. Hydrogeological instability in Italy: hazards and risk indicators, Report 356/2021, Higher Institute for Environmental Protection and Research

[38] Polaris Cnr-Irpi, 2022. Flooding in the Marche region: 15 September 2022, Population at Risk from Landslides and Floods in Italy, National Research Council - Institute of

Research for Hydrogeological Protection

[39] Agency for Territorial Security and Civil Protection, 2023. Damage assessment launched for agricultural and agri-food companies, Emilia-Romagna Region.

[40] Polaris Cnr-Irpi, 2023. The effects of storm Ciaràn in Italy, Population at Risk from Landslides and Flooding in Italy, National Research Council - Research Institute for Hydrogeologal Protection

[41] Polaris Cnr-Irpi, 2024. Periodic report on the risk posed to the Italian population by landslides and floods – Year 2023, Population at Risk from Landslides and Floods in Italy, National Research Council - Research Institute for Hydrogeological Protection

[42] Polaris Cnr-Irpi, 2023. Periodic report on the risk posed to the Italian population by landslides and floods – Year 2022, Population at Risk from Landslides and Floods in Italy, National Research Council - Research Institute for Hydrogeological Protection

[43] Castellini M., 2022. Combating drought/2: step two soil management, in: Drought and desertification: in search of the water that is not there, Creafuturo no.5, page 69-72

[44] European Commission, 2021. EU Soil Strategy 2030: Healthy soils for people, food, nature and climate, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions

[45] European Commission, 2023. Proposal for a Directive on Soil Monitoring and Resilience

[46] Frattarelli A., et al., 2023. The new reinforced conditionality 2023 – 2027: the contribution of GAEC standards to the increased environmental ambition of the CAP, National Rural Network (NRN)

[47] European Commission, Common agricultural policy funds

[48] European Commission, 2022. The common agricultural policy at a glance (last accessed 30th June 2023)

[49] Studies Service of the Chamber of Deputies, 2022. Budget Law 2023: interest profiles of the VIII Environment Committee, Dossier XIX Legislature

ISBN 979-12-81249-22-6