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How can banks integrate regenerative agriculture KPIs in their Pillar 3 ESG disclosure?

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ABSTRACT

Current agricultural system, characterised by intensive farming leading to high levels of GHG emissions and soil degradation, represents a significant driver in biodiversity deterioration, and it is recognized as one of the major contributors to climate change.
Urgent action is needed to halter the alarming situation that our planet is facing, impacting not only the agricultural industry, but all sectors and stakeholder. In particular, climate change and biodiversity loss represent critical risks for financial institutions, generating consequences they have to address.
Nature-based Solutions represent a valuable way to solve the problem, as their ultimate goal is to ensure protection and conservation of biodiversity and ecosystems, providing at the same time economic and social benefits.
Among them, regenerative agriculture is a model that thanks to its sustainable and environmentally respectful practices is capable to generate positive effects for both the climate and biodiversity.
However, in order to achieve a just transition toward more sustainable ecosystems, all actors and stakeholder have to commit, including financial institutions and banks.
Specific KPIs for regenerative agriculture are therefore needed, with the aim of demonstrating and measuring the positive impacts these practices are able to deliver, representing for banks an instrument to ensure compliance with ESG disclosure requirements and environmental objectives, to be integrated in their risk management.

Keywords: Intensive farming; Biodiversity loss; Climate Change; Regenerative Agriculture; ESG disclosure; Just Transition; Nature-based Solutions.

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ABBREVIATIONS

Ag-NbS: Agriculture Nature-based Solutions

AI: Artificial Intelligence

C3S: Copernicus Climate Change Service

CAP: Common Agricultural Policy

CAPEX: Capital Expenditure

CO_2: Carbon Dioxide

CH_4: Methane

CREA: Consiglio per la Ricerca in Agricoltura e l'Economia Agraria

CRD IV: Capital Requirements Directive IV

CRR: Capital Requirements Regulation

CSRD: Corporate Sustainability Reporting Directive

EAFRD: European agricultural fund for rural development

EAGF: European agricultural guarantee fund

EARA: European Alliance for Regenerative Agriculture

EBA: European Banking Authority

ECB: European Central Bank

EEA: European Environment Agency

EEFs: Enhanced Efficiency Fertilisers

EFRAG: European Financial Reporting Advisory Group

ESOTC: European State of Climate

ESRS: European Sustainability Reporting Standards

FAO: Food and Agriculture Organization

FSDN: Farm Sustainability Data Network

GBF: Global Biodiversity Framework

GHG: Greenhouse gas

GMOs: Genetically Modified Organisms

GWP: Global Warming Potential

IoT: Internet of Things

IPCC: Intergovernmental Panel on Climate Change

ISMEA: Istituto di Servizi per il Mercato Agricolo Alimentare

ISPRA: Istituto Superiore per la Protezione e la Ricerca Ambientale

ITS: Implementing Technical Standards

IUCN: International Union for Conservation of Nature

KPIs: Key Performance Indicators

KRIs: Key Risk Indicators

ML: Machine Learning

N_2O: Nitrous Oxide

NbS: Nature-based Solutions

NFS: Non-Financial Statements

NGFS: Network for Greening the Financial System

NGTs: New Genomic Techniques

OP2B: One Planet Business for Biodiversity

PNRR: National Recovery and Resilience Plan

R&D: Research and Development

RAF: Risk Appetite Framework

RAS: Risk Appetite Statement

RDPs: Rural Development Programmes

SAI: Sustainable Agriculture Initiative

SDGs: Sustainable Development Goals

SMEs: Small and Medium Enterprises

SOC: Soil Organic Carbon

SUR: Sustainable Use of plant protection products Regulation

TFEU: Treaty on the Functioning of the European Union

TSC: Technical Screening Criteria

VSME: Voluntary Standard for non-listed micro-, small- and medium-sized undertakings

WBCSD: World Business Council for Sustainable Development

WMO: World Meteorological Organization

WWF: World Wildlife Fund

INTRODUCTION

Agriculture and food systems are important drivers of economic development, providing food for both the global population and animal species, ensuring humanity's livelihood and survival[1].

Intensive agricultural model has been the primary response to the increasing global demand for food.

This industrial system aims to provide high levels of crop production from available land[2], relying on practices such as monocultures, heavy use of fertilizers and pesticides, and mechanization. These methods heavily industrialized and reliant on chemical resources are able to produce growing amounts of cereals, legumes, meat, and eggs in a short time. While these methods enable large-scale and fast food production, they have a significant negative impact on the environment and biodiversity[3].

Intensive agriculture is a major source of carbon dioxide (CO_2) emissions, generating approximately 13% of global greenhouse gas (GHG) emissions[4].

Additionally, mechanization and the extensive use of inorganic inputs contribute to the reduction of soil fertility and increased damages to ecosystems, threatening animal and plant species and diversity[5].

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[1] Food and Land Use Coalition. (2023). *Aligning regenerative agricultural practices with outcomes to deliver for people, nature and climate*. Food and Land Use Coalition. Retrieved from https://www.foodandlandusecoalition.org/wp-content/uploads/2023/01/Aligning-regenerative-agricultural-practices-with-outcomes-to-deliver-for-people-nature-climate-Jan-2023.pdf

[2] Foley, J. A., Ramankutty, N., Brauman, K. A., Cassidy, E. S., Gerber, J. S., Johnston, M., ... & Zaks, D. P. (2011). Solutions for a cultivated planet. *Nature*, *478*(7369), 337-342.

[3] Batini, N. (2019). Transforming agri-food sectors to mitigate climate change: the role of green finance. *Vierteljahrshefte zur Wirtschaftsforschung, (3), 7-42.* Retrieved from https://www.econstor.eu/bitstream/10419/225186/1/10_3790_vjh_88_3_007.pdf

[4] IPCC. (2019). *Summary for Policymakers*. In: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. Retrieved from https://www.ipcc.ch/site/assets/uploads/sites/4/2022/11/SRCCL_SPM.pdf

[5] Benton, T. G., Bieg, C., Harwatt, H., Pudasaini, R., & Wellesley, L. (2021). Food system impacts on biodiversity loss. *Chatham House, London,* 02-03. Retrieved from https://www.ciwf.com/media/7443948/food-system-impacts-on-biodiversity-loss-feb-2021.pdf

Given that our planet's resources are finite and the environmental degradation already caused by this model, continuing with these existing farming practices will lead to increasing deforestation and deterioration, exacerbating an already critical situation[6].

«2024 was the warmest year on record for Europe.
2024 saw the most widespread flooding since 2013.
July 2024 saw the longest heatwave on record for southeastern Europe.
Glaciers in all European regions saw a net loss of ice in 2024.
In 2024, surface soil moisture was drier than average for Europe as a whole.
The Mediterranean Sea recorded its highest annual surface temperature in 2024.»[7]

These are just some of the shocking statistics recently released in the 2024 European State of Climate (ESOTC) report, compiled by the Copernicus Climate Change Service (C3S) and the World Meteorological Organization (WMO).
These alarming data highlight the terrible environmental situation our planet is facing, a clear warning sign that emphasizes the urgent need for concrete measures to combat climate change and biodiversity loss.

Public institutions and organizations have recognized the urgency of this issue, by developing guidelines and frameworks and establishing goals and objectives to be achieved in the following years, requiring a commitment from all actors and sectors.
Indeed, it is important to stress that this crisis affects not only agriculture, but all sectors and the economy, in an interconnected way[8]. Among these, the financial sector is deeply involved. Indeed, climate change, by impacting agriculture industries, also affects

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[6] FAO. (2017). *The future of food and agriculture – Trends and challenges*. Rome. Retrieved from https://openknowledge.fao.org/server/api/core/bitstreams/2e90c833-8e84-46f2-a675-ea2d7afa4e24/content
[7] C3S and WMO. (2025). *European State of the Climate 2024*. https://climate.copernicus.eu/esotc/2024
[8] Joint Research Centre. (2023). *Decrypting the financial risks of climate change and biodiversity loss: a deeper understanding of ecosystem integrity and dependencies*. Retrieved from https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/decrypting-financial-risks-climate-change-and-biodiversity-loss-2023-12-18_en

financial sustainability, particularly by destroying firms' capital, reducing profitability and requiring, as a consequence, a portfolio reallocation[9].

The European Union's agricultural industry is losing €28 billion a year due to increasing climate risks[10]. In addition, the production of some key products, including rice, wheat, cocoa, soy, and coffee, is at significant risk because of climate impacts and biodiversity decline[11].

In this context, the relationship between the agricultural sector and finance is even more important, as adaptation measures for farmers require financial resources, together with innovative financial products and instruments[12].

Banks and financial institutions face climate-related and biodiversity-related financial risks. They originate from physical impacts linked to climate events, and from risks associated with the transition to a low-carbon economy[13]. These factors generate, in turn, risks associated to banks' reputation, regulatory compliance, and technological innovation, requiring adjustments to investment portfolios[14], prioritizing more innovative, resilient, and sustainable companies.

Therefore, given the existing state of the sector, a transition to a low-carbon, sustainable, resilient, and environmentally respectful model is necessary.

Nature-based Solutions represent a valuable instrument in this regard, defined as «*locally appropriate, adaptive actions to protect, sustainable manage and restore [...] ecosystems in order to address targeted societal challenges*»[15]. They simultaneously achieve three

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[9] Adiatma, T., Irianto, O., Hyronimus, D., & Kuntag, J. (2024). Impact of climate change on financial sustainability in agricultural industries. *AGROLAND: The Agricultural Sciences Journal (e-Journal)*. Retrieved from http://jurnal.faperta.untad.ac.id/index.php/agroland/article/view/2064/2145

[10] Bergin, C. (2025). Europe's farm sector loses €28 billion a year from climate risks. *Bloomberg*. Retrieved from https://www.bloomberg.com/news/articles/2025-05-20/europe-s-farm-sector-loses-28-billion-a-year-from-climate-risks

[11] Garancini, C. (2025). Cambiamenti climatici e perdita di biodiversità: la doppia minaccia alle importazioni alimentari dell'Unione Europea. *Lifegate*. Retrieved from https://www.lifegate.it/clima-biodiversita-minaccia-importazioni-alimentari-unione-europea

[12] Céu, M., & Gaspar, R. (2024). A Review on Climate Change, Credit Risk and Agriculture. *Rural Sustainability Research*.

[13] TCFD. (2017). *Task Force on Climate Related Financial Disclosures*. Retrieved from https://cebds.org/wp-content/uploads/2023/06/Sumario-Executivo-TCFD_EN.pdf

[14] Céu, M., & Gaspar, R. A Review on Climate Change, Credit Risk and Agriculture.

[15] Frelih-Larsen, A., Riedel, A., Hobeika, M., Scheid, A., Gattinger, A., Niether, W., & Siemons, A. (2022). Role of soils in climate change mitigation. *German Environment Agency*. Pag. 15. Retrieved from https://www.ecologic.eu/sites/default/files/publication/2023/50061-role-of-soils-in-climate-change-mitigation.pdf

goals: climate change mitigation and adaptation, enhanced biodiversity resilience, and consideration of farmers' and producers' needs and interests[16].

Among these solutions, regenerative agriculture stands out as a promising approach to making agriculture more sustainable and resilient. It is defined by the Food and Agriculture Organization (FAO) as a set of farming practices whose major benefits are to «*improve water and air quality, enhance ecosystem biodiversity, produce nutrient-dense food, and store carbon to help mitigate the effects of climate change*»[17], working in respect of nature while enhancing economic sustainability. Its key objectives include reducing GHG emissions, minimizing the use of chemical fertilizers, and enhancing ecosystem resilience. All these practices could help improving the soil's ability to capture and store carbon dioxide[18].

Despite the numerous benefits and advantages regenerative agriculture offers to biodiversity protection and increased resilience to climate change, the transition to this model presents challenges and risks[19].

This is especially true given considering the financing gap existing in Italy: on one side, farmers and Small and Medium Enterprises (SMEs) need to develop new knowledge and skills, and lack the necessary financial resources to make the transition on their own; on the other side, financial institutions perceive these investments as risky due to high uncertainty and the need to consider a long-term perspective[20]. According to Cristophe Hansen, the EU's commissioner for agriculture and food, biodiversity loss and climate change «*could restrict farmers' access to finance, as banks could become even more reluctant to take risks than they are today*»[21].

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[16] Sowińska-Świerkosz, B., & García, J. (2022). What are Nature-based solutions (NBS)? Setting core ideas for concept clarification. *Nature-Based Solutions*, *2*, 100009.

[17] FAO. (2022). *Regenerative Agriculture*. Retrieved from https://www.fao.org/family-farming/detail/en/c/1512632/

[18] Noreika, L. (2024). *Regenerative agriculture: Barriers to adoption and how leaders can help*. Forbes. Retrieved from https://www.forbes.com/councils/forbesbusinesscouncil/2024/07/01/regenerative-agriculture-barriers-to-adoption-and-how-leaders-can-help/

[19] Batini, N. (2019).

[20] De Boer, M. (2024). Review: Financing for regenerative agriculture by the Rockefeller Foundation. *ReNature.* Retrieved from https://www.renature.co/articles/review-financing-for-regenerative-agriculture-by-the-rockefeller-foundation-june-2024/

[21] EIB. (2025). *European agriculture faces growing climate risks that EU can help counter, new study finds*. Retrieved from https://www.eib.org/en/press/all/2025-214-european-agriculture-faces-growing-climate-risks-that-eu-can-help-counter-new-study-finds

Financial institutions therefore play a crucial role in supporting companies in their transition, especially considering that they are required to disclose ESG information demonstrating how they enable the transition toward Net Zero and the achievement of European commitments[22].

Therefore, the **objective of this research** is to explore how to overcome barriers hindering the adoption of regenerative practices, by analysing transitional opportunities and risks, and proposing a framework for financial institutions to support the transition in the agricultural sector. In particular, some Key Performance Indicators (KPIs) are identified to guide both farmers and banks, facilitating the evaluation of the benefits and the impacts of the practices implemented, with the ultimate goal of providing data that banks can use to meet their ESG disclosure requirements.

The **methodology** adopted is qualitative and interdisciplinary, combining literature review from agricultural economics, environmental science, and sustainable and transition finance. Starting from the available literature on these topics, this research tries to develop several KPIs that could be practically applied by banks in order to collect information to meet disclosure requirements, and consequently, integrate regenerative agriculture into the banking system.
In addition, the empirical analysis focuses on Italian farmers and SMEs, given the fact that the majority of Italian companies fall into this category and, unlike large companies, are more likely to encounter difficulties in the transition, given the limited resources available to them.
Fil rouge throughout the research is the numerous initiatives and measures planned at the European and national level.

This thesis is structured into several chapters.
The first chapter describes the existing agricultural sector, characterized by intensive practices that contribute to climate change and biodiversity loss. These factors generate

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[22] ECB. (2024). *ESG data quality: Pillar 3 disclosures in focus*. Retrieved from https://www.bankingsupervision.europa.eu/press/supervisory-newsletters/newsletter/2024/html/ssm.nl240221_1.en.html#:~:text=Environmental%2C%20social%20and%20governance%20risk,impacting%20the%20broader%20financial%20system.

risks affecting all sectors, including the financial sector. Therefore, connected climate-related financial risks are explored.

The second chapter presents an overview of regenerative agriculture, recognizing it as a valuable Nature-based Solution. After having identified its key practices and technologies, the chapter highlights its main benefits for climate change mitigation and biodiversity conservation and protection, also presenting important economic considerations for farmers.

Moreover, the risks and opportunities that farmers and banks face in the transition from an intensive and unsustainable model to a responsible and sustainable system are discussed in the third chapter.

Finally, in the last chapter, an overview of some Key Performance Indicators and metrics currently adopted is presented. Then, some KPIs are introduced as instruments that could be used by banks and farmers to better evaluate the impacts and advantages of regenerative practices. In the end, it proposes a framework for integrating these metrics into the banking system, using them to comply with ESG disclosure requirements and to integrate them in banks' risk management.

In conclusion, this research seeks to bridge the gap between the financial needs of farmers and the ability of institutions to invest in more sustainable practices, facilitating a transition that is crucial and vital for the sustainability of planet Earth and its protection and conservation, and to which every actor involved needs to contribute. Indeed, action from all of humanity, institutions, governments, and economic and financial actors is necessary, to ensure a fair and dignified life for present and future generations, fostering a prosperous world, rich in biodiversity, and respectful of ecosystems.

CHAPTER 1: INTENSIVE AGRICULTURE AND BIODIVERSITY LOSS

1.1 The existing agricultural system

Almost half of the world's habitable land (44%) is used for agriculture[23], a central sector for human survival, providing food and sustaining the increasingly growing global population, which is expected to reach 9.7 billion by 2050[24]. Agriculture has the responsibility to feed everyone.

Therefore, in order to meet the rising food demand, pressure on food production has increased, leading to the development of a model often referred to as intensive agriculture. This model aims to provide high levels of crop production from available land, primarily through the extensive use of resources and heavy machinery and equipment, reliance on synthetic fertilizers, pesticides, and herbicides, and monoculture cropping systems[25]. The goal of using these artificial resources is to maximise short-term productivity and increase yield, producing more than the land could naturally sustain, thereby earning more profits[26].

Among its practices, industrial monoculture is the most common one, which relies on the cultivation of the same single crop on large areas, without any rotation with other crops[27]. This practice focuses on delivering high levels of efficiency and productivity[28]. Indeed,

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[23] https://ourworldindata.org/grapher/breakdown-habitable-land?time=latest

[24] United Nations. (2021). *Population Projections*. Retrieved from https://www.un.org/en/global-issues/population#:~:text=The%20world%20population%20is%20projected,and%2010.4%20billion%20by%202100.

[25] Foley, J. A., et al. (2011).

[26] Agrierp. (2023). *Intensive agriculture*. Retrieved from https://agrierp.com/blog/intensive-agriculture/

[27] Rodríguez, S. L., van Bussel, L. G., & Alkemade, R. (2024). Classification of agricultural land management systems for global modeling of biodiversity and ecosystem services. *Agriculture, Ecosystems & Environment*, *360*, 108795.

[28] McGuire, A. (2015). Ecological Theories, Meta-Analysis, and the Benefits of Monocultures. *Center for Sustaining Agriculture and Natural Resources (CSANR).* Retrieved from https://csanr.wsu.edu/theories-meta-analysis-monocultures/

growing just a single type of crop demands less effort, resources, in terms of both machinery and capital, and knowledge and capabilities[29].

As a matter of fact, modern industrial machinery, including tractors, combines and harvesters[30], allows for large-scale farming, facilitating quicker planting and harvesting cycles, thereby reducing the time and labour needed for soil preparation and irrigation[31]. In addition, this system is characterised by the use of inorganic fertilizers, to supply plants with essential nutrients for their growth, and that are cheap and simple to use[32], and chemical pesticides, used for crop protection from pests and diseases[33].

An important aspect to consider is that only half of the world's croplands are used to grow crops for human's consumption: the remaining land is dedicated to industrial products and, in particular, to feed animals[34], coinciding with the drastic increase of meat consumption, which is expected to rise by 14% until 2030[35].

Therefore, intensive animal farming is another practice strictly linked to the intensification of agricultural activities. Thanks to this model, it is possible to produce more meat, dairy, and eggs very quickly, at very low cost[36], being capable of meeting the rising demand of these products. However, in order to achieve this result, animals are forced to live in overcrowded and extremely small cages that facilitate the spread of diseases and raise ethical concerns regarding animal welfare[37].

The European Environment Agency (EEA) defines this farming system as being characterized by «*high input use that strives for maximum production, often at the*

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[29]Kogut, P. (2025). Monoculture Farming in Agriculture Industry. *EOS Data Analytics*. Retrieved from https://eos.com/blog/monoculture-farming/#ref-anchor-1

[30] Falaksher, H. *Boosting Agriculture Production through Mechanization: A game changer for farmers*. Retrieved from https://wikifarmer.com/library/en/article/boosting-agriculture-production-through-mechanization-a-game-changer-for-farmer

[31] Ibidem.

[32] Cherlinka, V. (2025). Types of fertilizers and How to pick the right one. *EOS Data Analytics*. Retrieved from https://eos.com/blog/types-of-fertilizers/

[33] https://agriculture.ec.europa.eu/cap-my-country/sustainability/environmental-sustainability/low-input-farming/pesticides_en

[34] Ritchie, H. and Roser, M. (2019). *Half of the world's habitable land is used for agriculture*. Retrieved from https://ourworldindata.org/global-land-for-agriculture#article-citation

[35] Font-i-Furnols, M. (2023). Meat Consumption, Sustainability and Alternatives: An Overview of Motives and Barriers. *Foods*, 12, 2144.

[36] FAIRR. (2019). *What is "intensive animal agriculture" or "factory" farming?* Retrieved from https://www.fairr.org/news-events/insights/intensive-animal-agriculture

[37] Mustoe, M. (2023). Intensive farming. *EBSCO*. Retrieved from https://www.ebsco.com/research-starters/agriculture-and-agribusiness/intensive-farming

expense of environmental considerations»[38]. Indeed, the environmental and social impacts of this model are often overlooked.

Fossil fuel-based machinery contributes to greenhouse gas emissions, and the intensive use of chemicals leads to soil degradation and water contamination. For those exposed to these substances, these practices also contribute to health issues, such as respiratory problems[39]. Moreover, the quality of the food produced is compromised, becoming less nutritious and less safe[40]. Indeed, intensive farming methods are frequently associated with declines in soil quality and nutrient depletion, which directly affect the nutrient content and mineral composition of food crops[41]. As a result, people are overfed but undernourished, consuming enough calories, but not receiving the necessary vitamins and essential nutrients. Over 25% of the global population is affected by malnutrition[42].

This farming system has also several impacts on climate and biodiversity, contributing to their destruction.

It is important, and needed, to recognize the crucial role biodiversity, ecosystems, and the environment have in ensuring resilience and productivity in the sector.

However, this model does not really care about the negative impacts it generates.

In the following section, negative impacts and consequences of the current adopted production model are explored, shedding light on a worrying reality.

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[38] EEA. *Intensive farming*. Retrieved from https://www.eea.europa.eu/help/glossary/eea-glossary/intensive-farming

[39] Douglas, P., Robertson, S., Gay, R., Hansell, A. L., & Gant, T. W. (2018). A systematic review of the public health risks of bioaerosols from intensive farming. *International journal of hygiene and environmental health*, *221*(2), 134-173.

[40] ISPRA. *Un nuovo target e un nuovo indicatore per i pesticidi*. Retrieved from https://www.isprambiente.gov.it/it/attivita/biodiversita/ispra-e-la-biodiversita/articoli/un-nuovo-target-e-un-nuovo-indicatore-per-i-pesticidi

[41] ABhardwaj, R. L., Parashar, A., Parewa, H. P., & Vyas, L. (2024). An alarming decline in the nutritional quality of foods: The biggest challenge for future generations' health. *Foods*, *13*(6), 877.

[42] ESA. (2023). *Measuring nutrition in crops from space*. Retrieved from https://www.esa.int/Applications/Observing_the_Earth/FutureEO/Measuring_nutrition_in_crops_from_space

1.2 Consequences of intensive agriculture

1.2.1 Economic considerations

When it comes to agriculture and its productivity, an important aspect needs to be considered.

As mentioned, intensive agriculture developed in response to the growing global demand for food. These practices have allowed farmers and companies to achieve the highest yields possible, thereby increasing productivity and profits. By focusing on maximizing outputs, intensive agriculture meets market demand while using smaller territories, allowing food to be sold at affordable prices. These lower prices are justified by the fact that intensive farming relies on synthetic inputs that are cheap, easy to implement and, crucially, fast in delivering results, while requiring less labour[43].

To maximize productivity, intensive farming uses several techniques tailored to enhance efficiency and yield. These include monocultures, genetically modified seeds designed to be resistant to pests and diseases, mechanization, and extensive use of chemical inputs.

As a result, all these practices are designed to produce significantly more output than traditional farming methods.

Therefore, farmers are able to grow larger quantities of crops in the same area, maintaining high productivity and meeting the growing food demand. This contributes to food security, ensuring that the global population has access to affordable food supplies[44].

Consequently, intensive agriculture supports the economic growth of the agricultural sector, creating job opportunities, boosting export potential, and strengthening economies that depend on agricultural trade. Moreover, by integrating modern and innovative technologies, intensive farming drives technological advancements in the sector[45].

In addition to these considerations, however, a discussion on the environmental negative impacts of these practices cannot be ignored.

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[43] Cherlinka, V. (2023). Industrial agriculture: benefits and risks mitigation. *EOS Data Analytics*. Retrieved from https://eos.com/blog/industrial-agriculture/

[44] Swasya Living. (2022). *Intensive farming: balancing productivity and sustainability*. Retrieved from https://www.swasyaliving.com/post/intensive-farming

[45] Ibidem.

1.2.2 Negative impacts of intensive agriculture on climate and biodiversity

In light of the perceived benefits just mentioned, it is crucial to recognize the significant role intensive agriculture plays in contributing to climate change.

A key issue with modern agriculture practices is the amount of greenhouse gas emissions generated by fossil fuel-based machinery and, specifically the widespread use of chemical fertilizers and pesticides. These inputs are highly effective, helping farmers save time, increase yields, and offer consumers more affordable food. However, they are responsible for polluting, dangerously, the air. In particular, while carbon dioxide (CO_2) is the most emitted GHG, it is also the least harmful compared to other gases.

The Intergovernmental Panel on Climate Change (IPCC) has relied on the Global Warming Potential (GWP)[46] for over 30 years to measure and assess the warming impacts of different gases, using CO_2 as a reference (with a GWP of 1). Methane (CH_4), for instance, has a GWP between 27 and 30. However, the most concerning gas is nitrous oxide (N_2O), which has a GWP of 273. This gas remains in the atmosphere for over 100 years[47], making its long-term impact particularly severe. One of the major contributors to N_2O emissions is the use of nitrogen fertilizers, which are widely employed in agriculture to boost plant growth and productivity. They are responsible for about 70%[48] of global N_2O emissions, and in Europe alone, approximately 11 million tonnes of nitrogen fertilizers are applied to agricultural fields annually[49].

Moreover, pesticides, which are synthetic chemicals derived from fossil fuels, represent another source of GHG emissions. Although they are used to maintain crop yields, they also contribute to environmental pollution by contaminating water, soil, and air, and driving biodiversity loss[50].

In Europe, the largest agricultural producers are Germany, France, Spain and Italy.

In response to these environmental challenges, the European Commission presented the Sustainable Use of plant protection products Regulation (SUR) in June 2022, according

[46] EPA. (2025). *Understanding Global Warming Potentials*. Retrieved from https://www.epa.gov/ghgemissions/understanding-global-warming-potentials

[47] Ibidem.

[48] Tian, H., Pan, N., Thompson, R. L., Canadell, J. G., Suntharalingam, P., Regnier, P., ... & Zhu, Q. (2024). Global nitrous oxide budget (1980–2020). *Earth System Science Data, 16(6)*, 2543-2604.

[49] Royal Society for the Protection of Birds (RSPB). *Fertilisers and farming*. Retrieved from https://www.rspb.org.uk/helping-nature/what-we-do/influence-government-and-business/farming/fertilisers-and-farming

[50] European Environment Agency (EEA). (2023). *How pesticides impact human health and ecosystems in Europe*. Retrieved from https://www.eea.europa.eu/publications/how-pesticides-impact-human-health/

to which, each Member State should have achieved by 2030 a 50% reduction of the use of chemical pesticides[51]. However, this regulation was withdrawn in February 2024 due to significant pressure from the pesticide lobby[52].

Another crucial role in ensuring resilience and productivity in the agricultural sector is played by biodiversity and ecosystems. In addition to climate change, intensive farming contributes also to biodiversity loss, leading to soil depletion, reduction of pollinators, and extinction of several animal and plant species. The main drivers are the use of chemical inputs and standardized monocultures. In the case of monocultures, a single crop variety, usually corn, soy, rice or cotton, is chosen and typically replanted in the same area every year. This practice has significant consequences for the diversity of ecosystems, exacerbating soil erosion and nutrient depletion, and increasing crop vulnerability to diseases, which in turn increases the need for more pesticides. This situation leads to the destruction of natural habitats, creating hostile ecosystems for pollinators, which are essential for plant reproduction. The disappearance of insects, such as butterflies and bees, represents a serious concern, especially considering that a significant portion of crops relies on pollination, posing a direct threat also to food supply[53].

In addition, industrial farming has negative consequences on soil biodiversity and its organisms. Soil-dwelling insects, such as ants and termites, are responsible for pest suppression, nutrient redistribution, and organic matter decomposition, playing therefore an essential role in ensuring soil fertility[54].

All these organisms, therefore, are of primary importance for the long-term health of agricultural systems[55].

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[51] European Commission. (2022). *Proposal for a Regulation of the European Parliament and of the Council on the sustainable use of plant protection products and amending Regulation (EU) 2021/2215*. Retrieved from https://eur-lex.europa.eu/resource.html?uri=cellar:78120cfb-f5e4-11ec-b976-01aa75ed71a1.0001.02/DOC_1&format=PDF

[52] Revolve. (2024). *Sustainable Use of Pesticides Regulation Proposal Withdrawn*. Retrieved from https://revolve.media/insights/pesticides-regulation-withdrawn#:~:text=The%20withdrawal%20of%20the%20proposal,increasing%20polarization%20around%20the%20issue.

[53] Watson, M. (2024). Bees and other pollinators. *EBSCO*. Retrieved from https://www.ebsco.com/research-starters/zoology/bees-and-other-pollinators

[54] Narwade, D. K., Tupe, A. P., & More, P. R. (2024). Soil-Dwelling Beneficial Insects and Their Role in Soil Health.

[55] Ibidem.

It is evident how these practices are exacerbating climate change and contributing to the degradation of ecosystems and biodiversity, that have the fundamental and vital role of sustaining life and providing essential services to ensure humans' survival.
In the next paragraph, the importance of biodiversity is further explored, highlighting the contribution of the agricultural sector to its deterioration.

1.3 The alarming loss of biodiversity

Biodiversity was first defined in Article 2 of the Convention on Biological Diversity, one of the major outcomes of the United Nations Conference on Environment and Development, also known as the "*Earth Summit*", held in Rio de Janeiro, Brazil, in 1992. It is described as «*the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems*»[56].
Biodiversity has the fundamental role of sustaining life by providing essential services, including clean air, safe water, fertile soils, nutritious food, and a stable climate. It enables ecosystems, animal and plant species, and humans to adapt to changes and overcome challenges, ensuring therefore their survival.
Among its functions, one of the most critical is related to the carbon cycle, that is the process thanks to which CO_2 is exchanged among the different spheres of the Earth. Oceans, soil, and forests are among the main carbon sinks, capable of absorbing some of the CO_2 that is released into the atmosphere, thus contributing to reducing the impact of climate change[57].

[56] Convention on Biological Diversity (CBD). (1992). *Convention on Biological Diversity*. Retrieved from https://www.cbd.int/doc/legal/cbd-en.pdf
[57] Prajapati, S., Choudhary, S., Kumar, V., Dayal, P., Srivastava, R., Gairola, A., & Borate, R. (2023). Carbon sequestration: A key strategy for climate change mitigation towards a sustainable future. *Emrg. Trnd. Clim. Chng*, *2*(2), 1-14.

Biodiversity is also strictly connected to agriculture: pollination, maintenance of soil fertility, clean water, and pest and disease control are essential services for the activities of this sector.

Lastly, a significant quantity of modern medicines is derived from plants, further emphasizing its importance[58].

Therefore, it is evident that biodiversity is an irreplaceable resource.

However, despite its immense value, it is under severe threat due to human activities. If urgent action is not taken, there is the risk to irreversibly damage ecosystems and lose the diversity of all animal and plant species, jeopardizing the essential services provided by nature[59].

The loss and destruction of biodiversity that has been occurring over the last few decades are clearly visible – animal extinction, climate change, deforestation, and pollution are just some examples[60].

As already mentioned, the main cause is to be found in human activities, related in particular to the burning of fossil fuels, that pollute the air and release harmful gases into the atmosphere, contributing to climate change and global warming[61]. Rising temperatures and extreme weather events, like fires and droughts, are some of the most evident consequences, but also other warning signs need to be looked at, for example ocean acidification. Indeed, when it comes to biodiversity loss, it is also important to consider the marine ecosystem, as there is the tendency to focus solely on the land surface, easily visible and not hidden. Oceans, which have traditionally functioned as carbon sinks, are now not capable to absorb enough CO_2, endangering the entire ecosystem and marine species[62]. According to the International Union for Conservation of Nature

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[58] The Royal Society. (2021). *Why is biodiversity important?* Retrieved from https://royalsociety.org/news-resources/projects/biodiversity/why-is-biodiversity-important/#:~:text=Biodiversity%20is%20essential%20for%20the,also%20value%20nature%20of%20itself.

[59] Secretariat of the Convention on Biological Diversity. (2020). *Global Biodiversity Outlook 5*. Montreal. Pag. 156

[60] European Parliament. (2025). *Biodiversity loss: what is causing it and why is it a concern?* Retrieved from https://www.europarl.europa.eu/topics/en/article/20200109STO69929/biodiversity-loss-what-is-causing-it-and-why-is-it-a-concern

[61] United Nations. *What is climate change?* Retrieved from https://www.un.org/en/climatechange/what-is-climate-change

[62] Keong, C. Y. (2019). The Ocean Carbon Sink and Climate Change: A Scientific and Ethical Assessment. *International Journal of Environmental Science and Development*, *10*(8), 246-251.

(IUCN) Red List of Threatened Species, «*37% of sharks and rays and 33% of reef corals are facing extinction*»[63].

A major contributor to this crisis is, as a matter of fact, the agricultural sector.

To meet the rising food demand, intensive farming has expanded, causing deforestation, soil erosion, excessive use of chemical fertilizers and pesticides, and exploitation of natural resources.

According to the Food and Agriculture Organization (FAO), 31% of human-caused emissions originate from this sector, with deforestation being the largest source[64].

Since 1990, 420 million hectares of forest have been lost due to land conversion for other uses; the most shocking aspect is that almost 90% of this global deforestation is driven by agricultural expansion[65]. Nevertheless, it is worth mentioning that during 2015-2020, the rate of deforestation was estimated at only 10 million hectares per year[66].

A direct consequence is soil erosion: indeed, without plant cover, land loses its fertile soil, resulting in degradation or desertification. To cope with this situation, producers and farmers clear more forests, thus continuing a vicious cycle that will lead to the entire degradation of soil and land destruction[67].

Moreover, the diversity and richness of pollinators, including butterflies and bees, have drastically decreased, and many species are at risk of extinction. According to FAO, 75% of «*the world's most productive crop plants depend, at least in part, on pollinators*»[68]: without them, global food security is in danger.

These are just some examples of how the agricultural sector and its intensive practices negatively impact biodiversity, indicating the consequent importance of finding solutions as soon as possible, in order to protect human livelihoods, food security, all animal and plant species, and the economy.

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[63] International Union for Conservation of Nature (IUCN). *Marine Species*. Retrieved from https://iucn.org/our-work/topic/marine-species

[64] United Nations. (2021). *New FAO analysis reveals carbon footprint of agri-food supply chain*. Retrieved from https://news.un.org/en/story/2021/11/1105172

[65] Food and Agriculture Organization (FAO). (2021). *COP26: Agricultural expansion drives almost 90 percent of global deforestation*. Retrieved from https://www.fao.org/newsroom/detail/cop26-agricultural-expansion-drives-almost-90-percent-of-global-deforestation/en

[66] FAO. (2020). *The State of the World's Forests 2020*. Pag. 13. Retrieved from https://openknowledge.fao.org/items/d0f20c1c-7760-4d94-86c3-d1e770a17db0

[67] WWF. (2021). *Soil Erosion and Degradation*. Retrieved from https://www.worldwildlife.org/threats/soil-erosion-and-degradation

[68] FAO. *Global action on Pollination Services for Sustainable Agriculture*. Retrieved from https://www.fao.org/pollination/en/

Indeed, it is fundamental to recognize that our society and the global economy are strictly linked to the health of our environment, and how climate change and biodiversity loss are capable to shape every sector, as if everything was interconnected[69].

For this reason, the next paragraph addresses how ecosystems and the climate are sources of risks for the financial sector, potentially impacting its stability and its functioning.

1.4 Climate-related financial risks

In order to achieve the objective, set out in the European Green Deal, of making Europe the first climate-neutral continent by 2050[70], the financial sector is expected to play a key role[71].

It is fundamental to recognize the existing relationship between climate, biodiversity, and the economy, investigating how climate change and biodiversity loss affect the financial sector, generating significant risks.

In relation to climate-related financial risks, banks are subject to two types of risks:

- Physical risks, coming from the physical effects and consequences of climate change, including extreme weather events, such as floods, droughts, fires, and storms, and long-term changes in the climate, like temperature rise and changes in soil and land productivity[72].
- Transitions risks, arising from «*the transition to a low-carbon and climate-resilient economy*»[73], triggered for example by new environmental policies or technological advancements[74].[75]

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[69] Joint Research Centre. (2023).

[70] European Commission. (2019). *A European Green Deal – Striving to be the first climate-neutral continent*. Retrieved from https://ec.europa.eu/newsroom/know4pol/items/664852

[71] ECB. (2020). *Guide on climate-related and environmental risks*. Retrieved from https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.202011finalguideonclimate-relatedandenvironmentalrisks~58213f6564.en.pdf

[72] EFRAG. (2022). *Draft ESRS E1 – Climate change*. Appendix A: Defined terms; Pag. 16. Retrieved from https://www.efrag.org/sites/default/files/sites/webpublishing/SiteAssets/08%20Draft%20ESRS%20E1%20Climate%20Change%20November%202022.pdf

[73] Ibidem. Pag. 16

[74] ECB. (2020).

[75] See Chapter 3 – *Risks and opportunities in transitioning from intensive to regenerative agriculture*.

In particular, they impact economic activities, having consequences also on the financial system[76].

To address them, banks need to simultaneously achieve two intertwined objectives: on the one hand, they have to understand how climate change is able to impact their strategy, business model, and operations; on the other hand, they have to support their clients in transitioning to achieve Net Zero and align to sustainability commitments and goals[77].

In order to do so, the most important aspect is that banks need to consider how their financing operations will have to evolve to ensure a just transition, by focusing in particular on hard-to-abate sectors or clients that are particularly vulnerable to environmental risks[78].

As a matter of fact, biodiversity-related financial risks also need to be taken into account, arising from the dependency of certain sectors, such as agriculture, on biological resources and ecosystems services. Indeed, firms might face significant risks due to biodiversity loss, the degradation of ecosystems, and reduced availability of natural resources, affecting financial institutions' exposure[79]. Ecosystem and nature degradation will significantly affect financial stability[80]: Frank Elderson, vice-chair of the European Central Bank (ECB), stated that «*the grater the impact on firms, the higher the risk of defaults and the higher the risk on banks' balance sheets*»[81], highlighting the need for financial institutions to increasingly focus on the risks posed by nature degradation and ecosystem loss. For these reasons, banks are expected to meet certain ESG disclosure requirements set out in the Capital Requirements Regulation and the Capital Requirements Directive IV. In particular, the European Banking Authority has the responsibility to outline the guidelines necessary to ensure compliance with these requirements[82].

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[76] ECB. (2020).

[77] Sutcliffe, B. (20221). *Climate change and risk: 3 key challenges facing banks*. Retrieved from https://www.ey.com/en_gl/banking-capital-markets-risk-regulatory-transformation/climate-change-and-risk-three-key-challenges-facing-banks

[78] Ibidem.

[79] NGFS. (2019). *A call for action – Climate change as a source of financial risk*. Retrieved from https://www.ngfs.net/system/files/import/ngfs/medias/documents/ngfs_first_comprehensive_report_-_17042019_0.pdf

[80] Redgrave, G. (2025). ECB to "stress test" banks on nature-related risk. *Environmental Finance*.

[81] ECB. (2025). *Nature's bell tolls for thee, economy!* Retrieved from https://www.ecb.europa.eu/press/key/date/2025/html/ecb.sp250522~b371549cb6.en.html

[82] See section 4.3.1 – *Regulatory context*.

Since the agricultural sector is likely to be impacted by both types of risks, banks need to address them consequently. Given the intrinsic nature of its activities, climate change and extreme weather events pose significant challenges, affecting natural resources and the environment, which are fundamental to the sector. Additionally, since the sector is not sufficiently energy efficient and is associated with exploitation, extraction and use of fossil fuels, it is also impacted by the transition to a low-carbon economy, with the potential of assets to become stranded[83].

Furthermore, according to the Network for Greening the Financial System (NGFS), financial institutions have to be aware of the interconnection between climate-related and environmental risks, as they can reinforce each other, potentially generating greater impacts[84].

In light of this, it is necessary for every sector, including the agricultural one, to transition to more a sustainable model, with the support of financial institutions, that in turn can reduce the exposure of their investments and portfolios to climate- and biodiversity-related risks[85].

Adaptation and mitigation strategies have to be implemented, aiming to adjust to actual or expected climate and its effects (climate adaptation), while simultaneously reduce emissions or enhance the sinks of greenhouse gases (climate mitigation)[86].

Considering what has been discussed so far, the need for a transition toward a sustainable agricultural model is recognized. The next chapter, after presenting the current legislative framework, that is becoming increasingly focused on sustainability and delivering

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[83] ECB. (2020).

[84] NGFS. (2025). *Guide for Supervisors – Integrating climate-related and environmental risks into prudential supervision*. Retrieved from https://www.ngfs.net/en/publications-and-statistics/publications/guide-supervisors-integrating-climate-related-and-environmental-risks-prudential-supervision

[85] Becker A., Di Girolamo F. E., Rho C. (2023). Loan pricing and biodiversity exposure: Nature-related spillovers to the financial sector. *JRC Working Papers in Economics and Finance, 2023/11, European Commission, Ispra, Italy, JRC135774*.

[86] IPCC. (2018). Annex I: Glossary. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. *Cambridge University Press, Cambridge, UK and New York, NY, USA*, pp. 541-562. Retrieved from https://www.ipcc.ch/site/assets/uploads/sites/2/2022/06/SR15_AnnexI.pdf

positive impacts on the environment, outlines the role of Nature-based Solutions, identifying them as promising answers to the degrading current agricultural system. Among these, regenerative agriculture stands out as a key solution.

CHAPTER 2: REGENERATIVE AGRICULTURE AS A POSSIBLE SOLUTION

2.1 Regulatory landscape and policies

The awareness about the vital role of biodiversity and ecosystems is fortunately growing, and governments and institutions worldwide are implementing major initiatives to protect and restore ecosystems.

At a global level, the United Nations 17 Sustainable Development Goals – SDGs – for 2030 represent an urgent call to action for all countries. Among them, at least four are directly linked to biodiversity and sustainability in the agricultural sector: goals 6 (Clean Water and Sanitation), 12 (Responsible Consumption and Production), 13 (Climate Action), and 15 (Life on Land). Additionally, goal 2 (Zero Hunger) is deeply connected to sustainable food production and food security.

Figure 1: The SDGs. Source: The 2030 Agenda for Sustainable Development (UN), 2015

Even more recent are the decisions made during the COP16 Global Biodiversity Conference[87], held in Rome last February. All parties adopted a strategy that comprises several mechanisms and instruments in order to facilitate the mobilisation of the necessary funds for the implementation of the Global Biodiversity Framework (GBF), the ambitious roadmap aimed at halting and reversing nature loss.

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87 European Commission. (2025). *EU welcomes positive outcome of COP16 biodiversity negotiations in Rome*. Retrieved from https://environment.ec.europa.eu/news/eu-welcomes-positive-cop16-biodiversity-negotiations-outcome-2025-02-28_en

At a European level, the Green Deal includes two key strategies that aim to transform the agri-food sector.

The first one is the Farm to Fork Strategy[88], aiming to develop fair, safe, resilient, and environmentally-friendly food systems. In order to achieve and accelerate this transition, food systems should rely on research and new technologies, and they should concentrate on increasing public awareness and demand for sustainable food, fostering competitiveness and having a positive environmental impact.

The main objective is to ensure that food is produced in a sustainable and responsible way, meaning that farmers, fishers, and all producers in general need to transform their production methods and use nature-based and technological solutions. As a consequence, food security and safety are guaranteed, and people will benefit from the opportunity to access a wide range of nutritious, healthy, affordable and safe food. As already mentioned, technologies, research and innovation are key drivers, but investments are necessary to accelerate the transition.

The other important strategy linked to the topic is the EU Biodiversity Strategy for 2030[89], a long-term plan focused on protecting nature and restoring ecosystems, ensuring environmental resilience and benefitting society, the environment, the climate and the economy.

The strategy is based on four key pillars: protect nature, by expanding protected areas to 30% of the EU's land and sea; restore nature, through responsible and sustainable practices; enable transformative changes, thanks to improved and strengthened governance, research and investments; support biodiversity globally, by enhancing global biodiversity efforts and reducing environmental harm[90].

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[88] European Union. (2021). *Farm to Fork Strategy: For a fair, healthy and environmentally-friendly food system*. Retrieved from https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en
[89] European Commission. (2020). *Eu biodiversity Strategy for 2030: Bringing nature back into our lives.* Retrieved from https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en
[90] Ibidem. Pag. 8.

Moreover, the strategy makes explicit reference to blended finance, that requires collaboration between public and private entities, in order to unlock more potential for financing biodiversity.

A key component of the strategy is the EU Soil Strategy for 2030[91], which is the result of growing awareness of the importance of soil health. This aspect plays a central and essential role in achieving all the objectives set out in the two aforementioned strategies. Thanks to this framework, soils will be healthy, strong, and restored, capable of providing all necessary services and of coping with degradation and desertification.

Finally, another ambitious and bold progress is the Nature Restoration Law[92], entered into force in August 2024, integrating mandatory restoration targets to restore degraded ecosystems across Europe, making them resilient.

Specifically for the European agricultural sector, the main point of reference is the Common Agricultural Policy (CAP). It was first launched in 1962, and according to article 39 of the Treaty on the Functioning of the European Union (TFEU), it has five main objectives: «*to increase agricultural productivity; to ensure a fair standard of living for the agricultural community; to stabilise markets; to assure the availability of supplies; to ensure that supplies reach consumers at reasonable prices*»[93]. The CAP has undergone several evolutionary reforms in order to address emerging environmental and climate challenges.

It is with the reform of 2013 that environmental protection, innovation, and climate change are more enhanced and considered the core of the policy. Specifically, it addressed four main areas: rural development; CAP financing and monitoring; direct payments; market cooperation[94].

In response to the resilience test posed by the COVID-19 pandemic, the ongoing environmental degradation, and the increasing socio-economic inequalities between

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[91] European Commission. (2021). *The EU Soil Strategy for 2030: Reaping the benefits of healthy soils for people, food, nature, and climate*. Retrieved from https://environment.ec.europa.eu/topics/soil-and-land/soil-strategy_en

[92] European Commission. (2024). *Nature Restoration Law*. Retrieved from https://environment.ec.europa.eu/topics/nature-and-biodiversity/nature-restoration-law_en

[93] European Commission. (2012). *Consolidated Version of the Treaty on the Functioning of the European Union*, article 39

[94] Wrzaszcz, W., & Prandecki, K. (2020). Agriculture and the european green deal. *Problems of Agricultural Economics/Zagadnienia Ekonomiki Rolnej*, 156-179.

different areas, the need for another reform arises, leading to the development of the 2021-2027 CAP. This reform is designed to deliver progress on environmental, economic, and social sustainability goals simultaneously, representing an essential tool for contributing to achieving the ambitions of the European Green Deal, and aligned with EU's Farm to Fork and Biodiversity strategies[95].

Member States have the flexibility to develop their strategic plans, tailored on the particular and specific circumstances and characteristics of their respective territories.

The CAP now articulates its ambition through ten strategic objectives grouped across three sustainability pillars – environmental, social, economic.

Figure 2: The 10 CAP Objectives. Source: CAP 2023-2027

The CAP 2023-2027 is backed by €386,6 billion, divided between two main pillars:

- Pillar I – Direct payments and Market interventions; these two measures are financed through the European agricultural guarantee fund (EAGF), with an allocation of €291,1 billion.

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[95] European Commission. *A greener and fairer CAP.* Retrieved from https://commission.europa.eu/document/download/65086a2c-7011-4a65-a344-d589f83537b1_en?filename=factsheet-newcap-environment-fairness_en.pdf

- Pillar II – Rural development, financed by the European agricultural fund for rural development (EAFRD), with a budget of €95,5 billion.

Based on the farm's size in hectares, all farmers receive direct payments as a form of income support.

The EAGF also provides funding for interventions and measures aiming to stabilise agricultural markets and support specific sectors, such as wheat, rice, and olive oil, in adapting to market changes and fluctuations.

The EAFRD finances the CAP's contribution to sustainable development of rural areas through three long-term goals: ensuring the sustainable management of natural resources and climate action; promoting the competitiveness of agriculture and forestry; achieving a balanced territorial development of rural economies and communities. These objectives are accomplished through rural development programmes (RDPs), which are partially funded by national budgets[96].

Under this new CAP reform, farmers receive payments based on their performance, which is assessed using metrics and indicators established in strategic plans set by each EU member states (enhanced conditionality requirements). Connected to direct payments are eco-schemes, a mechanism included in Pillar I that supports farmers who adopt farming practices contributing to EU environmental and climate goals. Through eco-schemes, the EU incentivises farmers to preserve natural resources and implement techniques that contribute to the transition to a sustainable food system. 25% of the financial resources allocated for direct payments are directed towards eco-schemes.

There are five types of eco-schemes:

- EC01: enhancing animal welfare by reducing antibiotic use and allowing for the introduction of grazing or semi-wild farming systems;
- EC02: grassing and the associated management of permanent tree crops, with related soil management commitments, and limitation of the use of herbicides and pesticides;
- EC03: olive trees protection;

[96] European Commission. *Common Agricultural Policy Funds*. Retrieved from https://agriculture.ec.europa.eu/common-agricultural-policy/financing-cap/cap-funds_en

- EC04: rotation of extensive forage systems with commitments relating to the cultivation of grain legumes or forage and the avoidance of chemical herbicides and plant protection products;
- EC05: pollinator protection and the commitment not to use herbicides and pesticides[97].

A relevant framework for the financial sector is the EU Taxonomy, having as objective the identification of economic activities that can be considered environmentally sustainable, contributing to one of the six climate and environmental objectives[98]:

1. Climate change mitigation
2. Climate change adaptation
3. The sustainable use and protection of water and marine resources
4. The transition to a circular economy
5. Pollution prevention and control
6. The protection and restoration of biodiversity and ecosystems

This way, investments are directed to those activities that are more relevant and needed for the transition, scaling up sustainable investments[99].

The Taxonomy Regulation[100], entered into force in 2020, set the four conditions to be met by the economic activity to be qualified as environmentally sustainable. In particular, any activity has to adhere to four criteria:

1. It has to contribute substantially to at least one of the six objectives mentioned above;
2. It cannot significantly harm any of the other environmental objectives;
3. It has to respect minimum safeguards related to social key performance indicators;

[97] Kappler, L. (2024). Common Agricultural Policy & Strategic Plans 2023–2027: Financing sustainable and innovative investments for agriculture [Lecture slides]. *LUISS University, Course in Law, Digital Innovation and Sustainability.* Slide 20.

[98] Official Journal of the European Union. (2020). *Regulation (EU) 2020/852 or the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088.* Article 9. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020R0852

[99] European Commission. *EU taxonomy for sustainable activities*. Retrieved from https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en#legislation

[100] Official Journal of the European Union. (2020).

4. It has to comply with the Technical Screening Criteria (TSC) set out in the Delegated Acts[101].

All policies and frameworks just outlined highlight the importance of biodiversity and the environment, demonstrating how institutions are taking actions to protect them. In order to deliver significant positive impacts and achieve these commitments, multi-faceted solutions are needed, aiming at transforming the agricultural sector. Therefore, «*Nature-based Solutions can play a key role in a sustainable future of food*»[102].

2.2 The role of Nature-Based Solutions

As it is possible to note, restoration and recovery of biodiversity are at the core of all policies and strategies presented. It is therefore essential to adopt Nature-based Solutions (NbS) to ensure that these ambitious objectives are achieved through a sustainable, holistic, and effective approach and in a way that respects both the environment and local communities.

The IUCN and the European Commission developed their own definitions of the term, presented in the following table:

IUCN DEFINITION	**EUROPEAN COMMISSION DEFINITION**
Actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively,	*Living solutions inspired by, continuously supported by and using nature, which are designed to address various societal challenges in a resource-efficient and adaptable manner and to provide*

[101] Ibidem. Article 3.
[102] Iseman, T. and Miralles-Wilhelm, F. (2021). Nature-based solutions in agriculture – The case and pathway for adoption. *Virginia. FAO and The Nature Conservancy.* Pag. 7 Retrieved from https://openknowledge.fao.org/server/api/core/bitstreams/9c6d587e-1532-4252-852f-d2657634a66a/content

simultaneously providing human wellbeing and biodiversity benefits[103].	*simultaneously economic, social, and environmental benefits*[104].

Both share the same goal of addressing societal challenges through the use of ecosystem services, but while the first definition highlights the need for a restored and well-managed ecosystem, the second one is broader, placing emphasis on applying solutions inspired and supported by nature[105].

Thanks to these practices, exposure to climate risks is reduced, and they also contribute to climate change mitigation. Specifically, because NbS enhance the capacity of land and oceans to absorb CO_2 and other gases, thanks to better conservation and sustainable management of forests, wetlands, and oceans, GHG emissions decrease in certain sectors – including agriculture, forestry and other land-use activities[106].

Another important element distinguishing NbS is their ability to provide benefits to biodiversity, through enhancement of ecosystem functions, resilience, and health[107].

In addition, thanks to the integration with technological and engineering solutions, they address societal challenges in a fair and inclusive way, fostering transparency and broad stakeholder participation[108].

Therefore, NbS contribute simultaneously to the achievement of three objectives: improved farmers' livelihoods, climate change adaptation and mitigation, and enhanced resilience of biodiversity and agricultural sector[109].

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[103] Seddon, N., Smith, A., Smith, P., Key, I., Chausson, A., Girardin, C., ... & Turner, B. (2021). Getting the message right on nature-based solutions to climate change. *Global change biology, 27*(8), 1518-1546. Pag. 1520, table 1

[104] Maes, J. and Jacobs, S. (2015). Nature-Based Solutions for Europe's Sustainable Development. *Conservation Letters January/February 2017, 10(1), 121–124*. Pag. 121. Retrieved from https://conbio.onlinelibrary.wiley.com/doi/epdf/10.1111/conl.12216

[105] Cohen-Shacham, E., Walters, G., Janzen, C. and Maginnis, S. (eds.) (2016). Nature-based Solutions to address global societal challenges. *Gland, Switzerland: IUCN. xiii + 97pp*. Retrieved from https://portals.iucn.org/library/sites/library/files/documents/2016-036.pdf

[105] FAO. (2022).

[106] Ibidem.

[107] Reise, J., Siemons, A., Böttcher, H., Herold, A., Urrutia, C., Schneider, L., ... & Davis, M. (2022). Nature-based solutions and global climate protection. Assessment of their global mitigation potential and recommendations for international climate policy. *German Environment Agency*. Retrieved from https://www.ecologic.eu/sites/default/files/publication/2022/50061-Nature-Based-Solutions-and-Global-Climate-Protection.pdf

[108] Cohen-Shacham, E., et al. (2019). Core principles for successfully implementing and upscaling Nature-based solutions. *Environmental Science & Policy, 98*, 20-29. Pag. 23

[109] https://www.fao.org/land-water/overview/integrated-landscape-management/nature-based-solutions/es/

However, it is fundamental not to forget that the first and most crucial step toward ensuring a "*just transition*" to a low-carbon economy is to phase-out from fossil fuels. Indeed, Nature-based Solutions alone cannot fully address the loss of biodiversity that is occurring. They are just one of many available strategies that should be integrated and complemented with other instruments and approaches, using them in conjunction with other types of interventions[110].

In order to drive a systemic change and a successful transition to Agriculture Nature-based Solutions (Ag-NbS) it is necessary to involve all key stakeholder – including institutions, banks, private firms, NGOs, governments, and local communities – promoting a coordinated, inclusive and comprehensive action[111]. NbS play a significant and fundamental role as «*no long-term solution to climate change can be successful without fully drawing on them*»[112]

Nevertheless, one of the most promising Nature-based Solutions in the agri-food sector is regenerative agriculture.

2.3 What is Regenerative Agriculture?

Given the current situation, immediate action is needed to restore ecosystems, protect the diversity of all animal and plant species, and make every element recovered and resilient. In order to restore ecosystems, protect the diversity of all animal and plants species, and make every element recovered and resilient, regenerative agriculture emerges as a promising solution. FAO describes it as a set of farming practices whose major benefits are to «*improve water and air quality, enhance ecosystem biodiversity, produce nutrient-dense food, and store carbon to help mitigate the effects of climate change*»[113], working in respect of nature while enhancing economic sustainability. According to the Italian

[110] Iseman, T. and Miralles-Wilhelm, F. (2021). Nature-based solutions in agriculture – The case and pathway for adoption.
[111] The Nature Conservancy. (2021). Three things to know about nature-based solutions for agriculture. Retrieved from https://www.nature.org/en-us/what-we-do/our-insights/perspectives/three-things-nature-based-solutions-agriculture/
[112] Cohen-Shacham, E., Walters, G., Janzen, C. and Maginnis, S. (eds.) (2016). Pag. 15.
[113] FAO. (2022).

Consiglio per la Ricerca in Agricoltura e l'Economia Agraria (CREA), it is an agricultural model that combines the holistic approach of organic farming, without restrictions on the use of technological innovations, incorporating the objectives of carbon farming and adopting a vision that is more market- and consumer-oriented[114].

From the very first approach to the topic, an initial challenge emerges. While various organizations have attempted to define regenerative agriculture, sometimes their interpretations tend to be generic, highlighting the absence of a single, clear, and widely recognized definition. Indeed, academics and researchers primarily focus on two different aspects: on the one hand, the outcomes and results to be achieved; on the other hand, the processes and methodologies put in place.

Some scholars have adopted an outcome-based approach, where the emphasis is on the final objectives to be reached and to be delivered to nature, without reference to the procedures used. Grant (2017)[115] stressed the importance of achieving key environmental results, such as soil restoration and water quality, ecosystems health, biodiversity conservation, and the production of highly nutritious food. Similarly, Elevitch et al. (2018)[116] highlighted the enhancement of soil health, water quality, biodiversity protection, and carbon sequestration as the primary goals of regenerative agriculture. In both cases, the desired and expected results are central to the definition.

To the contrary, there are definitions that concentrate more on the practices and methodologies employed. Francis (1985)[117] defined regenerative agriculture through a set of techniques, including integration of crops and livestock, crop rotation, agroforestry, and removal of chemical inputs, all aimed at improving soil fertility. Sherwood and Uphoff (2000)[118] included also soil cover and limited tillage as promising tools. In both cases, the emphasis is placed on the mechanisms, techniques, and methodologies to be adopted for an agricultural system to be considered regenerative.

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114 Viggiani, G. (2024). Giornata del Mais CREA 2024: Focus sul ruolo chiave dell'agricoltura rigenerativa per rilanciare un comparto in grande sofferenza. *CREA.*

115 Grant, S. (2017). Organizing alternative food futures in the peripheries of the industrial food system. *The Journal of Sustainability Education*. https://www.susted.com/wordpress/content/organizing-alternative-food-futures-in-the-peripheries-of-the-industrial-food-system_2017_05/

116 Elevitch, C. R., Mazaroli, D. N., & Ragone, D. (2018). Agroforestry standards for regenerative agriculture. *Sustainability*, *10*(9), 3337. Pag. 2

117 Francis, C. A. (1985). Rationality of new technology for small farmers in the tropics. *Agriculture and Human values, 2*(2), 54-59.

118 Sherwood, S., & Uphoff, N. (2000). Soil health: research, practice and policy for a more regenerative agriculture. *Applied Soil Ecology, 15*(1), 85-97.

This ambiguity in defining regenerative agriculture produces several challenges. Firstly, it becomes difficult for researchers to verify and measure the actual benefits of the practices adopted, given the absence of clear and accepted criteria. Secondly, consumers risk being misled or confused about the truthfulness of a claim associated with a product presented as deriving from regenerative practices, leading to distrust and dissatisfaction. Finally, another critical concern regards producers who could exploit the term "*regenerative*" unfairly, through non-transparent marketing strategies, generating greenwashing-related issues and undermining the credibility of the entire sector[119].
In light of this, definitions trying to integrate both approaches are emerging, combining both outcomes and processes. For instance, LaCanne and Lundgren (2018) define regenerative agriculture as a set of practices that «*increase soil quality and biodiversity [...] while producing nourishing farm products*»[120], by using techniques such as «*abandoning tillage […] and integrating livestock and cropping operations on the land*»[121]. These attempts represent a step forward toward greater clarity and consistency in defining this practice, with the goals of ensuring its more transparent and effective application.

Despite this challenge, regenerative agriculture is regarded as a promising and ambitious sustainable farming approach, integrating multiple methodologies, innovative technologies, and traditional knowledge to promote soil health, biodiversity, and ecosystem resilience.
The following criteria are widely recognized as its fundamental principles[122]:

- Minimizing soil disturbance (low- or no-tillage)
- Maximizing crop diversity to enhance resilience against diseases and pests
- Keeping the soil covered all year round to prevent erosion
- Maintaining living roots throughout the year, in order to improve soil fertility

[119] Newton, P., Civita, N., Frankel-Goldwater, L., Bartel, K., & Johns, C. (2020). What is regenerative agriculture? A review of scholar and practitioner definitions based on processes and outcomes. *Frontiers in Sustainable Food Systems, 4*, 577723.
[120] LaCanne, C. E., & Lundgren, J. G. (2018). Regenerative agriculture: merging farming and natural resource conservation profitably. *PeerJ, 6,* e4428. Pag. 4
[121] Ibidem. Pag. 4
[122] Jaworski, C. C., Krzywoszynska, A., Leake, J. R., & Dicks, L. V. (2024). Sustainable soil management in the United Kingdom: A survey of current practices and how they relate to the principles of regenerative agriculture. *Soil Use and Management, 40*(1), e12908.

- Integrating livestock, in particular to increase soil organic matter

Consequently, regenerative agriculture should be seen as a holistic approach that combines traditional practices with technological innovations, ensuring a sustainable and responsible implementation to enhance the quality and protection of the environment and the support of local communities.

The next section will briefly explore specific practices and technologies that characterize this agricultural model.

2.4 Main practices and technological innovations

2.4.1 Core practices in regenerative agriculture

As previously mentioned, regenerative agriculture is based on several farming methodologies that were commonly used in the past.
They are summarized in the following table:

PRACTICE	DESCRIPTION
Minimum- or No-tillage	Reduced or no soil tillage to minimize soil disturbance and maintain its structure.
Cover crops	Plants that are planted simultaneously or sequentially with a productive crop for agronomic or environmental purposes.
Crop rotation	Rotating different crops on the same area to improve fertility and enhance biodiversity.
Integration of livestock	Integrating animals and livestock into farming systems.

Reduce chemicals use	Reduction of chemical fertilizers and pesticides, in favour of natural solutions, such as compost and manure.
Agroforestry	Simultaneous integration of trees and shrubs into farming systems.

The most widely adopted and relevant practices are explored in more detail below.
One of the core principles of regenerative agriculture is minimum or no tillage, a technique aiming to minimize soil disturbance. This practice helps prevent soil compaction, allowing for better aeration and improved movement and exchange of nutrients, water, and oxygen. Some experts also believe that carbon sequestration can be increased, thereby contributing to climate change mitigation. As a result, soil becomes healthier, more fertile, and resilient, capable of sustaining long-term biological productivity.
Another principle that is often applied is cover crops, that are usually grown between main crops and that provide significant benefits to soil health. This practice ensures that the soil remains always covered with living plants, preventing nutrient depletion and soil erosion. If left uncultivated, soil can quickly degrade, losing its fertility[123]. Cover cropping enhances soil biodiversity, improves fertility, and increases water infiltration, while also playing a role in carbon sequestration. Furthermore, crop diversity enhances productivity, making plants more resilient to pests and diseases.
Another fundamental principle of regenerative agriculture is crop rotation, also referred to as diversification. This practice boosts yields and profitability by alternating different crops in the same field over time. By doing so, it prevents nutrient depletion, maintaining soil health and functionality. However, its most significant benefit is its ability to disrupt the life cycles of pests and diseases, also reducing the need for chemical treatments.
In addition, regenerative agriculture aims to reduce the use of chemical fertilizers and pesticides, in favour of natural alternatives, such as compost and organic pest control methods. Indeed, organic waste can be recycled and used as compost, enhancing plant growth and enriching soil nutrients, fostering a more sustainable and resilient ecosystem.

[123] Alpego. 2024. Cover crops, la guida alle colutre di copertura. Retrieved from https://alpego.com/news/cover-crops-la-guida-alle-colture-di-copertura/

Finally, the biggest novelty of regenerative agriculture is the integration of livestock. This approach improves soil health by enriching it with organic matter, while diversifying farmers' income streams. Indeed, rotational grazing contributes to soil regeneration, enhances microbial activity, and increases carbon sequestration, making it a crucial component of sustainable farming systems[124].

These methodologies provide multiple benefits for both the environment and biodiversity. At the same time, alongside these more traditional practices, numerous technological innovations are increasingly being integrated, offering new opportunities to enhance efficiency and sustainability.

2.4.2 Main technological innovations

Several technological innovations support the adoption of regenerative agriculture. They are summarized in the following table:

TECHNOLOGY	DESCRIPTION
Remote sensing	Use of space technology to collect detailed data on soil conditions and water resources.
Artificial Intelligence (AI) and Machine Learning (ML) and Internet of Things (IoT)	AI, ML and IoT can be used to monitor critical environmental factors that are crucial for optimal crop growth, allowing farmers to gain insights into soil health and make informed decisions on resource allocation[125].

[124] Khangura, R., Ferris, D., Wagg, C., & Bowyer, J. (2023). Regenerative agriculture—a literature review on the practices and mechanisms used to improve soil health. *Sustainability, 15*(3), 2338.
[125] Agarwal, H., Kaur, S., Kataria, S., Roy, S., Chaudhary, D., Shukla, S., ... & Joshi, N. C. (2024). Artificial intelligence and its role in soil microbiology and agricultural sustenance. *Methods in Microbiology, Volume 55, pages 141-177.*

Blockchain	It is one of the most innovative tools to ensure transparency and traceability along the entire food chain[126].
Gene editing	Technology used to change the genetic structure of an organism to boost some of its properties.

Among these technologies, the most cutting edge are remote sensing and gene editing, as they provide opportunities to optimize resource use and improve resilience.

Remote sensing is a tool used to «*monitor the earth's resources using space technology in addition to ground observations*»[127]. It is based on the collection and analysis of electromagnetic data reflected or emitted from the Earth, which can include multispectral, infrared, or radar images. In a context of scarcity of resources and need for a more sustainable agriculture, detailed information on land use, soil conditions, water resources, and on the risks of natural disasters is essential. Indeed, remote sensing systems play an important role in providing these insights and therefore they are widely applied across various sectors.

In agriculture, these systems allow the monitoring of crop conditions, observing nutrient availability in the soil, detecting water stress, disease and pest attacks, and optimizing the use of water and fertilizers (precision farming). Indeed, agronomic practices become site-specific: fertilization, irrigation, treatments, and planting are tailored to soil characteristics, with optimized input doses. This way, waste is reduced, and resources are used only where needed, avoiding excess where unnecessary and shortages where more is required[128].

Thanks to these systems it is also possible to detect the well-being of plants, by analysing the reflectiveness and the pigment of their leaves.

[126] D'Ausilio, F. (2024). Food traceability and the digitisation of the food-supply chain [Lecture slides]. *LUISS University, Course in Law, Digital Innovation and Sustainability.* Slide 26.
[127] Ray, A. S. (2016). Remote sensing in agriculture. *International Journal of Environment, Agriculture and*
Biotechnology, 1(3), 238540. Pag. 363
[128] Singh, A. K. (2010). Precision farming. *Water Technology Centre, IARI, New Delhi*, 165-174.

Moreover, genome editing is a method that allows scientists to change the genetic structure of an organism, by adding, deleting or altering its DNA, to boost specific properties, such as nutrient content, growth efficiency, or resilience to climate change. It focuses on making plants and animals more resistant to environmental challenges, such as drought and heat, while also improving food production and agricultural yields.

For instance, thanks to the CRISPR/Cas9 technique, scientists were able to develop rice with improved tolerance to high temperatures, and maize with increased drought tolerance.

In addition, this technology is useful in developing disease resistance in both plants and animals, reducing the need for chemical pesticides and antibiotics.

Therefore, gene editing aligns with the principles of regenerative agriculture by promoting sustainability, reducing environmental impacts, improving crop yields, and enhancing food security and nutrition. Indeed, it could be very useful in addressing the issue of malnutrition: by enriching crops with essential proteins, vitamins, and minerals, the nutritional quality of food can be improved, benefitting in particular vulnerable communities.

However, despite its great potential, its widespread application faces regulatory and public acceptance challenges[129].

In Italy, these organisms are classified as Genetically Modified Organisms (GMOs) and therefore are subject to the same legislation: their cultivation for commercial purposes is prohibited, but their marketing is allowed in compliance with labelling rules.

A big step forward was reached in June 2023, when the Italian *Decreto Siccità* (D.L. 39/2023)[130] authorized the testing of New Genomic Techniques (NGTs) not only in the laboratory, but also in the field. Under this decree, the University of Milan requested authorization to conduct field trials for a genetically modified Arborio rice variety resistant to rice blast, a fungal disease that severely impacts rice cultivation[131].

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[129] Karavolias, N. G., Horner, W., Abugu, M. N., & Evanega, S. N. (2021). Application of gene editing for climate change in agriculture. *Frontiers in Sustainable Food Systems*, *5*, 685801.

[130] Italian Government. (2023). *Decree-Law No. 39 of April 14, 2023, on urgent measures to deal with water scarcity and promote the use of water resources*. Retrieved from https://www.gazzettaufficiale.it/eli/id/2023/04/14/23G00047/SG

[131] https://lastatalenews.unimi.it/via-sperimentazione-italiana-riso-realizzata-tecniche-evoluzione-assistita

Moreover, at the European level, in July 2023, the European Commission proposed a new regulation[132] for NGTs, distinguishing between two categories: on the one hand, plants comparable to conventional ones; on the other hand, plants with more complex modifications. The two categories will be subject to different regulatory requirements for market approval. In February 2024, the European Parliament accepted the proposal, making a significant step forward.

In the following section, positive impacts and benefits of this agricultural model and its practices are explored, considering also farmers' needs related to productivity and profits.

2.5 Impacts of regenerative agriculture

2.5.1 Positive impacts of regenerative agriculture on climate and biodiversity

Regenerative agriculture offers a valuable solution to mitigate climate change. By replacing chemical substances with organic ones, such as compost and manure, regenerative agriculture can reduce GHG emissions, with an estimated reduction of approximately 0,203 Mg CO_2 eq/ha[133]. These more sustainable practices not only reduce the reliance on pesticides but also improve soil health, enhance carbon sequestration, and help mitigate climate change[134].

Furthermore, the production and use of fossil-fuel based machinery contribute to climate change by releasing GHG and diminishing the soil's ability to absorb CO_2. No-tillage practices, a key component of regenerative agriculture practices, help mitigate emissions by reducing soil disturbance and promoting residue retention, slowing down decomposition. These practices have been shown to reduce CO_2, N_2O, and CH_4

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[132] European Commission. (2023). *Proposal for a regulation of the European Parliament and of the Council on plants obtained by certain new genomic techniques and their food and feed and amending Regulation (EU) 2017/625*. Retrieved from https://food.ec.europa.eu/document/download/c03805a6-4dcc-42ce-959c-e4d609010fa3_en?filename=gmo_biotech_ngt_proposal_2023-411_en.pdf

[133] Rehberger, E., West, P. C., Spillane, C., & McKeown, P. C. (2023). What climate and environmental benefits of regenerative agriculture practices? an evidence review. *Environmental Research Communications, 5(5)*, 052001. Pag. 5

[134] Ibidem.

emissions, lowering their global warming potential by 15%, 7,5% and 19,8% respectively[135].

Simultaneously, cover crops serve as a valuable way to capture and store CO_2. Since each crop species has unique root systems, switching between different crops can accelerate the accumulation of soil organic carbon (SOC). Legumes, in particular, contribute significantly to SOC thanks to their ability to fix atmospheric nitrogen and produce biomass in the soil[136].

Thus, thanks to all these methods, soil becomes an important instrument for mitigating climate change. By shifting away from chemical inputs and adopting practices that restore soil health and reduce emissions, regenerative agriculture benefits not only the climate but also promotes long-term agricultural sustainability.

For what concerns biodiversity, regenerative agricultural practices are able to enhance and protect ecosystems.

In particular, cover crops and crop rotation positively influence biodiversity, by providing the soil with different varieties of crops, allowing pest predators and pollinators to thrive. Moreover, maintaining a permanent soil organic cover of at least 30%, as suggested by FAO[137], with crop residues and/or cover crops, contributes to soil protection from erosion, compaction, and the impacts of extreme weather events[138].

In addition, one of the most promising solutions for both climate change mitigation and biodiversity protection, is agroforestry which involves the integration of trees into farming systems. Agroforestry offers several benefits, including acting as windbreaks, preventing soil erosion, and safeguarding crops from extreme weather. These systems promote higher biodiversity and are more resilient to climate change, thanks to the variety of plants, animals, and soil diversity they generate[139]: they help regulate temperature,

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[135] Kai Yue, Dario A. Fornara, Petr Heděnec, Qiqian Wu, Yan Peng, Xin Peng, Xiangyin Ni, Fuzhong Wu, Josep Peñuelas. (2023). No tillage decreases GHG emissions with no crop yield tradeoff at the global scale. *Soil and Tillage Research, Volume 228*.

[136] Mahanty, A. & Dasgupta, K. (2024). Carbon Sequestration in a Changing Climate: Management Techniques and Strategic Solutions.

[137] FAO. (2023). *Soil cover estimation*. Retrieved from https://www.fao.org/fileadmin/user_upload/GSP/GSDP/Field_exercises/NEW_Field_exercises/P07-soil-cover-EN.pdf

[138] Marcelino, S. M., Gaspar, P. D., do Paço, A., Lima, T. M., Monteiro, A., Franco, J. C., Santos, E. S., Campos, R., & Lopes, C. M. (2024). Agricultural Practices for Biodiversity Enhancement: Evidence and Recommendations for the Viticultural Sector. *AgriEngineering*, *6*(2), 1175-1194

[139] Torquebiau, E. (2024). Agroforestry at work. *Tropical Forest Issues 62*, pp. 21-27.

create a stable microclimate for crops and livestock, attract pollinators, and store carbon dioxide[140].

2.5.2 Economic considerations

In relation to farmers' and producers' interests, it is estimated that farmers adopting regenerative practices can increase their profits by 70% compared to conventional farming, with the potential for 120% increase in later stages[141]. Indeed, by simultaneously integrating several methods, such as cover crops, reduced tillage, and crop rotation, farmers can use inputs more efficiently and benefit from healthier, safer, and more nutritious soil. This approach not only improves soil health but also enhances farm productivity in the long term.

However, until now, it has been considered the long-term perspective. Indeed, results and increased profits from regenerative agriculture take time to materialize, necessitating 3-5 years to be visible. During the first phase of transition, farmers' profits remain the same or, even, will experience a decline. In fact, «*the 3-5 year transitional period may see profits dip by an average of 30-60%*»[142]. This loss is driven by additional costs, including investments in new knowledge, training, machinery, and the necessary adjustments to implement a more sustainable farming system. In particular, the primary reason behind this profit loss is that both biodiversity and soil need time to regenerate and adapt to new conditions.

For these reasons, it is essential that farmers and SMEs are supported financially during the transition by banks and public institutions. Therefore, it is fundamental to address the existing financing gap and the importance of integrating data and information on the impacts of regenerative agriculture in the banks' disclosure requirements in order to promote and accelerate the transition of the sector[143].

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[140] Morrison, R. (2024). Regenerative agriculture is a promising solution for the future. *Illuminem*. Retrieved from https://illuminem.com/illuminemvoices/regenerative-agriculture-is-a-promising-solution-for-the-future

[141] World Business Council for Sustainable Development (WBCSD). (2023). *Cultivating farmer prosperity: investing in regenerative agriculture*. Retrieved from https://www.wbcsd.org/wp-content/uploads/2023/09/Cultivating-farmer-prosperity_Investing-in-regenerative-agriculture.pdf

[142] Ibidem. Pag. 11.

[143] See Chapter 4 – *Regenerative agriculture KPIs and ESG disclosure requirements*.

Before delving into this discussion, it is important to evaluate the risks and opportunities that farmers and banks face when transitioning from intensive to regenerative agriculture, with reference to the Italian context.

CHAPTER 3: RISKS AND OPPORTUNITIES IN TRANSITIONING FROM INTENSIVE TO REGENERATIVE AGRICULTURE

In the previous paragraphs, the positive impacts of sustainable practices on biodiversity and climate have been analysed. It has been demonstrated how, from a climate change mitigation perspective, these methods reduce the use of chemical inputs, thus decreasing pollution in the air, soil, and water, while producing healthier, higher-quality products. At the same time, these practices benefit the soil by making it more fertile and enriched with organic matter, resulting in more nutritious food. Moreover, ecosystems and biodiversity also benefit from these methods becoming increasingly resilient. Regenerative agriculture, as the term suggests, contributes to the regeneration of plant diversity, which has been severely diminished in recent decades, thus enabling long-term sustainability in agriculture.

However, alongside these benefits, there are limits that cannot be overlooked. One of the main challenges is the timeframe: these practices improve soil quality and biodiversity, but gradually, requiring a long-term commitment. Additionally, scalability remains a significant issue: how can these principles be effectively applied on a large scale? There is a risk that companies might adopt these practices only partially, undermining their effectiveness.

In this context, it is important not only to focus on the positive aspects of regenerative agriculture, as numerous as they are, but also to address the uncertainties and challenges that remain. The risks and opportunities that farmers, and later banks, face when transitioning from conventional to regenerative agriculture are explored below.

Starting with the opportunities for farmers, the positive impacts on biodiversity have already been discussed and mentioned several times. Additionally, farmers can benefit from reduced costs related to fertilizers and pesticides.

At the same time, they have the opportunity to increase their yields by accessing emerging markets. Indeed, a recent study revealed that, in 2024, sales of organic products in Italy «*increased by 5,7%*»[144], reaching more than 6,5 billion euros. This data represents a significant opportunity for farmers who, within 2-5 years, could enter this expanding market. Consumers are becoming more conscious of their purchasing decisions for two main reasons: some are motivated by a desire to consume healthier food for their well-being, while others are concerned about the environment and the climate crisis. Furthermore, producing certified food enhances farmers' reputations and attracts more consumers. In fact, the study reports that 47% of consumers prefer products that are locally produced or made in Italy, while 34% actively seek certifications such as DOP/IGP. For this reason, farmers and SMEs should consider adopting certifications like the relatively new Regenerative Organic Certified label. This certification, which applies to food, textiles, and personal care products, represents the highest standard in organic agriculture, with stringent criteria for soil health and social fairness[145].

However, the transition to more sustainable agriculture also presents several challenges and risks that need to be considered.

The first aspect is related to the ability to meet the global food demand. While it is true that food production needs to increase by 70% by 2050 to feed the expected 9 billion people on the planet[146], how much should organic production increase to meet this need? This issue is also connected to deforestation. Since organic agriculture typically yields less, more land is required to produce the same amount of food. As a result, additional land is needed, which comes with environmental impacts that cannot be overlooked. Due to place-based heterogeneity, producers also need to adopt practices that are relevant to their local context, meaning that the specific best solutions need to be identified to achieve results and bring environmental benefits.

Furthermore, changes in consumer diets are necessary. While consumers are becoming more conscious of their food choices, this shift is not enough. According to World Wildlife Fund (WWF), 59% of Italians are reducing their meat consumption, but only

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[144] La Repubblica. (2025, February 24). *Il biologico italiano in crescita: consumi interni ed export trainano il settore nel 2024*. Retrieved from https://finanza.repubblica.it/News/2025/02/24/il_biologico_italiano_in_crescita_consumi_interni_ed_export_trainano_il_settore_nel_2024-191/

[145] Regenerative Organic Alliance. *Why regenerative organic?* Retrieved from https://regenorganic.org/why-regenerative-organic/

[146] FAO. (2024). *The role of agriculture in mitigating climate change: perspectives from the global community*. Retrieved from https://www.fao.org/4/k6021e/k6021e.pdf

10% of the population is vegetarian or vegan[147]. Therefore, there is still limited consumer willingness to adopt a more plant-based diet or to prioritize environmentally sustainable purchases.

Related to farmers' implementation of sustainable practices is the issue of initial costs and investments, both in terms of time and money. Farmers face increased initial transition costs for new equipment and training. A critical aspect to consider is that, to implement these practices effectively, a high level of specialization and knowledge is required: skills that many farmers might lack, particularly considering that in Italy, the majority of farms are small, family-owned businesses. Moreover, as previously mentioned, achieving the desired results and increasing yields often requires several years of efforts[148].

Risks related to new stringent policies coming into force and a constantly changing technological landscape need to be considered too.

Risks and opportunities faced by farmers in the transition are summarized in the table below:

OPPORTUNITIES	**CHALLENGES AND RISKS**
Contribution to climate change mitigation and biodiversity protection	Ability to meet global food demand
Reduced costs (related to fertilizers and pesticides)	Changes in consumer diets
Access emerging markets, thus increasing yields	Increasing initial costs and investments
Adoption of labels and certifications to enhance reputation and attract consumers	High level of specialization and knowledge required
-	Regulatory and litigation risks
-	Technology risk

[147] WWF. (2024). *Vegan day: il 59% degli italiani reduce il consume di carne*. Retrieved from https://www.wwf.it/pandanews/societa/vegan-day-il-59-degli-italiani-riduce-il-consumo-di-carne/

[148] Boix-Fayos, C., & de Vente, J. (2023). Challenges and potential pathways towards sustainable agriculture within the European Green Deal. *Agricultural Systems, 207*, 103634.

For all these reasons, it is essential that farmers and SMEs receive financial support, especially during the early stages of the transition. Both public institutions and the private sector must play a role in providing this support.

However, the situation is more complex than it might appear. For banks, the transition from intensive farming to regenerative and sustainable agriculture also comes with both risks and opportunities.

From a financial perspective, regenerative agriculture offers a way to enhance commercial opportunities in the sector. Through investments, it is possible to align food and agricultural value chain investments to changing climate conditions and take advantage of potential opportunities in transition investing[149]. Biodiversity presents financing opportunities such as cost reductions, new income streams, and, more importantly, improved climate resilience and protection against climate-related and environmental risks.

One of the main financial benefits of investing in biodiversity restoration and conservation is the reduction of operational costs. Sustainable farming practices require fewer inputs, like chemical fertilizers, to achieve crop yields, and well-managed land can remain productive for longer, leading to significant long-term savings.

Moreover, there is an increasing number of financial opportunities and instruments related to biodiversity conservation, including green bonds, sustainability linked loans, and sustainable investment funds.

Investing in biodiversity also plays a vital role in climate change mitigation and strengthens the planet's resilience against extreme weather events. As a consequence, healthy soils and ecosystems better handle droughts, floods, and other climate challenges, ensuring the provision of essential ecosystem services over the long term.

Lastly, since the financial sector depends on the nature's functioning, investing in ecosystems preservation helps mitigate the financial risks associated with the destruction of biodiversity[150].

[149] The Rockefeller Foundation. (2024). *Financing for regenerative agriculture*.

[150] Bosma, D., Hendriks, M., & Appel, M. (2022). *Financing regenerative agriculture*.

Generally speaking, the transition to a sustainable, net-zero future involves a series of risks that financial institutions and banks need to face. It is needed not to only consider traditional risk categories, such as credit, market, and operational risks, but also physical, and particularly, transition risks need to be addressed.

When it comes to the agricultural sector, the starting point is the recognition that biodiversity loss presents a series of risks to the financial sector. As already anticipated[151], given the nature of their clients' activities, they are exposed particularly to physical risks as these businesses rely heavily on ecosystem services such as water, air, and soil. When these natural resources are depleted, the essential ecosystem services are no longer guaranteed, negatively impacting the financial health of the institutions involved. This risk is amplified by the increasing frequency of extreme weather events.

In addition to physical risks, transition risks play a key role. Banks and financial institutions have to be able to adjust to evolving policies and new regulations coming into force. In this case, the situation is made more challenging by the political and regulatory context, which is constantly changing and, sometimes, also contradictory. Moreover, they need to align their portfolio to ESG requirements in order to avoid reputational risks related to environmental controversies. Indeed, inadequate efforts to support the environment, or incidents of greenwashing, damage the reputation of both the companies involved and the institutions that support them. As a result, liability and litigation risks might arise[152].

Technology risks need also to be mentioned, arising from the evolving technological landscape.

Therefore, it is possible to see how, starting from transition risks, because of transmission channels, the risks arising from the transition are capable of influencing the other traditional risk categories, such as credit, market, and operational risks.

Indeed, physical and transition risks faced by farmers translate into economic risks at both the micro and macro levels, which consequently reflect in financial risks[153].

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[151] See section 1.4 – *Climate-related financial risks*.

[152] ECB. (2020).

[153] NGFS. (2024). *Nature-related Financial Risks: a Conceptual Framework to guide Action by Central Banks and Supervisors*. Retrieved from https://www.ngfs.net/system/files/import/ngfs/medias/documents/ngfs-conceptual-framework-nature-risks.pdf

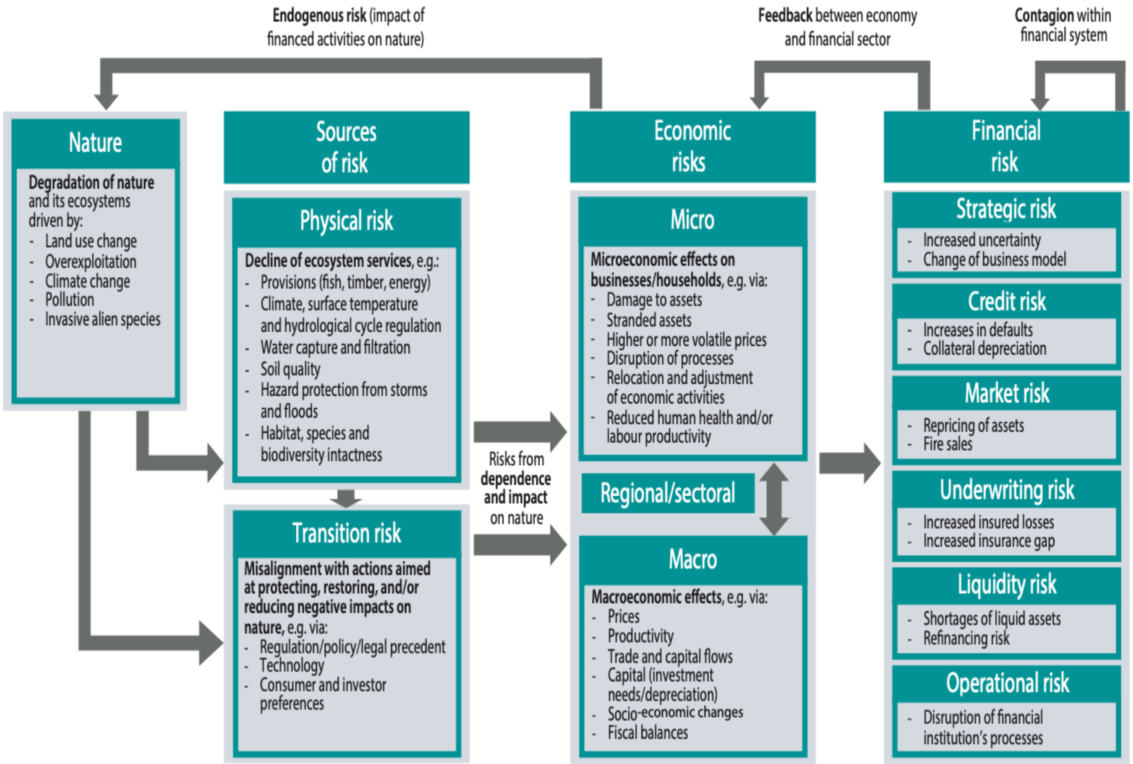

Figure 3: Transmission Channels. Source: NGFS.

Risks and opportunities faced by banks and financial institutions in the transition are summarized in the table below:

OPPORTUNITIES	RISKS
Improved climate resilience and enhanced protection from climate-related risks	Physical risk
Reduction of operational costs	Transition risk
Increasing number of financial opportunities and instruments	Regulatory risk
Compliance with policies and new requirements	Reputational, liability, and litigation risks
-	Technology risk

However, even if banks face several risks in the context of the transition, these risks need to be compared to the non-transition risks, summarized in the table below:

TRANSITION RISKS	NON-TRANSITION RISKS
Initial costs and investments for farmers and SMEs	New stringent policies coming into force
Shift in market preferences and consumer diets	Reputational risk
Need for new equipment and less-carbon intensive technology	Contribution to climate change and rising GHG emissions
Lack of standardised metrics and indicators to measure the impacts of regenerative agriculture	Contribution to biodiversity loss
-	Liability and litigation risks
-	Increased operational costs and economic risks
-	Technology risk
-	Risk of stranded assets or carbon lock-in
-	Risk of business shutdown

In light of this, it is important for financial institutions to face these risks by considering several aspects related for instance to their clients' transition plans, their investments in low-carbon agricultural methods, and the support provided by banks to their clients in transitioning to a low-carbon economy[154]. At the same time, risks arising from the non-adoption of more sustainable practices are very serious. Because of transmission channels, banks that do not finance transitional activities and, therefore, support the pathway to achieve Net Zero, exacerbate the other traditional risks they are subject to – such as operational, credit, and market risks.

Another important barrier to the transition is the absence of standardized metrics and guidelines to measure the success and advantages of regenerative agriculture. Not only do banks lack the necessary expertise in this area, but the absence of clear, reliable, and

[154] UNEP FI. (2023). *Climate Risks in the Agriculture Sector*. Retrieved from https://www.unepfi.org/wordpress/wp-content/uploads/2023/03/Agriculture-Sector-Risks-Briefing.pdf

simple Key Performance Indicators (KPIs) to evaluate the outcomes and positive effects of these practices represent a major obstacle to financing and implementing regenerative agriculture projects.

Moreover, the long-term nature of regenerative agriculture has to be considered. Most sustainability-related investments take time to deliver financial returns, leading to a misalignment between «*the ecological time of nature [and] the anthropocentric timing of finance*»[155].

In addition, scalability remains a significant issue, as most projects are still too small for many financial institutions to consider them viable for large-scale funding[156].

There is, as a consequence, a financing gap: on the one hand, SMEs and farmers lack the knowledge and competencies to develop these practices and, in particular, the financial resources to implement them; on the other hand, policies exist to facilitate the transition to more sustainable practices, but banks do not have the capabilities or the willingness to invest in these projects.

In the next chapter, several metrics and KPIs that can be used for regenerative agriculture will be presented: they are instruments that could help farmers show and measure the benefits of their practices, and that could enable banks to demonstrate and to support the transition in the agricultural sector. In order to do so, these metrics can be integrated into the banking system and used to collect data and disclose information on the transition and the commitment to achieve Net Zero in the sector.

[155] The Rockefeller Foundation. (2024). Pag. 23
[156] Ibidem.

CHAPTER 4: REGENERATIVE AGRICULTURE KPIS AND ESG DISCLOSURE REQUIREMENTS

In the previous chapters, the benefits of regenerative agricultural practices on biodiversity and climate have been explored, identifying the opportunities and advantages for both farmers and banks in transitioning from a traditional and conventional system to a more sustainable one, focused on environmental health and resilience. The most relevant advantages concern access in emerging markets, reduction of operational costs, increasing number of financial opportunities, and increased resilience.

Considering a more comprehensive perspective, it has been important to also take into account the needs and interests of farmers. Therefore, the risks that the transition poses to farmers, which also affect financial institutions, have been discussed, recognizing in particular reputational risks, the need for new equipment and knowledge, regulatory risks arising from new stringent policies, and the need to adopt low-carbon technologies.

As already anticipated, this comparison reveals a financing gap[157]. Indeed, while farmers struggle to access investments, banks perceive such investments as very risky[158]. The main reason is linked to the intrinsic nature of agricultural activities, which are highly vulnerable to physical risks from extreme events and offer slow economic returns, requiring to adopt a long-term perspective. In addition, transition risks arising from the adoption of more sustainable practices need to be considered, as they impact farmers and banks and could jeopardise or discourage the transition and the achievement of specific goals.

For these reasons, this chapter will explore several metrics and Key Performance Indicators for regenerative agriculture, beginning with an overview of those currently available under European and Italian policies and frameworks.

Additionally, the chapter will discuss the financing gap in more detail, and specific KPIs for regenerative agriculture will be developed, serving as evaluation tools for both farmers and banks to measure and demonstrate the success and benefits of regenerative practices.

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[157] Fi-compass. (2020). *Financial needs in the agriculture and agri-food sectors in Italy*. Retrieved from https://www.fi-compass.eu/sites/default/files/publications/financial_needs_agriculture_agrifood_sectors_Italy.pdf

[158] Ibidem.

Finally, these metrics will be integrated in the banking system to meet ESG disclosure requirements for the agricultural sector.

Before delving into the details, it is necessary clarify a few points. For the purposes of this research, the focus is on Italian SMEs for several reasons. First, about 98%[159] of agricultural companies in Italy fall into the category of small and medium-sized enterprises. Moreover, the transition is particularly challenging for SMEs. As a matter of fact, unlike larger companies, SMEs often face difficulties in accessing financing, as they typically have limited resources and need to develop and strengthen their skills and knowledge to keep pace with technological innovations and evolving demands[160].
However, SMEs can also act as drivers of innovation, contributing to the spread of this change.
They are thus central to the Italian agricultural sector, and their support is crucial for promoting the transition to sustainable, responsible, and regenerative agriculture.

4.1 Introduction to regenerative agriculture metrics

Regenerative agriculture, as previously discussed, aims to restore biodiversity and ecosystem health. Its main objectives include improving soil fertility by increasing carbon, organic matter, and nutrients, reducing the use of pesticides and chemical fertilizers, and ensuring the efficient and responsible use of natural resources, including water. These practices have a positive long-term impact on the environment, which has to be measured.
However, evaluating these benefits presents challenges, mainly because of the variety of frameworks available, and consequently, the many indicators that can be considered. The

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[159] CIA (Confederazione Italiana Agricoltori). (2020). *Censimento Istat: meno aziende agricole, ma più grandi e sempre familiari*.
[160] Pissareva, L. et al. (2025), "Equipping SMEs with the skills to navigate the twin transition", *OECD SME and Entrepreneurship Papers*, No. 65, OECD Publishing, Paris. Retrieved from https://www.oecd.org/en/publications/equipping-smes-with-the-skills-to-navigate-the-twin-transition_caf420e6-en.html

multiplicity of definitions, metrics, and indicators creates a non-standardized situation, which can lead to confusion and difficulties in collecting and analysing data.

Before delving deeper into this discussion, it is important to define the different types of indicators that can be used.

First, indicators can be defined in numerous ways. In general, indicators are used to track the progress of various interventions aimed at achieving a specific goal, while also helping to assess the effectiveness of these measures.

Specifically, there are three types of indicators, which are often used together:

- Practice-based indicators, which evaluate the integration of specific regenerative farming techniques, regardless of immediate environmental results (e.g., implementing a certain practice)[161].
- Result-based indicators, which assess whether the intervention has had the desired effects, such as measuring reductions in chemical inputs[162].
- Outcome-based indicators, which evaluate the status of key ecological parameters like water, soil, and biodiversity. These include indicators like erosion rate or soil organic carbon content and are the most important as they prove and attest actual improvements in the agricultural ecosystem[163].

European and Italian national sources have developed some specific indicators for regenerative agriculture, that are presented here, addressing the four most relevant areas of impact: soil, water, nutrients, and pesticides.

The CAP has identified several indicators based on the six desired outcomes of regenerative practices:

- Increased water holding capacity, with indicators such as water infiltration rate and soil compaction;
- Reduced erosion, which considers erosion rate and soil cover;
- Increased biodiversity;

[161] Schreefel, L., Creamer, R. E., van Zanten, H. H. E., de Olde, E. M., Koppelmäki, K., Debernardini, M., ... & Schulte, R. P. O. (2024). How to monitor the 'success' of agricultural sustainability: A perspective. *Global Food Security*, *43*, 100810.

[162] Ibidem.

[163] Ibidem.

- Increased carbon sequestration, which takes into account the increase in soil organic matter, essential for improving resilience and mitigating climate change;
- Increased nutrient cycling, which studies microorganisms' activity within the soil;
- Pest and disease suppressiveness[164].

Moreover, *BENCHMARKS*[165], as part of the EU Soil Strategy, is a project aiming at developing a transparent and standardized monitoring framework with indicators that can be easily applied to measure regenerative agriculture outcomes. The development of the framework began in 2023 and is expected to be completed by 2027[166].

More general targets have also been identified in the Farm to Fork Strategy. Specifically, it addresses pesticide use by aiming to reduce the use of chemical and hazardous pesticides by 50% by 2030, ensuring no deterioration in soil fertility by reducing nutrient losses, and promoting the development of organic farming in the EU, «*with the aim to achieve 25% of total farmland under organic farming by 2030*»[167].

To quantify progress in the reduction of pesticide use, the European Commission has established a Harmonised Risk Indicator[168], and the Farm Sustainability Data Network (FSDN)[169] is used to collect data on the targets and indicators of the Biodiversity and the Farm to Fork Strategies[170].

For what concerns Italy, pursuant CAP 2023-2027, the National Strategic Plan has been developed, which includes all the interventions to be implemented, the financial plan, and commitments regarding the environment and climate. Among these, there are measures and interventions necessary to address climate change and improve the resilience of

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[164] EU CAP Network. (2024). *Focus Group – Regenerative agriculture for soil health. Mini Paper 3: Outcomes and indicators for regenerative agriculture across Europe*. Retrieved from https://eu-cap-network.ec.europa.eu/publications/eu-cap-network-focus-group-regenerative-agriculture-soil-health_en#section--resources

[165] https://soilhealthbenchmarks.eu/about-us/

[166] https://cordis.europa.eu/project/id/101091010/it

[167] European Commission. (2020). *Factsheet: From farm to fork: Our food, our health, our planet, our future*. Retrieved from https://ec.europa.eu/commission/presscorner/api/files/attachment/874820/Farm%20to%20fork_EN_2023.pdf

[168] European Commission. *Harmonised risk indicators*. Retrieved from https://food.ec.europa.eu/plants/pesticides/sustainable-use-pesticides/harmonised-risk-indicators_en

[169] European Commission. *Farm sustainability data network*. Retrieved from https://agriculture.ec.europa.eu/data-and-analysis/farm-structures-and-economics/fsdn_en

[170] European Commission. *Farm to Fork Strategy*. Retrieved from https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en

ecosystems, delivering positive benefits and impacts to the environment. The most relevant ones include integrated production, sustainable use of water resources, cover crops, reduction in the use of plant protection products, reduced tillage techniques, and increased organic matter in the soil. For each intervention, the territorial application scope, objectives, indicators, and other specific details are defined[171].

In addition to institutional frameworks and policies, there are several organizations that are starting to deliver indicators, working in collaboration with stakeholders.
For instance, the Sustainable Agriculture Initiative (SAI) Platform[172] developed an approach, in collaboration with other stakeholders, to facilitate the transition to regenerative agriculture. This approach identifies key impact areas where regenerative practices create positive change, such as soil health, water, biodiversity, and climate. Based on these areas, various outcomes and corresponding indicators are outlined. There are no specific practices to be implemented, allowing farmers the freedom to achieve the objectives putting in place the measures the best suit their context and their preferences.
Another example is the collaboration between the World Business Council for Sustainable Development (WBCSD) and the One Planet Business for Biodiversity (OP2B) coalition: together, they develop the "*Business guidance for deeper regeneration*"[173], articulated in five chapters, respectively dedicated to biodiversity, climate, social and economic aspects, soil, and water. For each topic they designed several metrics and suggested opportunities to implement them, with the ultimate goal of accelerating the transition to regenerative agriculture.
Lastly, an initiative that is worth mentioning is the partnership launched in June 2024 between EIT Food, an organisation supported by the EU that invest in projects and initiatives to achieve a healthier and more sustainable food system, and the European Alliance for Regenerative Agriculture (EARA), an organisation led by farmers supporting the transition to regenerative agriculture. In order to facilitate access to CAP funding,

[171] https://www.reterurale.it/PAC_2023_27/SRA
[172] Sustainable Agriculture Initiative Platform (SAI Platform). (2024). *A Global Framework for Regenerative Agriculture*.
[173] https://www.wbcsd.org/resources/business-guidance-for-deeper-regeneration/

they suggest using two main indicators, that are higher photosynthesis and increased soil cover, as they are key in producing better yields and environmental benefits[174].

While the topics addressed are often similar, the variability in indicator definitions, measurement methods, targets, and benchmarks leads to a fragmented and confusing system. The situation is further complicated by the context specificity in which practices are implemented. Consequently, a specific practice may not be effective in different geographical areas due to varying morphological characteristics.

Even if agricultural companies have many evaluation tools available, they do not always easily access the financing opportunities provided by banks and financial institutions. This results in a financing gap, where companies apply for funding but do not receive it, or, due to expected rejection, do not even apply. The reasons for this gap are further explored below, making specific reference to the Italian agricultural sector, where the issue is particularly relevant.

Key characteristics of the sector include fragmentation: 88% of agricultural businesses are classified as small or medium-sized enterprises, with an average utilized agricultural area of less than 20 hectares. Additionally, most of these businesses are family-owned, and the generational turnover is low: 41% of businesses are led by individuals over 64 years old, while only 15% are led by individuals under 44. Another factor contributing to the fragmentation is that half of Italy's total agricultural output comes from the northern regions, particularly *Lombardia*, *Emilia-Romagna*, and *Veneto*[175]. These factors limit the willingness to innovate, partly due to a lack of knowledge, and complicate access to bank credit.

While Italy's major banks offer financial products and services to farmers, few of them have departments or staff with expertise in agriculture, which prevents them from fully understanding the risks involved and effectively managing requests.

The financing gap for the Italian agricultural sector is estimated to be between 110 million and 1.3 billion euros[176]. Farmers' financial needs are high, but the available financial

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[174] EIT Food. (2024) Building a new CAP by farmers, for farmers with the European Alliance for Regenerative Agriculture. Retrieved from https://www.eitfood.eu/news/building-a-new-cap-by-farmers-for-farmers-with-the-european-alliance-for-regenerative-agriculture

[175] European Commission. (2021). *Statistical factsheet – Italy*. Pag. 16. Retrieved from https://agriculture.ec.europa.eu/system/files/2021-12/agri-statistical-factsheet-it_en_0.pdf

[176] Fi-compass. (2020). *Financial needs in the agriculture and agri-food sectors in Italy*. Pag. 8

offerings are considered insufficient and not tailored to the sector's specific needs. Evaluation tools currently integrated in the banking systems do not consider specific and relevant aspects related to regenerative agriculture.

The demand for financing is mostly driven by the need for medium-to-long-term investments, particularly in machinery and equipment. The sector receives financial support through Pillar I of the CAP, with direct payments and market support, and through Pillar II to improve competitiveness[177]. Additionally, some financial instruments, such as guarantee funds provided by the *Istituto di Servizi per il Mercato Agricolo Alimentare* (ISMEA), are available.

However, the financial needs of agricultural companies are not fully met, and banks should improve the conditions of their products in relation to the sector's specifics and the activities being implemented[178].

In order to address the role of banks in supporting the transition to regenerative agriculture by presenting a proposal for metrics' integration into the banking system, some specific KPIs have been developed, with the aim of facilitating the evaluation of regenerative agriculture practices.

4.2 KPIs for regenerative agriculture and benchmark identification

In order to facilitate access to financial instruments, some KPIs should be considered, with the aim of measuring the benefits of regenerative practices in a simple and understandable way for both farmers and banks.

For this thesis, ten KPIs have been developed, inspired by the indicators provided by the Italian National Strategic Plan for organic and integrated farming and for some specific practices[179].

The reference timeline is 3 years, considering the time needed for this agricultural model. Specifically, the indicators are the following:

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[177] See section 2.1 – *Regulatory and policy landscape*.
[178] Fi-compass. (2020).
[179] https://www.reterurale.it/PAC_2023_27/SRA

1. Percentage of agricultural land used for cover crops;
2. Percentage of agricultural land used for crop rotation;
3. Percentage of agricultural land used with a reduction in fertilizer use;
4. Percentage of agricultural land used with an increase in soil organic matter;
5. Volume of water resources used for irrigation;
6. Technology expenditure;
7. R&D expenditure;
8. Low-carbon CAPEX;
9. Implementation of better farming practices;
10. Share of R&D in mitigation technologies.

These indicators address the main impact areas identified before – soil, pesticides, water, and nutrients – alongside other fundamental aspects that need to be considered, related to technological innovations and economic aspects.

Below, the ten indicators are further explained.

1. *Percentage of agricultural land used for cover crops*

The first KPI requires to indicate the percentage of land allocated to regenerative practices that allow the soil to regenerate, thus increasing its fertility. Specifically, the practice of cover crops is to be implemented, which ensures the land is always covered to prevent erosion and guarantee fertility.

The benchmark[180] is set at 25-50% of cultivated land within the first 3 years, with an annual increase of 15-20%, aiming for 100% coverage approximately within the first 5 years of implementation.

Regarding the metrics for banks, the minimum area ranges from 0 to 5 hectares, with at least one annual planting of cover crops.

This indicator could help farmers monitoring progress towards sustainability goals. Additionally, the 15-20% annual increase represents a gradual and feasible approach for SMEs, without requiring radical changes.

For financial institutions, it represents a clear and understandable measure of soil improvement.

[180] Regenerative Organic Certified. (2023). *Framework for Regenerative Organic Certified*. Pag. 10. Retrieved from https://regenorganic.org/wp-content/uploads/2023/03/Regenerative-Organic-Certified-Framework.pdf

2. *Percentage of agricultural land used for crop rotation*

The second indicator requires indicating the percentage of land dedicated to crop rotation. The benchmark[181] is a minimum of 3 crops rotated on the same area.

Specifically, at least one crop must be legumes (lentils, beans, peas), known for their benefits to biodiversity (nitrogen fixation in the soil), and another crop should be herbs and forages (such as clover), to improve organic matter in the soil.

Crop rotation is a fundamental practice. The inclusion of legumes and forages in the benchmark ensures that the rotation not only improves soil quality but also contributes to the soil's natural fertility, reducing the need for fertilizers, as required by the third indicator. Since most farms in Italy are small and family-run, rotation helps increase biodiversity, and for those who traditionally use a variety of crops, it allows easy adaptation to specific needs. This increased production diversification also reduces the economic risks associated with monocultures, enhancing productivity. Additionally, this practice, by reducing the risk of crop loss due to diseases and pests, increases the resilience of agricultural projects, helping financial institutions assess the effectiveness of regenerative practices in maintaining long-term profitability.

3. *Percentage of agricultural land used with a reduction in fertilizer use*

This indicator requires to indicate the percentage of land where a reduction or elimination of pesticide use (or other chemical resources like fertilizers) in favour of natural elements (e.g., compost and manure) is possible.

In line with European objectives[182], the benchmark is an annual reduction of 10% in the use of pesticides and fertilizers, aiming for a total reduction of 50% by 2030. The commitment to reduce this usage should be applied to the entire agricultural area, and in any case, a minimum of 5 hectares.

For farmers, a specific KPI on pesticide and fertilizer reduction helps measuring and documenting the transition to more natural and sustainable practices, also increasing the economic sustainability of the project due to lower dependence on expensive chemical

[181] Ibidem. Pag. 10-11.

[182] European Commission. *Farm to Fork Strategy*.

inputs. SMEs will thus have lower costs and fewer reputational risks, improving their image and increasing consumer trust.

For banks, this KPI is also important because it allows them to evaluate the farm's financial stability, which reduces operational costs. Moreover, reducing the use of such inputs helps mitigate environmental and reputational risks associated with harmful practices, demonstrating farmers' commitment to sustainability and reducing the risk of penalties related to environmental legislation.

4. *Percentage of agricultural land used with an increase in soil organic matter*

The fourth indicator measures the increase in soil organic matter in a given percentage of agricultural land. This increase could be achieved, for instance, through reduced tillage techniques. No-tillage or minimum-tillage techniques improve soil fertility, enhance soil structure, and combat the loss of organic matter.

The reference benchmark aligns with European goals of reducing nutrient loss by 50% by 2030[183]. The minimum area varies from 0 to 2 hectares.

For SMEs dependency on chemical fertilizers is reduced, and the increased resilience of the soil allows to better withstand extreme weather events.

5. *Volume of water resources used for irrigation*

The fifth indicator relates to water withdrawal, that is the volume of water resources used for irrigation. This indicator requires responsible, sustainable, and efficient use of water. Regenerative agriculture allows the use of advanced precision technologies[184]. Through precision farming methods, for example, water use can be optimized and tailored to the soil's characteristics and needs. Consequently, water resources can be used responsibly, which is of particular importance for a country like Italy, where certain regions experience high water scarcity, according to the *Istituto Superiore per la Protezione e la Ricerca Ambientale* (ISPRA)[185]. Taking this aspect into account, the percentage of the area subject to this commitment varies depending on regional characteristics; however, in general, the minimum area is set between 0,5 and 1 hectare.

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[183] Ibidem.

[184] See section 2.4.2 – *Main technological innovations*

[185] ISPRA. (2025). *Lo stato di severità idrica a scala nazionale.* Retrieved from https://www.isprambiente.gov.it/pre_meteo/idro/SeverIdrica.html

6. *Technology expenditure*

This indicator measures the amount of resources and investments allocated to new technologies and machinery.

The benchmark is at least one digital solution implemented within 3 years.

Banks should consider the amount of financial resources spent by companies on new technologies and modern machinery.

Specifically, agricultural companies should adopt technologically advanced machinery in order to remain competitive, optimise production, and keep pace with the evolving technological landscape[186]. Technologies used in regenerative agriculture include for instance IoT, remote sensing and precision farming machinery[187]. However, to ensure a just transition and achieve Net Zero, it is necessary for SMEs to stop using outdated fossil fuel-based machinery, exacerbating pollution and contributing to GHG emissions. Therefore, it is essential to adopt not only smart technologies, but also green equipment, powered by renewable energy for instance, that is efficient and ensures a concrete transition.

7. *R&D expenditure*

This indicator measures the amount of resources and investments a company allocates to Research and Development (R&D).

The benchmark is set at 3% of the company's total revenues or production costs, in line with the requirements for qualifying as an innovative SME[188].

Regarding the metrics, banks should consider the amount of R&D spending[189].

These investments are a fundamental driver for the improvement of agricultural productivity and are necessary for the sector's concrete evolution. Even if R&D may not be at the core of the challenges of transitioning in the food sector, it is crucial to encourage

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[186] European Commission. *The digitalisation of the European agricultural sector*. Retrieved from https://digital-strategy.ec.europa.eu/en/policies/digitalisation-agriculture

[187] See section 2.4.2 – *Main technological innovations*.

[188] Italian Government. (2015). *Decree-Law No. 3 of January 24, 2015, on urgent measures for the banking system and investments.* Article 4, letter e. Retrieved from https://www.gazzettaufficiale.it/eli/id/2015/01/24/15G00014/sg

[189] World Economic Forum. (2025). *Nature Positive: Corporate Assessment Guide for Financial Institutions*. Pag. 38. Retrieved from https://reports.weforum.org/docs/WEF_Nature_Positive_Corporate_Assessment_Guide_for_Financial_Institutions_2025.pdf

the adoption, improvement, and diffusion of new technologies, products, and processes[190]. Supporting innovation and experimentation is key, as it enables companies to become more competitive and adapt to evolving and changing markets. In addition, fostering and stimulating learning and growth is highly relevant. Efforts in R&D are crucial also to develop new alternatives and solutions to align with sustainability objectives, improving a company's resilience, compliance and innovation.

8. *Low-carbon CAPEX*[191]

This indicator measures capital expenditure (CAPEX), which refers to all investment expenditures aimed at the long-term growth of the company, invested to reduce GHG emissions.

As no benchmark currently exists, the evaluation is qualitative and based on the proportion of CAPEX allocated to reducing GHG emissions. Specifically, for the timeline considered, the share of CAPEX in reducing GHG emissions is expected to be around 10% in the first 3 years. The goal is to gradually increase this percentage, aiming to achieve a situation in which the company has more than 10% of CAPEX invested in reducing GHG emissions and quantifies the resulting GHG emissions reduction.

Regarding the metrics, banks should consider the amount of spending and investments dedicated to solutions reducing GHG emissions and representing a low-carbon alternatives.

For agricultural companies, it is crucial to invest in practices such as improving manure management or limiting pesticide use in order to become a low-carbon aligned company. Thanks to these investments companies become more resilient and the probability of stranded assets or carbon lock-in is reduced.

[190] ACT Initiative. (2024). *ACT Agriculture & Agrifood – Low-carbon transition assessment methodology*. Pag. 71. Retrieved from https://actinitiative.org/wp-content/uploads/pdf/act_agriculture_agrifood_methodology_v2.0.pdf

[191] Ibidem, AG 2.4. Pag. 55.

9. Implementation of better farming practices[192]

This indicator assesses how SMEs implement farming practices that contribute to reducing their GHG emissions footprint. In particular, the practices considered are those outlined in the European Taxonomy[193], which differentiate between perennial crops, non-perennial crops, and livestock. They include, for instance, crop rotation, soil tillage, optimised fertilisation, and manure management.

The benchmark is the percentage of measures implemented, multiplied by the share of relevant production affected (area covered). The initial target is a percentage of approximately 40%, with a gradual increase aimed at achieving over 75%.

This indicator is valuable for understanding how a company is addressing global warming, by evaluating the number and scope of practices implemented to reduce emissions and enhance carbon sequestration. In addition, companies have to disclose how their choices contribute to climate change mitigation, whether they will use pesticides, and if they plan to rely on fossil fuels to heat greenhouses for off-season production.

Thanks to this information it is possible to assess and make a judgement about a company's actions to tackle global warming and climate change, by considering how the practices implemented enable GHG emission reduction and carbon sequestration.

10. Share of R&D in mitigation technologies[194]

Lastly, this indicator measures the share of Research and Development investments in mitigation technologies relative to total R&D investments.

The benchmark is set at 10-15% of total R&D investments in mitigation technologies and projects within the first 3 years. In the following years, the goal is to increase this share to at least 40%.

Specifically, mitigation technologies include, for example, manure-management technologies, alternative thermal systems, drought-tolerant species, and the use of "*enhanced efficiency fertilisers*" (EEFs) to limit emissions. These investments are crucial for reducing emissions.

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[192] Ibidem, AG 2.7. Pag. 64.

[193] EU Technical Expert Group on Sustainable Finance. (2019). *Taxonomy Technical Report*. Retrieved from https://finance.ec.europa.eu/system/files/2019-06/190618-sustainable-finance-teg-report-taxonomy_en.pdf

[194] ACT Initiative. (2024). AG 3.1. Pag. 69.

Thanks to these technologies, companies can align to sustainability objectives, keep pace with regulatory and technological changes, avoiding carbon lock-in and ensuring compliance to new requirements.

All characteristics are summarized in the following table:

KEY PERFORMANCE INDICATORS	BENCHMARK	METRICS	IMPACT FOR FINANCIAL INSTITUTIONS
Percentage of agricultural land used for cover crops	25-50% within the first 3 years, with an annual increase of 15-20%, aiming for 100% coverage approximately within the first 5 years of implementation.	Minimum area ranges from 0 to 5 hectares, with at least one annual planting of cover crops.	A climate change mitigation practice that helps increase the resilience of companies and their commitment to the transition.
Percentage of agricultural land used for crop rotation	A minimum of 3 crops rotated on the same area.	Minimum area ranges from 0 to 5 hectares and a minimum of 3 crops rotated.	A climate change mitigation practice that reduces risks for both the company and the bank.
Percentage of agricultural land used with a reduction in fertilizer use	An annual reduction of 10% in the use of pesticides and fertilizers, aiming for a total reduction of 50% by 2030.	Entire agricultural area; in any case, a minimum of 5 hectares.	A measure aimed at reducing GHG emissions, contributing to the transition; reputational risks and risks related to stricter regulations

			coming into force decrease.
Percentage of agricultural land used with an increase in soil organic matter	Reduction of nutrient loss by 50% by 2030.	Minimum area varies from 0 to 2 hectares.	Increased carbon sequestration and soil improvements help reduce transition risks.
Volume of water resources used for irrigation	Responsible use of water resources.	The percentage of the area subject to the commitment varies depending on regional characteristics; in general, the minimum area is set between 0,5 and 1 hectare.	Responsible use of water resources signals greater resilience in cases of shortage or drought, improving company's resilience to physical risks.
Technology expenditure	At least one digital solution implemented within 3 years.	Amount of financial resources spent on new technologies and modern machinery.	It contributes to risk mitigation and enhances competitiveness in the market.
R&D expenditure	3% of the company's total revenues or production costs.	Amount of R&D spending.	It demonstrates the company's commitment to innovation and transition, showing its ability to adjust and adapt quickly.
Low-carbon CAPEX	10% low-carbon investments in the	Amount of spending	It is a concrete signal of mitigation

	first 3 years, followed by a gradual increase to achieve more than 10% of CAPEX invested in reducing GHG emissions and quantified emissions reduction.	dedicated GHG emissions reduction.	actions implemented by a company, through which it transforms its business model to align with the transition.
Implementation of better farming practices	40% of measures implemented, with a gradual increase to achieve over 75%.	Area covered by better and sustainable farming practices.	It shows how much a company is concretely and effectively adopting sustainable practices and actions for the environment.
Share of R&D in mitigation technologies	10-15% of total R&D investments within the first 3 years, aiming for at least 40% in the following years.	Amount of R&D spending in mitigation technologies.	It demonstrates a company's intention to innovate and invest in a long-term perspective in technologies for transition and emissions reduction.

These ten indicators could be an effective tool to facilitate SMEs' access to financing, but in particular, they could be used by banks in their ESG disclosure requirements, to provide data and information on the transition of the sector.

Farmers can use them as guide to gradually improve their practices, while banks and financial institutions can use them to evaluate risks and make financial decisions.

Indeed, being measurable and accessible to smaller agricultural enterprises, they could be integrated in the banking system to evaluate the reliability and sustainability of farmers' agricultural practices. This way, banks are able to comply with disclosure requirements and support the transition to a low-carbon and sustainable agricultural sector, achieving Net Zero[195].

Additionally, an essential aspect to consider is the synergy between the regenerative practices outlined in the various indicators. The combination of these practices allows multiple objectives to be achieved simultaneously, creating a resilient and sustainable agricultural system.

4.3 Proposal for metrics and KPIs integration in the banking system

4.3.1 Regulatory context

Banks are expected to comply with ESG disclosure requirements under the Capital Requirements Regulation (CRR). These indicators could serve as evaluation tools to comply with provisions in the context of regenerative agriculture.

Before delving into this discussion, it is important to provide some context.

The CRR is the European regulation implementing the guidelines of the Basel III agreement, a series of three international agreements on banking regulation. It consists of three pillars:

- Pillar I establishes a capital requirement to cover risks typically associated with banking activities, such as credit, operational, and market risks;

[195] See section 4.3 – *Proposal for metrics and KPIs integration in the banking system*.

- Pillar II requires banks to hold additional capital to cover any further bank-specific risks;
- Pillar III introduces transparency requirements to allow a more accurate assessments of banks' solidity and exposure to risks by the market.

In the European context, the regulatory references are the aforementioned CRR and the Capital Requirements Directive IV (CRD IV), both regulating banking activities and the disclosure obligation, with the ultimate goal of increasing «*regulatory harmonization in the EU*»[196].

Regulation 876/2019[197] (CRR2) introduces the obligation, starting from 2022, for large institutions to provide disclosure on ESG risks as well. CRR3 (Regulation 2024/1623)[198] extends the scope of application to all entities, including small and non-complex institutions[199].

Indeed, it is necessary to strengthen the resilience of banks against environmental, social, and governance risks, recognizing their key role in mitigating climate change.

For this reason, banks are obliged to consider the impact of their lending and investment activities on ESG factors, also taking into account European goals such as emission neutrality, supporting the transition to a zero-carbon economy. This information is useful for stakeholders to assess environmental risks and sustainable finance strategies implemented by banks[200].

The CRR requires the European Banking Authority (EBA), the European authority responsible for maintaining financial stability in the EU and ensuring the orderly functioning of the banking sector, to develop the standards and indicators for ESG

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[196] ECB. (2024). *Capital requirements in Pillar 1 or Pillar 2: does it matter for market discipline?* Pag. 6. Retrieved from https://www.ecb.europa.eu/pub/pdf/scpwps/ecb.wp2988~25e3305cfa.en.pdf

[197] Official Journal of the European Union. (2019). *Regulation (EU) 2019/876 of the European Parliament and of the Council of 20 May 2019 amending Regulation (EU) No 575/2013 as regards the leverage ratio, the net stable funding ratio, requirements for own funds and eligible liabilities, counterparty credit risk, market risk, exposures to central counterparties, exposures to collective investment undertakings, large exposures, reporting and disclosure requirements, and Regulation (EU) No 648/2012.* Article 449a. Retrieved from https://eur-lex.europa.eu/eli/reg/2019/876/oj/eng

[198] Official journal of the European Union. (2024). *Regulation (EU) 2024/1623 of the European Parliament and of the Council of 31 May 2024 amending Regulation (EU) 575/2013 as regards requirements for credit risk, credit valuation adjustment risk, operational risk, market risk and the output floor.* Article 449a. Retrieved from https://eur-lex.europa.eu/eli/reg/2024/1623/oj/eng

[199] PwC. (2025). *La disclosure ESG nell'informativa di Terzo Pilastro (Pillar III)*. Retrieved from https://www.pwc.com/it/it/services/esg/doc/disclosure-ESG.pdf

[200] Council of the European Union. *Basel III: international regulatory framework for banks*. Retrieved from https://www.consilium.europa.eu/en/policies/basel-iii/

disclosure. Specifically, the EBA published the final version of the Implementing Technical Standards (ITS) for these disclosures on ESG risks in January 2022. The ITS refers to qualitative information about environmental, social, and governance-related risks. Additionally, there are 10 quantitative templates related to «*climate-related risk, actions to mitigate those risks, exposure to green assets, and information on sustainable risk management*»[201].

For this thesis, transition and physical risks will be explored and addressed, specifically templates 1 and 3 – *Climate Change transition risk* – and template 5 – *Climate Change physical risk*.

4.3.2 Bilateral client engagement

Having provided this background, which is necessary for better understanding the context, it is possible to proceed with the explanation of the proposed framework for integrating regenerative agriculture KPIs into the banking system.

Indeed, in order to comply with the ESG disclosure requirements, banks have to be able to provide information on the sustainability of their investments and financing to their counterparties and non-financial institutions, demonstrating the effort of each sector in transitioning to achieve net-zero.

To meet this demand, banks can rely on information contained in the Non-Financial Statements (NFS) and sustainability reports, in compliance with the Corporate Sustainability Reporting Directive (CSRD)[202] requiring the use of the European Sustainability Reporting Standards (ESRS), developed by the European Financial Reporting Advisory Group (EFRAG). The CSRD however, applies only to large and listed companies. In addition, in light of the new Omnibus package[203], proposed in

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[201] MSCI. *What are the EBA ESG Pillar 3 disclosures?* Retrieved from https://www.msci.com/documents/1296102/34809851/What+are+the+EBA+ESG+Pillar+3+Disclosures+-+transcript.pdf

[202] Official Journal of the European Union. (2022). *Directive (EU) 2022/ 2464 of the European Parliament and of the Council of 14 December 2022 amending Regulation (EU) No 537/2014, Directive 2004/109/EC, Directive 2006/43/EC and Directive 2013/34/Eu, as regards corporate sustainability reporting*. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32022L2464

[203] European Commission. (2025). *Proposal for a Directive of the European Parliament and of the Council amending Directive (EU) 2022/2464 and (EU) 2024/1760 as regards the dates from which Member States are to apply certain corporate sustainability reporting and due diligence requirements*. Retrieved from https://finance.ec.europa.eu/document/download/29624c4a-94e1-4b47-b798-

February 2025 by the European Commission, the scope of application of the CSRD is drastically reduced: it now applies only to the largest companies that are more likely to have significant impacts on people and the environment, having more than 1000 employees. The sustainability reporting for SMEs is postponed until January 2028.
In Italy, the companies interested with sustainability reporting obligations decreases from 10.500 to approximately 1.300[204].

In relation to the agricultural sector, since most Italian companies operating in the sector are SMEs, they are still not obliged to sustainability reporting obligations. Consequently, whether it is true that CSRD can provide information on the low-carbon pathway of a company, for SMEs there is the need to find other solutions.
To overcome this situation, they can adopt the Voluntary standard for non-listed micro-, small- and medium-sized undertakings (VSME)[205] published by the EFRAG. These voluntary standards require undertakings to disclose sustainability information. However, since these data do not require assurance, their quality and reliability are highly questionable. Moreover, certain information is reported only in specific circumstances, in compliance with the "*If applicable*" principle – that is, «*only if considered "applicable" by the undertaking*»[206].
For all these reasons, another solution is to develop a trustworthy bilateral client engagement. Banks, indeed, should work responsibly with their own clients and customers to support them in the transition to more sustainable business models and activities, and to assess the banks' impacts[207]. Therefore, banks have to identify indicators to collect sustainability data directly from clients. This way, it is possible to integrate an analysis of SMEs implementing sustainable and responsible activities, as required by

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db7883f79c87_en?filename=proposal-postponing-requirements-csrd-transposition-deadline-application-csddd_en.pdf

204 https://ratingagency.cerved.com/il-decreto-omnibus-e-la-corporate-sustainability-reporting-directive-csrd-impatto-sulle-aziende-e-sul-patrimonio-informativo-ambientale/

205 EFRAG. (2024). *EFRAG Voluntary Sustainability Reporting standard for non-listed SMEs (VSME).* Retrieved from https://www.efrag.org/sites/default/files/sites/webpublishing/SiteAssets/VSME%20Standard.pdf

206 Ibidem. Pag. 6.

207 UNEP FI. (2024). *Guidance on Client Engagement.* Geneva. Retrieved from https://www.unepfi.org/wordpress/wp-content/uploads/2024/09/PRB_Guidance-on-client-engagement.pdf

Pillar 3 of the CRR. Specifically, Pillar 3 requires disclosing information for each sector, including the agricultural sector.

Banks, therefore, have to identify all those transitional and enabling activities for the sector and disclose information and data. With the aim of doing so, current engagement practices do not integrate in an exhaustive way regenerative agriculture criteria. However, thanks to the KPIs developed, it is possible to demonstrate how regenerative agriculture has a positive and significant impact on banks' portfolio transition.

4.3.3 Metrics integration for Pillar 3 ESG disclosure requirements

With this information, banks can facilitate the financing of regenerative agriculture projects, demonstrating and contributing to the increase of their own sustainability and commitment to supporting the transition to a low-carbon economy.

Specifically, the relevant templates for this thesis are Template 1 of the ITS, *Credit quality of exposures by sector, emissions and residual maturity*, which provides an overview of the bank's exposure to sectors with high climate transition risks. Information is required for the "*Agriculture, forestry, and fishing*" (Sector A). The KPIs for regenerative agriculture can demonstrate how a company contributes to mitigating its climate impact, aligning with decarbonisation scenarios.

The most relevant KPIs will therefore be those related to the positive impacts of regenerative agricultural practices, as they certify and quantify tangible benefits for the soil (indicators 1, 2, 4) and pollution and emissions (indicators 3, 9).

Template 3, *Alignment metrics*, refers to all those actions aligned to European climate goals that contribute concretely to achieving them. A relevant indicator will then be number 5, for the efficient use of water resources, number 8, which quantifies the percentage of investments dedicated to sustainable technologies or infrastructures, or number 7, which provides an overview of R&D initiatives, thus translating into greater innovation.

Thanks to these two templates related to transition risks, it is possible to provide an overview of the actions implemented by counterparties to reduce their emissions, and how the bank is supporting its clients and, in general, the transition towards a low-carbon economy in the agricultural sector.

Template 5 deals with *Exposures subject to physical risk*, showing how vulnerable the bank is to physical risks arising from climate events. Given the nature of agricultural activities, these risks are particularly important.
Key indicators are numbers 1, 2, 3, 4, ad 5, which demonstrate how regenerative practices can mitigate physical risks, leading to actual soil improvement and increased resilience.

Through these indicators and their integration into the banking system, banks are capable to demonstrate their commitment to achieve Net Zero and enable the transition in the agricultural sector, while facilitating access to financing for farmers. In the next section, the integration is further explored and explained.

4.5 Integration of transmission channels from regenerative agriculture into financial risks and application of KPIs to financial products

Transmission channels can be used to understand how transition risks, stemming from regenerative agriculture practices, can be used to trace financial risks. The correlation is found in the development of sector specific KPIs, which can be integrated into the banking system to ensure an effective transition in the agricultural sector, incorporating them in banks' risk management.
In this regard, the materiality assessment conducted by financial institutions, is the first step in the identification of which sector specific transition risks constitute an impact within the risk management system of the bank. Fundamental is to develop a well-informed understanding of relevant transition-related risks stemming from regenerative agriculture practices, supported by a mapping of transmission channels to traditional risk categories for banks. Based on this understanding, material risks are identified, defining those that significantly affect banks' risk profile and business model, by using qualitative and quantitative approaches[208].

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[208] EBA. (2025). *Final Report – Guidelines on the management of environmental, social and governance (ESG) risks.* Retrieved from https://www.eba.europa.eu/sites/default/files/2025-01/fb22982a-d69d-42cc-9d62-1023497ad58a/Final%20Guidelines%20on%20the%20management%20of%20ESG%20risks.pdf

For transition- and climate-related risks, the EBA requires to consider exposures toward sectors highly contributing to climate change, including agriculture, which is among the sectors driving significant risks. As mentioned earlier, it contributes considerably to the global levels of GHG emissions and, through its practices, destroys and deteriorates biodiversity and ecosystems. Furthermore, given the nature of its activities, it is vulnerable to physical risks arising from extreme events. Moreover, due to numerous regulations in constant flux and a continuously advancing technological landscape, transition risks are high. Therefore, since financial institutions are exposed to climate- and environmental-related risks through their exposures to companies and SMEs, these risks have to be addressed. Specifically, regarding regenerative agriculture, by enhancing biodiversity resilience and contributing to climate change adaptation and mitigation, it is necessary to evaluate the risk profile.

For each of the above-mentioned KPI[209], connected transitions risks are identified that, through transmission channels, impact traditional financial risks.

KEY PERFORMANCE INDICATORS	**TRANSITION RISKS**	**TRANSMISSION CHANNELS**	**FINANCIAL RISKS**
Percentage of agricultural land used for cover crops	Political and behavioural changes, together with physical risks.	Reduced productivity and increased operational costs.	Credit and operational risks.
Percentage of agricultural land used for crop rotation	Political and behavioural changes, alongside physical risks.	Lower asset performance.	Market and credit risks.
Percentage of agricultural land used with a reduction in fertilizer use	Political changes and pressure on chemical reductions; reputational risk.	Compliance and legal costs and initial productivity reduction.	Operational and credit risks.

[209] See section 4.2 – *KPIs for regenerative agriculture and benchmark identification.*

Percentage of agricultural land used with an increase in soil organic matter	Physical risks.	Lower initial profitability and increased initial costs.	Credit risks.
Volume of water resources used for irrigation	Policy changes; reputational risks; physical risks.	Increased cost of compliance and legal costs.	Operational risks.
Technology expenditure	Technological and policy changes.	Compliance costs and increased CAPEX.	Credit and operational risks.
R&D expenditure	Technological and policy changes.	Initial costs and lower profitability.	Liquidity and operational risks.
Low-carbon CAPEX	Technological and policy changes.	Increased CAPEX.	Credit risks
Implementation of better farming practices	Policy changes, reputational and behavioural changes.	Initial costs and lower profitability.	Operational and reputational risks.
Share of R&D in mitigation technologies	Technological and policy changes.	Initial costs and lower profitability; stranded assets.	Operational and reputational risks.

Therefore, this table shows, for each indicator, the transition risks arising from the transition to regenerative agriculture (Column 2), how and through which channels these risks are transmitted to financial institutions (Column 3), and finally, in which type of traditional financial risk the impact is translated into (Column 4).

Generally speaking, transition risks mostly translate into credit, market, and operational risks.

Through the proposed Risk table, it is possible to guide exposure and understand which materiality thresholds can be found to be relevant for the financial institution[210]. With the integration of regenerative agriculture KPIs, banks are able to assess sector-specific exposures.

Once the risks have been identified, along with actions banks intend to implement in order to manage them, in line with their broader business strategy, financial institutions should ensure that their risk appetite addresses these risks. The risk appetite should specify the level and types of sector specific transition-related risks banks are willing to assume in their portfolio[211].

The Risk Appetite Statement (RAS) is one of the fundamental risk management tools used by banks to manage risks, identifying operational limits for dealing with traditional financial risks, and now also with climate-related risks.

Financial institutions are expected to implement a comprehensive limit system that sets specific quantitative thresholds for individual risk types: as a matter of fact, according to the ECB, limits are necessary to ensure that «*risks and losses can be limited effectively in line with the capital adequacy concept*»[212]. Therefore, it is essential to integrate in the RAS sector-specific climate indicators and limits to ensure alignment between risk management and long-term climate objectives.

The RAS is one of the instruments included in the Risk Appetite Framework (RAF), a governance system and instruments that allow banks to translate the RAS into concrete, operational practices[213]. Processes for control, monitoring, and reporting should be put in place to ensure the actual risk remains within the established limits. Therefore, for ESG risks, the KPIs developed, along with other potential Key Risk Indicators (KRIs), can assist in measuring and controlling these risks.

These two tools are particularly important in the governance of banks, as they influence the financial instruments and products a bank offer, finances, or include in its portfolio.

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[210] ECB. (2022). *Good practices for climate-related and environmental risk management*. Retrieved from https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.thematicreviewcercompendiumgoodpractices112022~b474fb8ed0.en.pdf

[211] EBA. (2025). *Final Report – Guidelines on the management of environmental, social and governance (ESG) risks*.

[212] ECB. (2022). *Good practices for climate-related and environmental risk management.* Pag. 41.

[213] Auzepy, A., & Bannier, C. E. (2025). *Integrating Climate Risks in Bank Risk Management and Capital Requirements*.

In light of this, the KPIs and their integration into banks' risk management, and therefore into banks' financial instruments, represent an opportunity to facilitate access to specific financial products, ensuring a transition that is more tailored to the client, contributing to the resolution of the existing financing gap[214].

[214] See section 4.1 – *Introduction to regenerative agriculture metrics*.

CONCLUSIONS

In conclusion, this thesis focused on agricultural sector, examining the existing system characterized by industrial methods and chemical and inorganic resources, contributing to climate change and biodiversity loss. As a matter of fact, because of GHG emissions generated, the overexploitation of resources, and soil erosion, this model represents a serious threat to the agricultural sector's sustainability and resilience, that is expected to feed the growing population.

Regenerative agriculture is identified as a promising solution to the increasing environmental challenges. Its main focus is the restoration and conservation of biodiversity, recognizing the immense value ecosystems represent, not only for the agricultural industry, but also for the economy and all other sectors.

This research has started by presenting the current agricultural context, characterized by industrial farming, illustrating the negative consequences it generates, impacting both the climate and biodiversity.

Nature-based Solutions were identified as a valuable answer to the alarming situation our planet is facing. Indeed, they are capable of delivering simultaneously environmental, social, and economic benefits, enhancing ecosystems resilient, implementing solutions that are supported or inspired by nature.

Among them, regenerative agriculture has been identified as a promising model. After having introduced its main practices and technologies, the benefits that it is able to deliver to both the climate and biodiversity have been explored, together with some economic considerations.

Recognizing the importance of achieving Net Zero, the risks and opportunities of the transition to a more sustainable agricultural model were presented, highlighting how also banks and financial institutions are impacted by climate-related financial risks.

In the end, specific Key Performance Indicators for regenerative agriculture were developed, serving as evaluation tools for both farmers and financial institutions, enabling the transition. These KPIs could be practically applied by banks, with the goal of making the evaluation of regenerative agriculture projects simpler and more standardized, collecting data and information that can be integrated into the banking system, using them to comply with ESG disclosure requirements under Pillar 3 of the Capital Requirements Regulation and incorporating them in banks' risk management.

In light of this work, it is evident that for the necessary just transition to sustainable agriculture to succeed, collective commitment is required, involving all actors – public institutions, financial operators, and the farmers themselves – to ensure a fair and resilient future that preserves natural resources for future generations.

Indeed, to achieve this goal and implement sustainable development in the broadest sense of the term, it is important to underline the role that institutions, businesses, and individual citizens play: we are all burdened, at least morally, with the duty to engage and adopt more ethical behaviours in order to reduce our impact on the Earth and try not to worsen the already drastic situation our planet is facing.

It is almost axiomatic to assert that growth and sustainable development must be inclusive, involving the three dimensions of sustainable development – economic, social, and environmental. These must be considered global challenges, beyond any national borders. Therefore, coordinated solutions at the international level and cooperation are necessary to support all countries in achieving these goals for the benefit of all.

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