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Creation of a Carbon Farming scheme in Europe: exploratory analysis through a multidisciplinary approach

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Introduction

This is a thesis about soil, and how humanity is literally in danger of "losing the earth beneath its feet". While writing this thesis, this reminded me that one of the first notions I studied, when I began my course of study in economics, was related to the soil as well. The first topic I studied in macroeconomics was Ricardo theory, eminent economist of the first half of the 19th century, who placed the agricultural sector at the basis of his analyses. Trying to explain, among other things, the dynamics of land rent, Ricardo comes to several considerations which can be simplified as: a) there is a limited amount of fertile land, and this generates income for its owner, b) as the population increases, less fertile land must be cultivated, and this leads to a decrease in productivity and an increase in production costs (Dornbush et al., 2014). As of this moment, land and soil have practically disappeared from the economics courses I attended, replaced by formulas and letters to denote the concept of resource. Indeed, in the last 50-year soil has not only disappeared from macro courses, but also from the political agenda and debate, especially in the privileged Western World. Our society has become convinced that hunger had been defeated by increased yields and productivity, and this implies mechanical tillage of soil by huge tractors, adding ever-increasing quantities of fertilizers. Thanks to the chemical and technological innovations brought by the Green Revolution of the 1970s, developed countries were able to increase agricultural productivity by leaps and bounds, feeding a growing population, which, since Ricardo's time, has increased dramatically by 7 billion, and is expected to consistently grow in the future (IlSole24Ore, 2017). The World Resources Institute foresees that more than 539 million hectares will need to be cultivated, an area which is comparable to twice the size of India (Liu, 2022).

Yet, in recent decades, the problem identified by Ricardo is coming back to the forefront, as the productivity of agricultural soils and the entire complex ecological system related to agricultural production is greatly threatened by climate change, productivity started to decline. Climate Change is caused by the greenhouse effect produced by an excessive presence of CO_2 and other Green House Gases (GHG), generated by human activities, and that include also farming and livestock intensive farming. Data show that the total amount of carbon in the atmosphere has increased by 30%, and science agrees in linking this increase with the dangerous warming of our planet because of an increased greenhouse effect, altering temperatures and seasonality which are essential to ensure adequate crops growth (Esa, 2022). At the same time, fertilizers abuse, and intensive practices have led to soil depletion, deterioration of water quality and desertification. In 2020, 195ml tons of chemical fertilizer have been used around the world, and the application rate increases by 2% per year, nevertheless hunger still affects 768mln people, and this number has grown by 16% compared to 2019 (FAO, 2017). This has also a huge economic impact, the sum of the total nitrogen loss in soils brings an estimated loss of around $200mln annually and has high costs to human health and environmental impact estimated at $400 billion per year (FAO, 2022).

We have been producing more but running in fourth gear and not looking at the fuel needle. At some point, the gasoline ran out. And productivity started to decline.

The 6th International Panel on Climate Change (IPCC) Report states that Agricultural lands occupy about 40-50% of the Earth's land surface, and agriculture accounts for the emission of about 10-12% of total global anthropogenic emissions of greenhouse gases (IPCC, 2022). Agriculture and breeding are a cause, but they can also be part of the solution since soil has an incredible capacity of absorbing and storing CO_2. According to the Ecological Society of America, soils contain approximately 75% of the carbon pool on land—three times more than the amount stored in living plants and animals (Esa, 2022).

The looming climate and food emergency has led to a collective awareness, which has resulted in several crucial initiatives in responding to the emergency. At global level, in 2015 the ONU launched the Agenda 2030 for Sustainable Development, which aim to lead people, companies and institution's action in achieving the 17 Sustainable Development Goals, broken down into 169 specific targets with related indicators (UN, 2015a). Also in 2015, the Paris Agreement was signed by 55 countries, presenting for the first time at the global level an action plan aimed at limiting global warming by defining the long-term goal of keeping the earth's atmosphere warming below 2 degrees (UN, 2015b).

Following these political will to take action, and driven by scientific evidence of the incumbent emergency and growing collective public awareness, the European Commission decided to foster the role of the agricultural sector launching a new plan, which is expected to achieve what numerous Common Agriculture Policy (CAP) and previous strategies have not reached yet: push for a broad and deep transformation of the agricultural sector, surpassing the era of intensive and impactful practices, in order to attain a similar productivity, but based on different cycles and techniques. To do this, a radical change in an entire sector is necessary, and very challenging. The transition toward a sustainable production system must meet the need to maintain economic and social sustainability, in order to make the transition acceptable. If some progress has been made in the agricultural field, for example through integrated cultivation and organic farming, much remains to be done, and the radical transformation has not occurred yet.

Reflecting on these failures, literature has recently started to address the problem of soil governance, and how it has been relegated to the more technical aspects of cultivation for too many years. On this regard, technical, political, and economic aspects of soil use and management need to be stressed and merged holistically, to derive a new multidisciplinary theory of soil governance (Juerges et al., 2018). The same has been recently stated also by L. Montanarella, prominent expert of Soil Science and founder of the Fao's Soil Partnership, which stressed the importance to study and manage soil with a holistic and transversal approach (Montanarella, 2012).

This work of thesis aims to fill this gap, taking the opportunity offered by the legislative developments proposed by the European Union regarding the implementation, by 2023, of the EU Carbon Farming Strategy, and the attempt to foster its adoption through the creation of a Voluntary Carbon Market (VCM) to enable farmers to transform the CO_2 absorbed in agricultural soils into credits that can be sold on a voluntary market open to companies wishing to offset their emissions. This is the background to this thesis, which aspires to answer the following research question: "*Which are the emerging success and risk factors for the implementation of a Carbon Farming VCM? and how are they considered within the legislative development toward the definition of the EU Carbon Farming Strategy*?"

To answer this question, an explorative qualitative research has been carried out, based on an extensive literature review, which sought to combine theoretical concepts, relating to the environmental economics approach to pollution target identification exposed in chapter 1 and related policy instruments presented in chapter 2 with a focus on market instruments and carbon markets. The literature review focused also on the technical and ecological area linked to the functioning of biological and ecological systems of the carbon cycle and the challenge of their monitoring which are presented in chapter 3, concluding with an analysis of the political approach implemented at European level in chapter 4. The general background highlighted by the literature review has supported the explorative research, which aims to give a novel multidisciplinary perspective of the issue of soil governance based on the creation of a VCM, through the conduction of several interviews with different actors of the sector, representing both the demand and supply side of the possible VCM. Given the novelty of the topic explored, and the time constraints, this thesis goal is to provide an initial exploration of the issue, reporting and analysing information and data stemming from different stakeholders (e.g., farmers, consultants, investors and agriculture and ecology experts). The explorative analysis presented aims to identify interesting factors and to propose a comprehensive reading of the legislative unfolding, which will need to be subjected to more extensive validation, such as through surveys to validate the identified factors within a larger audience.

Ch. 1: Emission target identification and related parameters (or how to define M*?)

The present chapter aims to introduce the main core concepts of this research work, deemed necessary to have a clear vision and a complete understanding of all the following notions. This will be done through the explanation of an environmental economics model of dynamic efficiency, as in the author's opinion it lends itself very well not only to explain the concepts, but also to give a general but complete idea of the correlation between different notions and how each one differently impacts the difficult compromise which need to be found among ecological benefits and social growth. The model is extensively presented by Perman et al., (2011) in their book, while links to the research concepts are the author's own elaboration. The goal of the chapter is to present the following concepts:

- Pollution Flow, Pollution Stock, and their relationship;
- Absorption of Emissions Rate and why it is important;
- Social Discount Rate, and how it has been changing in recent days;
- The lever of the Shadow Price for the internalization of emissions.

It is important to point out that the model presented in the next paragraphs is based on simplified assumptions, and therefore cannot be used for accurate numerical analysis.

Some basic concepts need to be clarified before going on, namely:

- CO_2 emissions are negative externalities;
- The regulator must define what is the efficient level of pollution under many constraints;
- Pollution damage is the result of flow and stock pollution.

The first concept which need to be addressed is externality, and the reasons why it is possible to define CO_2 and other equivalent GHGs emissions as a negative externality. Externality is defined in economic theory as the unintended effect, whether beneficial or harmful, that consumption or production activity of one or more agents generates on the consumption or production activity of other agents, without economic compensation (Frank et al., 2016). The fact that there is no economic compensation creates de facto a market failure, as the absence of price means that there is a lack of a specific market allowing to understand the offer and the supply of externalities. This simple issue has rather large repercussions, since this means that, in the case of negative externalities (i.e., the effects which goes to the detriment of those not directly involved in the activity of production or consumption) in absence of external corrections, the market will tend to produce too much of the good causing the externalities compared to the efficient quantity. The lack of price determines the lack of boundaries for production.

Given this brief explanation, it is evident that CO_2 emissions, and pollution more in general, can be ascribed to the category of negative externalities. Considering pollution as a good, it is possible to understand how it is a commodity produced within other production or consumption processes (e.g., emissions generated by burning oil or natural gas to produce energy), and how it has negative effects on society, triggering harmful and potentially irreversible phenomena such as the greenhouse effect, with all its consequences. Before moving on, it is important to briefly elaborate on this concept by referring to actual data.

The presence of CO_2 emission into the atmosphere is a natural and benefic process, which has always occurred throughout Earth's history. Fig. 1 shows how global average concentrations of CO_2 in the past 800.000 years have constantly fluctuated, never exceeding 300 parts per million, and how this trend dramatically changed with the industrial revolution in the second half of the 1800s, because of the advent of industrial systems and the use of fossil fuels, primarily coal and oil (Pörtner et al., 2022). The other important issue emerging from the analysis of this graph is that not only the level of CO_2 concentration has increased, but also the rate changed: historical peaks of CO_2 concentration tended to occur over centuries or thousands of years, caused by sporadic events of very large magnitude called Milankovitch cycles (periods of increasing and decaying CO_2 coincide with the onset of ice ages (low CO_2) and interglacial ages (high CO_2). On the other hand, the new peak, which has already overpassed the limit of 400 ppm, has happened in less than 200 years, thus eliminating the possibility for the living systems to adapt to global warming associated with increasing concentrations of CO_2 and GHG equivalent in the atmosphere (Ritchie et al., 2020).

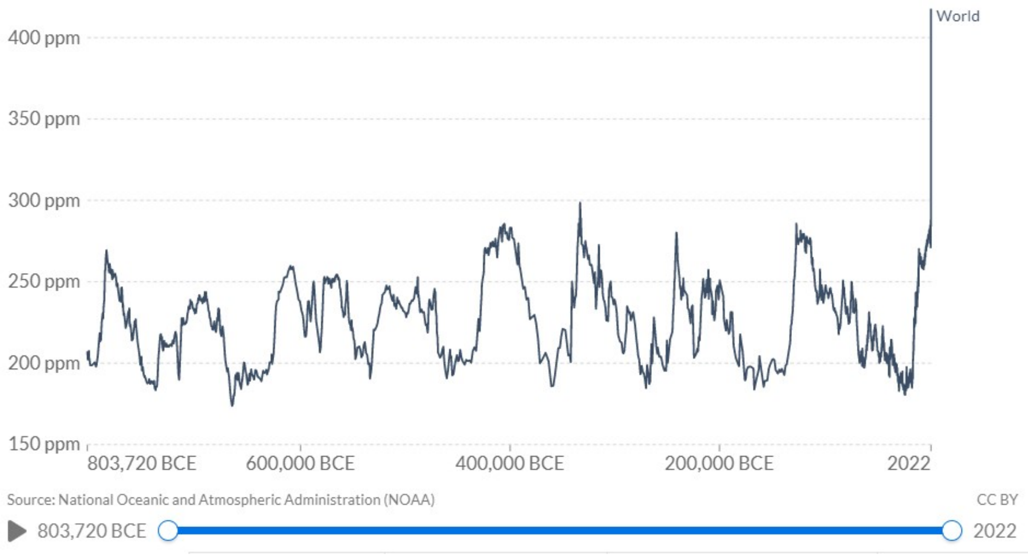

Fig 1: Global Atmospheric CO_2 concentration, (Source: Ritchie et al., 2020)

Completing the above-mentioned definition of externalities, the impacts of the emissions must be considered, and in the graph below, taken from the summary for policy makers of the latest IPCC report, it is possible to see clearly how the projected increase in global temperature, caused by GHG emissions through the greenhouse effect, will impact terrestrial ecosystems and marine ecosystems (on which we depend for food, water, tourism etc.) and also our direct human health. In particular, the graph (a) shows three possible future scenarios: a very high rise in temperatures in case there is no reduction in the current pollution trend and a "limited" but present reduction in case the climate targets are met (Pörtner et al., 2022).

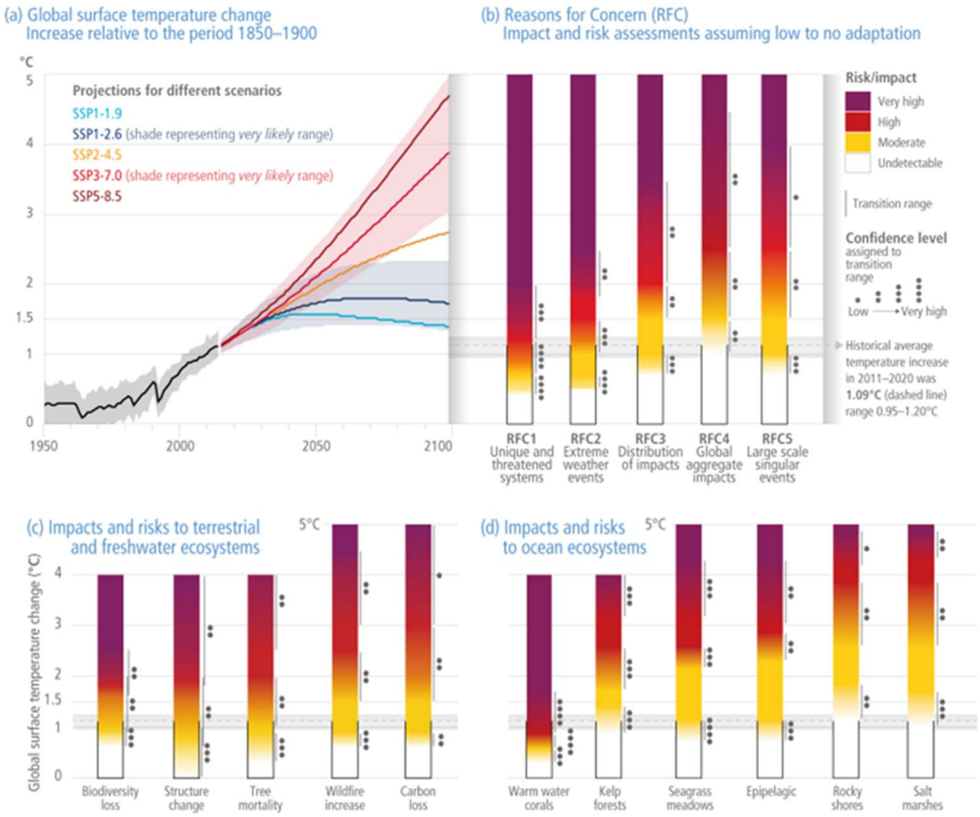

Fig 2: Global and regional risks for increasing level of global warming (Source: Pörtner et al., 2022)

This graph is designed on the assumption that facing and understanding the risks posed by rising temperatures and thus the amount of emissions emitted, the political will to act to limit pollution will mobilize to define target and policy to achieve them. As specified above, emissions are generated by human productive activities, and therefore what would be the ecological optimum, that is, to immediately bring emissions to zero, would entail the cessation of most productive activities, which would entail an unimaginable social cost. Moreover, it is widely documented in the literature how reducing emissions to zero to date is not only factually impossible but would not even be likely to stop global warming (Perman et al., 2011), and the basic logic behind this statement is presented in the figure below.

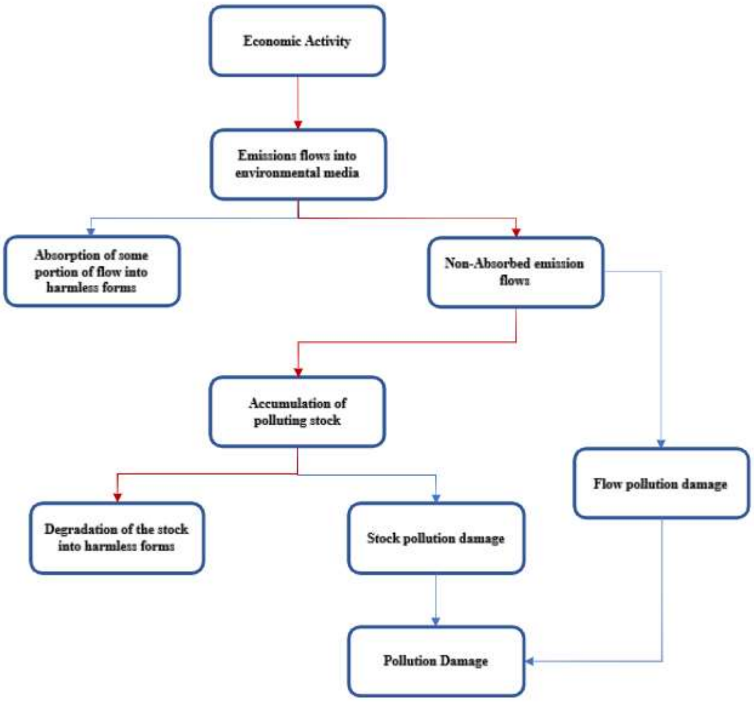

Fig 3: Economic Activity, residual flows, and environmental damage (Source: Perman et al., 2011)

From this chart emerges what already stated, i.e., that economic activity produces emission flows into the environment. What needs to be underlined looking at the red rows in the figure is that a portion of these emissions flows is quickly absorbed and transformed into harmless forms (one of the main processes through which this happen is photosynthesis, which will be presented in chapter 3), and the amount of this absorbed pollution depends on the carrying capacity of the ecosystems. However, the dramatic increase in CO_2 concentration presented in the above graph has far exceeded the amount that can be absorbed naturally, and consequently non-absorbed emission flows remain in the atmosphere creating the stock of pollution, which is also subjected to decay but in a very slow rate and the persistence of which is the cause of the well-known greenhouse effect. Thus, it emerges how the damage created by pollution is thus determined by the sum of the pollution flux at time t (i.e., emitted in present time) plus the accumulated pollution in the atmosphere.

In the end, given the interdependence between our economic well-being and the level of pollution, defining the acceptable level of emissions and the rate at which this can be reduced without causing the cessation of productive activities becomes a very difficult task for policy makers, a game whose rules can be schematized according to the model, which is based on the following assumptions:

M = is the amount of CO_2 emissions emitted and calculated in tons of CO_2 (GHG equivalent), in this first analysis it expresses ONLY the flow of the emissions, assuming for the moment that no stock is accumulated.

Damage caused by pollution = D = D(M), these are the costs that the society bares for pollution (health, resource erosion, climate change effects etc), Damages are represented by an increasing curve with increasing increments (graph a), and its derivative is a curve with first derivative higher than zero (graph b), meaning that the damages caused by pollution increases more than proportionally to the increase in emissions. This is in line with the results of the scientific literature, which states that as emissions increase, the damages will not only be growing but also in unpredictable way (Pörtner et al., 2022).

Benefits of pollution = B = B(M), represents the increase in social welfare due to increased productivity of firms (economically this is represented by the savings firms can obtain by carrying on polluting activities thus increasing the output produced). The benefit curve is shaped as an increasing curve with decreasing increments (graph a) and has therefore a negative derivative (graph b). Mathematically, this shows how benefits increase as emissions increase, but following a decreasing trend, once passed the maximum point. This represents the fact that, having reached a certain threshold, benefits are still bound to decrease even in the presence of increased production (and thus emissions). This could happen, for example, due to depletion of natural resources. Once again, this is a graphic representation of the concept of an impossible infinite "traditional" growth with limited resources, which is well documented in the literature beginning with the seminal "The limits to growth" report published in 1972 (Meadows et al., 1972).

Net Benefit = NB = B(M) – D(M) is the difference between the benefits obtained by the pollution activities and the damages caused. From the graph we see that Net Benefits are maximised when the difference between the harms and benefits is maximal, that is, the derivative before the marginal benefits is equal to the derivative of the marginal damage curve (point of intersection in graph B).

Reading fig. 4 helps us in understanding what has been said so far:

M^ → represents the natural level of pollution, i.e., what would naturally occur in the absence of instruments to resolve the externality, and thus have productive enterprises internalize the costs of the harm that society must bear.

M* → is the efficient level of pollution, i.e., the level of pollution whereby the economic benefits from pollution equal the damages incurred by society. This is the level of pollution deemed economically and socially efficient, and thus represents the policy target. M* does not occur naturally but only because of government intervention leading firms to internalize some of the costs of negative externalities.

μ* emission shadow price, is the price firms must pay, in terms of lost profit caused by reduced output, to internalize negative externalities.

It clearly emerges that reducing the level of pollution from M^ to M* it results in a consistent reduction in both harm and benefit, where:

A = Damage reduction realized by a reduction in the pollution level from M^ to M*

B = Benefit Reduction realized by a reduction in the pollution level from M^ to M*

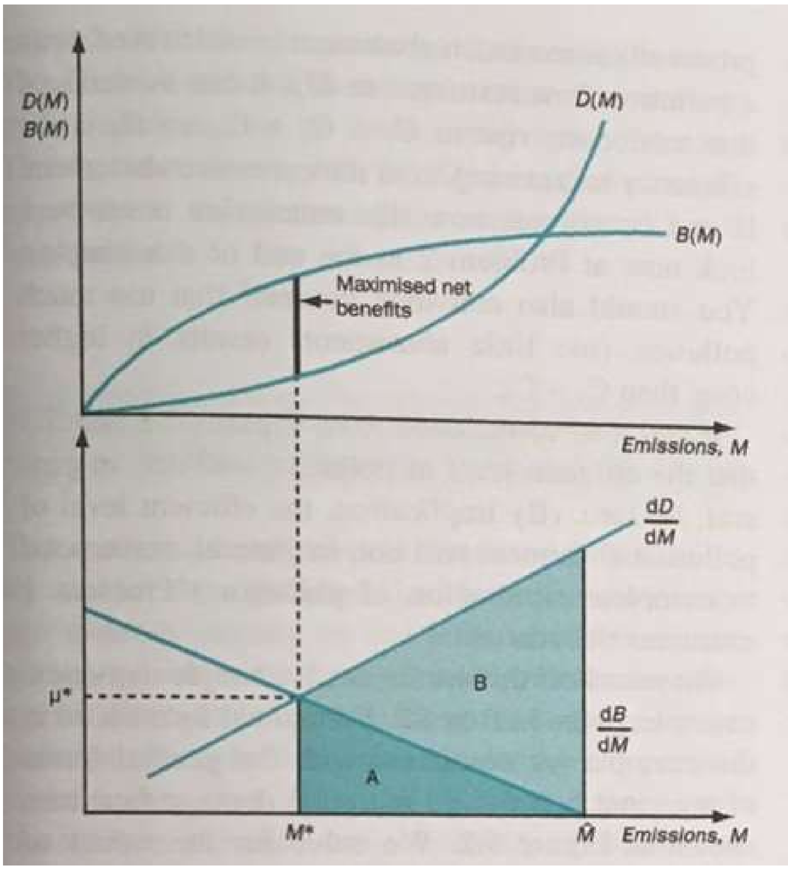

Fig 4: Total and marginal damage and benefit functions, and the efficient level of flow pollution emissions (Source, Perman et al., 2011)

So far, the model has helped us understanding the interdependence between the economic and social benefit from polluting activities and the social and environmental damage caused by them. Consequently, the main challenge for the policy maker is to identify the efficient level M*. It is now possible to slightly complicate the matter by introducing the concept of time (t), and therefore of accumulation of the pollution stock.

By inserting time and stock, the functions of damage and benefit change consequently:

Dt = D(At) the damage function now depends also on the accumulated pollution stock (At)

Bt = B(Mt) the benefit function still depends on the emission flow since they are released by the economic activity.

According to the general rule that if the decay rate of the pollutant is lower than the accumulation rate, the stock grows over time and vice versa. This concept is summarized by the differential equation representing the emission stock-flow relationship (Called the Law of Stock Accumulation):

$$\frac{\partial A}{\partial t} = Mt - \propto At$$

Where α is a constant value ranging between 0 and 1, representing the absorption rate of emissions, i.e., the rate at which emission naturally decay in the ecosystem (α =0 means a perfectly persistent stock, α =1 means that all emissions are instantly absorbed). αAt is the amount of pollution decay.

To correctly identify the M * level of pollution, the marginal benefits and the marginal damages must always be put equal, but this time we obtain a new family of optimal solutions, where the stock accumulation law appears as a constraint:

$$Max \int_{t=0}^{\infty} [B(Mt) - D(At)] e^{-rt} dt \; s.t. \; \frac{\delta At}{\delta t} = Mt - \alpha At$$

Which can be solved in the steady state, i.e., fixing $\delta At/\delta t$ =0, and it emerges that the final solution depends on α and the new parameter r.

a) Firstly, we see that the Law of Stock Accumulation changes, and that the stock is fully dependant on alpha values. Higher the alpha, minor the stock accumulated, confirming what has been stated before.

$$\mathrm{A} = \frac{\mathrm{M}}{\propto}$$

b) Secondly, the parameter r is the so-called social discount rate. it represents the weight that the society recognizes to the quality of the future environment. If r increases the society recognises less importance to environmental quality, therefore it will be more willing to tolerate an increase in emissions in exchange for a greater economic benefit.

This brief overview of the model presented by Perman et al., (2011) is useful to draw the following conclusions, in line with as already been stated:

1) Mt=0 does not lead to D(M) = 0, a sudden stop of polluting activities would not magically resolve damage because of the accumulation of pollution in the atmosphere,
2) Mt=0 can have a very high social and economic cost, so emission reduction is a process that should be handled very carefully and gradually,
3) The level of efficient pollution depends on α (absorption capacity of emissions) and r (weight that society accords to the damage caused by pollution),
4) It is possible to lead companies to internalize their emissions, and this can be done through the recognition of the shadow price of emissions.

This analysis shows how, according to environmental economics theory, the policy makers identify the emission targets, and which are the main parameters which need to be taken into consideration. In the next chapters each one of the above-mentioned conclusions will be detailed, by showing how each of these parameters occurs within the implementation of a VCM system based on Carbon Farming. Chapter 2 presents a brief overview of the tools policy makers can resort to reach M* disposal. While presenting the functioning of carbon markets, it will be also presented in detail how the latter create the market for negative externality, creating a price to bear for CO_2 emissions equal to mu *. Chapter 3 presents a more technical overview on carbon farming, and on how, through the implementation of ad hoc practices, it is possible to effectively increase the capacity of the soil and of the agricultural ecosystem in general to absorb CO_2, and therefore achieve an increase in alpha parameter. Finally, chapter 4 presents in detail the application of what has been explained in chapter 2 and chapter 3, namely the creation of a voluntary carbon credit trading system for the agricultural sector. Presenting the reference legislative framework and in particular the climate objectives that Europe has set itself, it emerges that the discount rate r has now much decreased compared to the past, and that there is a strong commitment to achieve climate neutrality by 2050, which in fact means setting M * = 0.

Ch. 2: Overview of instruments to internalize emissions (or how can we get to the M*?)

In the previous chapter we explored briefly the main parameters affecting decisions on emission reduction by policy makers, and the main related trade-offs. It emerged that governments usually have different objectives on their agenda when identifying environmental targets, and related policies, and for this reason the choice and adoption of a particular instrument is never easy nor immediately evident.

Table 1 shows an example of the different criteria adopted for the selection of pollution control instruments.

Table 1: Criteria for selection of pollution control instruments (Source: Perman et al., 2011)

Criterion	***Brief Description***
Cost-Effectiveness	Does the instrument attain the target at a least cost?
Long-Run Effects	Does the influence of the instrument strengthen, weaken, or remain constant over time?
Dynamic Efficiency	Does the instrument create continual incentives to improve products or production processes in pollution-reducing ways?
Equity	What implications does the use of an instrument have for the distribution of income or wealth?
Dependability	To what extent can the instrument be relied upon to achieve the target?
Flexibility	Is the instrument capable of being adapted quickly and cheaply as new information arises, as condition changes, or as targets are altered?
Costs of use under uncertainty	How large are the efficiency losses when the instruments is used under incorrect information?
Information Requirements	How much information does the instrument require that the control authority possess, and what are the costs of acquiring it?

As it emerges, the final decision will depend mainly on the relative weights associated to each criterion by the policy makers/environmental agency, and for this reason the intervention is often made of a combination of different instruments.

2.1 Overview of non-market instruments to reach emission targets

Perman et al., (2011) in their book identifies three main categories of instruments:

1) Institutional approaches to facilitate internalization of externalities;
2) Command and Control Instruments;
3) Economic incentives and other market tools.

The institutional approaches to facilitate internalization of externalities consists of the implementation of actions to improve already existing social or institutional ways to contain environmental damage. Also referred to as "soft instruments" to control pollution, the most adopted are:

- **Facilitation of bargaining**: which aim to reduce transition costs that prevent individuals from spontaneously reaching an agreement on the socially accepted amount of pollutants emitted. This solution refers to the Coase theorem, according to which under conditions of a regime of well-assigned property rights and transparent information, free negotiation among individuals can correct the problems arising from the production of negative externalities, and lead to efficient resource allocations *(*Frank et al., 2016). One example is the case in which polluter information are placed in the public domain, for example trough transparent lifecycle assessment or adequate labelling on products.
- **Specification of liability:** which goes mainly through the codification and regulatory definition of liability in case of environmental damage. One example of a practical implementation of this instrument has been the liability established in Japan for polluters causing respiratory damages in the population. The quotas paid by the polluting subjects were used as compensation directly for the sick subjects and therefore victims of the negative externality (Botta et al., 2020).
- **Development of social responsibility**: these instruments respond to the logic that pollution is mainly caused by self-interested and uncoordinated behaviours. Therefore, they aim to encourage people within society to behave as informed citizens, aware of the dependency between their individual and social well-being and the containment of emissions. The main tools on this regard are environmental programmes in schools/environmental education, environmental labelling, or energy conservation campaigns.

The main objective of this category of instruments is to prevent the emergence of externalities or push for a spontaneous internalization. This is a very broad category of tools that can be applied in different phases of the production sector; they are generally considered to be relatively simple to implement, but their effectiveness is often visible only in the long-term, and they are rarely decisive. Their purpose is to act synergistically with more incisive instruments.

A category of tools that are certainly more immediately effective, but much more complex to implement, is the so-called command and control instruments. This category consists of these instruments which allow regulators and environmental agencies to exercise a direct control over polluter subjects. They can be designed to be applied at any stages of the production chain, since emissions are mainly related to production processes, and this makes them particularly adaptable. Therefore, they are among the most adopted tools in many countries (Perman et al., 2011). The main instruments ascribed to the category of command and control are:

- **Input controls over quantity and/or mix of inputs**: imposition of requirements to use only non-pollutants inputs or prohibitions and restriction on the use of pollutant ones. An example is the ban of toxic chemicals announced by the Eu Commission with a plan called Restriction Road Map (European Commission, 2022 a).
- **Technology controls**: imposition of specific requirements during the production process. An example is the establishment of the Best Available Technology requirement within the EU (WeCoop, 2010).
- **Output quotas or prohibitions**: prohibition of the introduction of specific pipelines or polluting practices in the production process. An example is the ban of the adoption of the DDT for agricultural uses in the 70's in Europe (European Commission, 2013).
- **Emission licenses**: definition of allowable pollution limits and allocation of non-transferable permits among the various polluting industries. An example, which will be presented later in this chapter, is the European Trading Scheme (European Commission, 2021).
- **Location controls**: Regulations relating to admissible location of activities. An example is the creation of productive districts in the city of New York and the creation of ad hoc environmental legislation (Novik, 2021).

As presented, command and control instruments operate by imposing mandatory obligations or restrictions on the pollutant subjects. For this reason, its application requires strong State intervention, which in democratic regimes must necessarily be based on a broad base of political consensus. This is often difficult to achieve, as well as the needed almost complete sharing of information on processes and materials used by industries and, above all, the implementation of an adequate control capacity to monitor and possibly punish those who do not respect the limits imposed (Sinclair, 1997). For these reasons, the adoption of command-and-control instruments can often be only partially implemented. Another general critic carried on against this category of tools is that they there is not a sophisticated enough mechanism to evaluate or price the abatement costs of the pollutants, which could lead this type of intervention to have very high costs for the single company and, when broadly applied, for the society in general (Cunningham, 2018). The other and more liberal approach is the implementation of market instruments, which are now presented in more detail.

2.2 Overview of market instruments to reach emission targets

Perman et al., (2011) in their book define market instruments as "*Incentive-based tools which work by altering the structure of pay-offs that agents face, thereby creating incentives for individuals or firms to voluntarily change their behaviour*" (Perman et al., 2011 pg 195). The main lever of action is the alteration of the relative prices faced by economic agents, and the main instruments to do so are:

a) Imposition of taxes on emissions
b) Payment of subsidies for emission reduction
c) Institution of a tradable emission permit framework

The imposition of a **tax on a polluting activity** is the most immediate market tool. The tax impact company's activities by reducing the marginal benefit to pollute, therefore making it convenient to reduce the amount of polluting emissions released into the atmosphere. This can happen through a contraction of production or, if the tax is applied in a synergic manner with other types of intervention such us technology change incentives, through the transition to cleaner technologies, adoption of renewable energy sources or through a transformation of the production chain.

The creation of a well-designed and effective tax can have important benefits in terms of emission reduction, and a good case study is the example of the carbon and fuel tax applied in British Colombia. As a matter of fact, in 2008 British Colombia decided to adopt a broad-based carbon tax, the first State to do so in North America. Although initially this imposition was greeted with much criticism from the conservative party, and a substantial part of public opinion, to date the results are very positive: fossil fuel use has dropped by 16% and at the same time the economy has gone through an unexpected shift and recovery even in the hardest years of the economic crisis (Cunningham, 2018). Moreover, it is important to consider that the British Colombia carbon tax was designed to be revenue neutral, meaning that all the state revenue obtained thanks to the tax were employed to reduce other taxes. This factor, together with the fact that the tax was designed in a progressive manner, with an initial value of $5C per 1 tonne of GHGs before reaching $30C in 2012, allowed to reach a broad social acceptance, with nearly 60 percent of citizens saying they were in favour of the tax in 2016. However, it is essential to consider that in almost all the province energy comes from the hydraulic systems at the dams, and therefore the tax has not impacted energy production nor the underlying habits of citizens, but rather the production systems. These conditions do not always occur, and therefore the implementation of environmental taxes is a delicate issue on the political agenda and requires careful planning and compensation. On this regard, an example of the damage caused by the imposition of a tax which is not accepted by citizens can be the riots that occurred in France with the Jilet Jaune movement, triggered in 2018 precisely by the initiative to impose a new fuel tax (Grunberg, 2019).

As a quite natural consequence, the far more easily acceptable **subsidies for reducing polluting activities** have developed. In practice the subsidy acts much like a tax, reducing the marginal benefit to the firm from polluting and reducing the perceived cost of the reduction of pollutant emissions. However, the challenges of implementing an effective subsidy regime are equally complex, first and foremost the weight of the expense on the state budget (Perman et al., 2011).

The third way of action that a regulator can adopt to reduce the level of pollution within the market system by acting through market instruments is the creation of a **tradable emission permit framework**.

It is one of the basic assumptions of economics that new global challenges are always stimulus for the creation of new markets, and as it is emerging on these last years, the ongoing climate crisis and the rising emissions are no exception. A good example of this is the case of case of **carbon credit markets**, which can be defined in very general terms as a system in which, within a defined legislative framework, polluting entities can purchase units of CO_2 or other GHG absorbed by other actors (CarbonCredits, 2022a). The competent authority can obtain a gradual reduction of the total cap through the reduction of the number of allowances released each year, and this is intended to happen in a cost-effective way since allowances are freely tradable (Kotzampakis et al., 2020). In the end, the whole process can be summarised saying that Carbon Markets transform CO2 into a commodity, and by creating a price to it solve the externality problem.

The first implementations of tradable emission reduction systems started in the 90's, and one successful example is the creation of the Sulphur Trading System established in the USA in the 1990. The initial good results obtained by this scheme fostered the action at international level, which culminated in the signature of the Kyoto Protocol (Cunningham, 2011).

As a matter of fact, in 1997 the Kyoto Protocol has been ratified by all the industrialized nations in the world (with the only important exceptions of the US and Australia, while Canada withdrew in 2012). The protocol established a mechanism called emission trading to control greenhouses gas emission. This is also called cap and trade approach. It is composed on the following step:

1. Definition by the regulator of the cap (acceptable level of pollution), or better mandate the upper limits on how much each economy or sector or specific industry is allowed to pollute;
2. Definition of the rule: companies which can reduce their emission more than mandated are free to sell the carbon credits on a specific regulated market
3. Companies which are not willing to cut their emissions (or cannot) can buy these credits to compensate their emissions (Unfccc, 2022).

Before delving further into the subject, an important distinction needs to be made between the terminology adopted, and the and the different meanings with which often the same words are used, going to increase the confusion in front of a subject already rather complex. (CarbonCredits.com, 2022a). As a matter of fact, the term carbon credit is often used to express three concepts that, although have similar application, have substantial differences that cannot be ignored. As it is summarized in Figure 5, the unit of 1 ton of CO2 or Greenhouse Gas Equivalent can have different shades of significance. Establishing that the regulator and the society goal is to reach emission level equal to zero (M=0), and that the efficient level of pollution is identified at M* in the current time (t0), with the willingness to abate it and bring it as close as possible to 0 in the next future (M → 0), the single unit of 1 ton of CO_2 can be referred to:

- the unit of measure adopted to indicate the quantity of CO_2 defined as cap (equal to M*) and divided among the pollutants defined by the system, and so technically speaking it can be seen as an allowance. Still, in the literature the term used is still carbon credit, as stated by Gupta (2011, pg. 17), "O*ne carbon credit allows one tonne of carbon dioxide or a corresponding amount of other greenhouse gases to be discharged in the air*". Carbon Credit are bought by companies that cannot or are not willing to abate their pollution level.
- It can refer to the concept of emission saved, i.e., when a company implement a set of actions, such as adoption of new technologies, renewable energies sources etc., which bring to the saving of 1 tonne of CO_2 which can be reduced from the cap initially established. In this term we can refer to emission savings.
- 1 tonne of CO_2 can also refer to the amount of CO_2 that was already emitted and has been removed from the atmosphere and stored through a restoration project (e.g., the planting of trees in certain circumstances, or the implementation of ad hoc actions within other production processes (e.g., the implementation of conservation agriculture practices). Offsets are defined by Gupta (2011 pg 18): "*A carbon offset credit is equivalent to reduction of one metric ton of CO_2 or equivalent greenhouse gas in the atmosphere*".

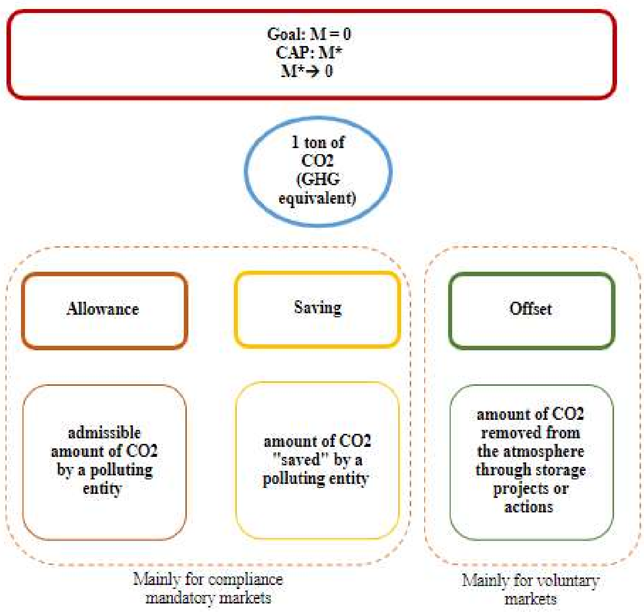

Fig. 5: Breakdown of the different uses of the term carbon credit

It is interesting to note that the first two concepts of carbon allowance and carbon saving refer above all to a type of mandatory market in which the emissions cap is established, while the third refers above all to a voluntary market in which there is no predetermined emissions cap but rather the aim is to store as much CO_2 as possible.

The second main distinction need to be done among mandatory and voluntary carbon markets.

- Mandatory Compliance Markets
- Voluntary Carbon Markets

Mandatory compliance carbon markets fall entirely under the control of the policy maker (CarbonCredits.com). In this case, the regulator identifies the maximum level of emissions deemed socially acceptable, identifies polluting firms that must reduce their emissions, and allocates the amount of emissions "available" among polluting entities in the form of permits or credits to pollute. The assignment of these permits can be done directly (and in this case the company does not incur in any expense) or by auction and therefore with a variable price and dependent on demand. Pollutants companies can enter a specific regulated market where they can buy extra credits sold from other companies which manage to cut their emissions, and therefore do no longer need their quotas. Many states have established mandatory compliance trading Schemes now a day, Kotzampakis et al., (2020 pg 3) states that "*In 2020, one out of six people in the world live in a jurisdiction that operates a cap-and-trade program to curb climate change"*, and the volatility of the prices depends on the measures, limits and targets identified by the regulators. To provide an example, the figure below shows the real time prices of the two main Trading Schemes established, The European Trading Scheme and the California Carbon Market.

Fig 6: Daily price trend extracted to May 9, 2022 (Source: Carboncredits.com, 2022b)

The "California Cap and Trade Program" represents the allowances regulated by the California Carbon Allowance (CCA) program. One CCA credit represents one metric ton of CO_2 equivalent under California Assembly Bill 284 "California Global Warming Solutions Act of 2006".

The European Trading Scheme, established with the Directive 2003/87/EC (as last amended by EU Directive 2018/410), requires that, starting from January 1st, 2005, large emitting companies within electricity and heat generation, energy-intensive sectors (refineries, steel works, and production of iron, aluminium, metals, cement, lime, glass, ceramics, pulp, paper, cardboard etc.), commercial aviation within the European Economic Area cannot operate without a greenhouse gas emissions permit. Each permitted installation must annually offset its emissions with allowances (European Union Allowances - EUAs, equivalent to 1 tonne of CO_2), which can be bought and sold by the individual operators concerned. Companies are allowed to buy allowances at European public auctions or receive them free of charge. Alternatively, company can buy exceeding quotas sold on the market, by companies which have "saved" on their own emissions or credits realized through projects expressly considered by the directive. Each Member State establishes a National Quota Allocation Plan and has it approved by the European Commission. The Commission then ensures that the overall ceiling is not exceeded.

It is interesting to notice that the price difference is consistent, and this is due mainly to the fact that the two jurisdictions have adopted different targets: EU set a new intermediate target of emission reduction of 55% before 2030 (compared to 1990 levels) and aim to reach net-zero by 2050, while the California System has the goal to reach an intermediate target of emission reduction of at least 44% (compared to 1990 levels) and to reach a reduction of at least 80% below 1990 level by 2050. It is evident that also other factors influence this difference such as the fact that the two regulators have adopted very different regulatory approaches regarding the market stability, price limits and cost containment (Kotzampakis et al., 2020).

The creation of Emission Trading schemes all around the world has been celebrated as one of the most important actions to combat climate change, reaching in 2020 the total market size of US$261 billion, representing 10.3Gt CO_2 equivalent (CarbonCredits.com 2022a). Despite this important impact, there are several aspects that are widely criticized by industry experts.

For example, the European Trading Scheme in 2018 covered the actions of more than 11,000 pollutants from 31 countries, counting for about 40% of European Greenhouse Gas emissions (Barolini, 2018). Anyway, many scholars focus on how prices are very volatile, and not high enough to ensure a real impact on production systems. Jean-Yves Caneill, of the European Roundtable on Climate Change and Sustainable Transition (ERCST), points out that if climate targets are to be met, the price must not be less than 40 euros, whereas in past years prices have fallen to as low as 3/5 euros per 1 tonne of GHG (Barolini, 2018). This price volatility, which is not exclusive to the European system, is due primarily to two causes: first, a rather high initial cap on permitted emissions, and thus a relative abundance of permits; second, especially during the crisis and then in the subsequent years of economic regression, by the fact that companies have had to cut back on their production, and thus have sold their unused credits. In these cases, therefore, the sale of credits on the market was not due to the actual reduction of emissions, but rather to the general contraction of production (Cunningham, 2018).

Parallel to the compliance mandatory carbon markets, **voluntary markets** have evolved over time as voluntary systems which enable pollutant subjects to offset their emissions by the acquisition of carbon credits generated by projects or initiatives which remove or decrease the GHG emissions from the environment (Kreibich et al., 2021). The main difference that needs to be underlined is the fact that companies engage in this second scheme on their own, often as part of Corporate Social Responsibility initiatives or industry program.

VCM are a fast-growing reality, and their contribution to meeting climate goals is becoming increasingly evident (Kreikbich et al., 2021). The Bank of America Global Research underlines in its report that the segment will go through a 50-fold expansion in demand by 2050. This will especially be the case for some hard-to-abate sectors, including construction, aviation, shipping, and metals, for which the technology to reduce emissions is lagging, meaning that other methods are needed to make progress at decarbonising (Bank of America, 2021).

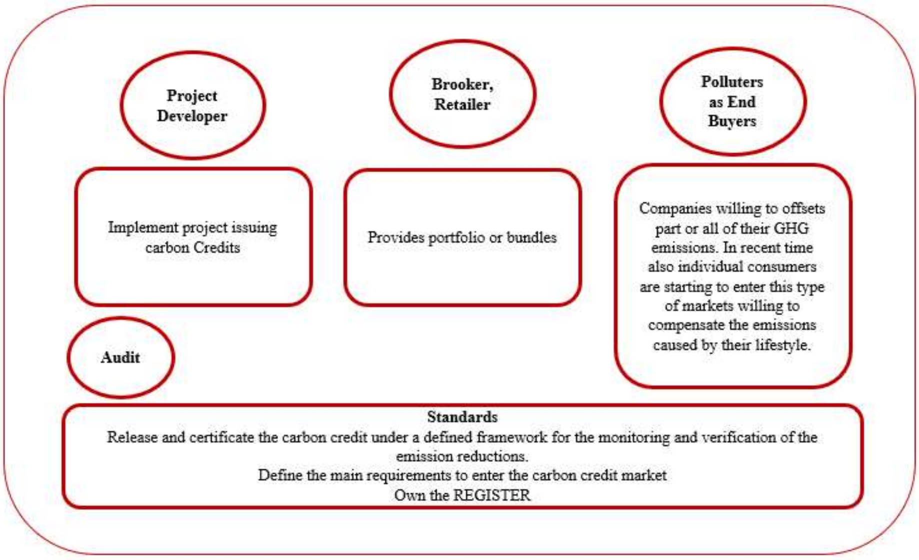

Fig 7: General structure of a Voluntary Carbon Market

Figure 7 shows the general functining of the VCM and the main actor involved. The project developers represent the supply side of the market, with projects which can range a lot in dimension and scale, while the nature of the project implemented may vary greatly from large renewable adaptation projects to community projects or reforestation ones. The presence of brokers and retailers is a growing phenomenon, together with the recent growth of the Voluntary Carbon Market itself, and their role is to facilitate the access of the end buyers to the market. The demand side is represented by polluting entities, willing to offset their emissions. The role of the audit is crucial in monitoring the credit exchanges and assess their validity against the standard.

As a matter of fact, Britsch et al. (2022) underlines the importance of the reference framework, and how it should always indicate:

- The requirements to be met when creating a project willing to create carbon credits. The main requirements are additionality the project, securing of permanent drop of emissions and exclusive claim, while other requirements can be established such as social or environmental benefits, often in line with the SDGs.
- The monitoring system adopted.
- The verification method and the metrics adopted to issue the carbon credit. These credits are usually (but not always) recorded in a register.

The dominant global standards are the Verra and the Gold Standards, both issued by private entities, but different local and public standards are also developing. To date, there are numerous standards with even substantial differences, however, most are beginning to converge, driven by requests for increasing uniformity from member companies, on the following parameters used to evaluate carbon farming projects (Liu, 2022):

- Realness: the effective absorbent of GHG is adequately measured
- Additionality: the absorbent is increased by project activities financed by carbon finance scheme
- Transparency: there is a third-party verification and information is clear and accessible
- Leakage: the project foresees mitigation of risks emerging during the activities
- Permanence: the carbon sequestered during the project is stored permanently (even if there is no accordance of a time framework)
- Completeness: the information is released regarding all the aspects of the project
- Ownership: the owner of the carbon offset is immediately identified
- Accuracy: the measurement is as specific and punctual as possible
- Conservativeness: the evaluation of the project is based on conservative assumptions in case of uncertainty.

Given the voluntary nature of VCM, there is currently a multitude of voluntary markets the various players can rely on. Each market adheres to one or more standards, that act as guarantors. This fragmentation, anyway, which is increasing exponentially as the phenomenon grows, raises material concerns for companies and regulators as the increase in demand, which also brings with it an increase in prices, will create a number of challenges are beginning to emerge for both companies and the regulator: in terms of reputational credibility and economic impact for the former, and in terms of the necessary transparency and impact on pollution levels for the latter (Britsch et al. 2022).

Fig 8: Daily price trend of Nature Based Carbon Offset extracted to May 9, 2022 (Source: Carboncredits, 2022b)

Figure 8 shows the trend of the market prices of N-GEO futures contracts, which are comprised of Nature-Based offsets projects under the Verra Standard. The credits objects of these contracts fall under the Agriculture, Forestry or Other Land Use categories, and have been selected as an example here because they are the most like to those possibly implemented by the carbon farming projects. As we can see, the prices are substantially lower than the compliance mandatory carbon schemes, but they have been consistently increasing, and volatility remains high.

The fact that prices are low and volatile, together with the fragmentation of the system are the main sources of concern about the proper and effective functioning of these markets, especially in the face of a demand that is continually growing (Britsch et al. 2022).

The fact that prices are low, on the one hand, encourages more companies to enter the market as buyers, but on the other hand, it becomes a major limiting factor in achieving climate goals. The above-mentioned report from the Bank of America underlines how, nowadays, voluntary carbon market prices range a day from 2$ up to 20$ per 1 ton of GHG, a price that is still considered too low, with the consistent risk of making voluntary markets an all-too-cheap route for companies wishing to offset their emissions rather than reduce them directly. In addition, the low level of prices can also discourage the implementation of projects aimed at issuing credits, or, as is happening now, encourage their implementation mainly in developing countries, where prices of realization are lower (Gillenwater et al., 2007).

The fragmentation and absence of regulation are the other main source of concern. British et al., (2022 pg 3) states that:" *VCMs are an often opaque, fragmented, and complex market and suffer from a lack of established standards. Although regulation and standardisation are gradually being introduced, it is coming from a low base*".

Important steps on this regard have been made during the 2021 COP26, where the final agreement outlined a structure for an UN-administered system in accordance with Article 6 of the Paris Agreement. Countries have finally established a set of rules to avoid double counting of emission reductions, according to what expressed in Art 6 of the Green Deal with the aim to foster confidence in emission markets (ukcop26, 2021).

Another relevant initiative is the Voluntary Carbon Market Integrity Initiative, which was launched in 2021 with support from the UK government. The Voluntary Carbon Market Integrity Initiative aims to develop high-quality and high integrity project performance criteria and eligibility to define core carbon market principles. The peculiarity of this initiative is the government support, which shows how institutions are starting to pay attention to a phenomenon that until a few years ago was considered almost entirely the prerogative of private entities. This does not mean that private entities have not understood the risks of an insufficiently credible and regulated voluntary market. Evidence of this is the creation of the Task Force on Climate-related Financial Disclosures (TCFD), which was established in 2015 by the Financial Stability Board (FSB) - the body that promotes and monitors the stability of the global financial system - to develop a set of recommendations on climate change risk reporting. Its goal is to guide and encourage companies to align their disclosed information with investor expectations and needs. The TCFD published its latest disclosure recommendations in October 2021. The TCFD provides a strong indication of what future compulsory disclosure related to carbon offsets will look like. The document recommends that organisations indicate the percentage of emission target to be achieved through emission reductions, removals, and offsets. It also encourages organisations to provide information on the type of offset and the offset provider, and to disclose their expected internal carbon price when making investment or strategic planning decisions.

Widening the spectrum of the analysis, the indications provided by these initiatives together with the analysis carried out by the literature, converge in establishing that to achieve a robust and credible voluntary carbon credit trading system, it is necessary to:

A) Create credits that are real, i.e. measured, monitored and verified to have actually occurred;
B) Release credits that are based on realistic and credible baselines, i.e. credited only beyond performance against a conservative baseline estimate of emissions that assumes the business as usual trajectory in the absence of the project;
C) Based on the criteria of additionality;
D) Secure that credits are counted once through the adoption of a transparent and accessible register.

To conclude this brief overview over the main concerns related to voluntary carbon market a crucial issue is raised by the Task Force on Scaling Voluntary Carbon Market (TSVCM), which is a private entity aiming to scale efficiently and effectively voluntary carbon markets. The TSCVM emphasizes how the existence of voluntary carbon markets risks becoming a mere substitute for corporate emissions abatement efforts, and together with the above-mentioned concern regarding the low level of prices, it underlines also how companies should still prioritize emission reduction actions and that carbon credits for net-zero claims as part of a science-based decarbonisation strategy, encompassing short, medium, and long-term targets.

Ch. 3: Carbon Farming (or how can we increase the alpha?)

Carbon farming falls into the category of nature-based solution, defined by the IPCC as solutions that provide multiple environmental, social, and economic benefits by intertwining disaster risk reduction, climate change mitigation and adaptation together with the restoration and protection of biodiversity and ecosystems. In the last decade, nature-based solutions have met growing interest in the policy system, and this has come together with the recognition of the strong interdependence between climate change, ecosystem degradation and biodiversity loss. This is a double-edged sword whereby ecosystem degradation is both caused and exacerbated by climate change. Ursula Von der Leyen recognised the power of the nature-based solutions and stressed how they play a central role in the European action plan to tackle climate change: "*Bringing nature back to health is crucial for our physical and mental wellbeing and is a tactical move in the fight against climate change and epidemics. It is at the heart of our growth strategy, the European Green Deal, and part of a European recovery that gives back to the planet more than it takes away*" (IPCCItalia, 2022).

Being Carbon Farming a Nature Based Solution and being its processes the key to the carbon scheme described within this thesis, it is important to devote some space to a brief explanation of the concepts of carbon sequestration and carbon balance, and the essential biological processes underlying them.

The fist concept that needs to be addressed is the concept of **carbon cycle** in nature, where carbon bonded with hydrogen or nitrogen forms the basic molecule of life and plays a dual role: 1) it is a structural component of organic molecules and 2) is the "energy storage" component, through its energy holding chemical bonds.

On the other hand, carbon bonded with oxygen forms Carbon Dioxide (CO_2), a heat trapping gas naturally present in terrestrial atmosphere, where together with other heat trapping gas such as water steam, carbon dioxide, nitrogen dioxide, methane, and chlorofluorocarbons, plays a key role as a regulator of the Earth's temperature, allowing the heat absorbed by the sun not to dissipate immediately into space, thus contributing to ensuring the conditions for life on Earth.

Through the carbon cycle, a single carbon molecule moves from one stage to another, and this occurs in nature mainly through photosynthesis and respiration.

Photosynthesis is the vital activity of plants, which allow the vegetation to absorb energy and create the fibres needed for its growth. Through photosynthesis, the plant transforms sunlight, water, and atmospheric carbon dioxide (CO_2) into carbohydrates and oxygen, its vital elements. Therefore, when studying biotic carbon pool, we refer mainly to photosynthesized carbon which has been fixed by the plant and "used" for its own growth. In addition, research in this field has for years shown that the carbon that is not immediately absorbed by the plant can be directly transported in the soil from plant's root as compounds that plant roots exude. Between 10% and 40% of photosynthesized carbon passes though the roots within an hour (Toensmeier, 2016). Plant respiration is the opposite process, though which carbon moves from the plants back to the atmosphere. For this reason, respiration is defined as the opposite of photosynthesis; it is important to distinguish between autotrophic respiration, the case in which carbon dioxide flux from plants, and heterotrophic respiration, which refers to respiration of soil biomass.

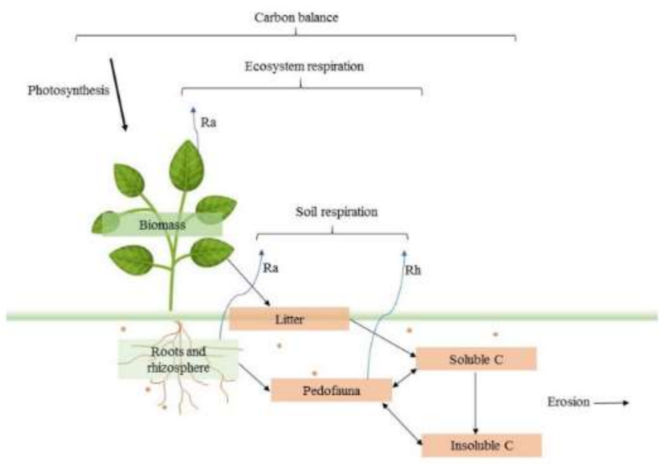

Fig. 9: Simplified picture representing carbon cycle (Source: CarbonFarming Scheme, 2022)

If rate of photosynthesis is higher than total respiration rate, the ecosystem stores more carbon than it emits. In this case we refer to soil and biomass as **carbon sink**, defined as any area that absorbs or holds more carbon than it gives off. A carbon sink absorbs carbon dioxide from the atmosphere, effectively filtering out excess carbon dioxide in the atmosphere. This process is known as **carbon sequestration**, and the difference between the carbon absorbed through photosynthesis and the carbon re-emitted into the atmosphere through respiration determines the **carbon balance**. Rate of respiration and rate of photosynthesis depends on several environmental, climatic, soil characteristic and species-specific factors (Bispo et al., 2017), and many other biotic factors intervene in this process such as plant input and soil organisms, weather (temperature and precipitation) and soil mineralogy (soil physio-chemical properties) (Luo et al. 2017).

Soil and biomass have the potential to trap and store carbon for long periods of time, and this makes them **carbon pools**. The definition of carbon sinks and carbon pools, and especially the temporal and quantitative limits for considering a ton of CO_2 absorbed, i.e., the permanence of CO_2 in soil or plants, is still debated in the literature. On this regard Carbon Dioxide is emitted also by other natural sources such as decomposing organic matter, forest fires, volcano eruptions etc. It is estimated that around 60-70% of carbon absorbed is released back in the atmosphere as CO_2 when the plant dies and the vegetal mass falls to the ground where is decomposed, and this is the permanence issue. On the other hand, the plant's root become soil carbon remaining "captured" underground, unless they are carried into the air by natural agents such as animals or by human action, e.g., this typically occurs through deep tillage practices, as it will be better present in the next paragraph. (Toensmeier 2016).

On Earth there are five major carbon pools, which operate incessantly to maintain the delicate balance of greenhouse gases in the atmosphere, enough to warm the planet sufficiently, without dramatically altering its stability.

- Oceans, which represent the 77,4% of global carbon pool, even if acidification of the waters is limiting their absorption power,
- Fossil carbon, which represents 14,9%
- Soil, which counts for 5%
- Biotic carbon pool (vegetations and animals), which represent 1.2%
- Atmospheric pool, which represent 1.5%.

Globally the annual flux of carbon between decomposition of organic matter and plant respiration is 119.7 Pg and photosynthesis flux is 123 Pg carbon per year, which makes soil a carbon sink (Bispo et al., 2017).

With the increasing development of human activities, and since the industrial revolution, abiotic factors have been added to the carbon cycle, undermining this delicate and vital balance. On this regard, human activities have altered the carbon balance on two main ways: 1) the amount of CO_2 emitted into the atmosphere has increased steadily and consistently 2) the capacity of carbon sinks to absorb and store carbon in carbon pools has decreased progressively. This is valid for all carbon pools, and in particular for soil and biomass. As a matter of fact, according to the 6th Assessment Report of the IPCC, greenhouse gas emissions resulting from human activities are responsible for the warming of about 1.1°C since the beginning of the 20th century, while deforestation and agriculture have caused the loss of terrestrial carbon. The estimated loss amount is 320 billion tons of carbon, and majority of this has happened since 1850 (Toensmeier, 2016). This number appear even more dramatic if we consider that about 33% of the world's soil is recognised as degraded, with large loss of Organic Soil Matter (SOM) which is the main source of Soil Organic Carbon (SOC), caused by human actions, mainly deforestation and intensive agriculture (IPCC, 2022).

For several decades literature has been studying how to restore degraded soils, and nowadays the huge value and the role that renovation of degraded soil could play in the mitigation of climate change is recognised in the SDGs framework, where the status of carbon stocks above and below ground is one of the three indicator used to determine the proportion of land that is degraded over a total land area, toward the towards achieving of SDG 15: *"Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss"*. The soil can be restored though conservative and regenerative practices, and the recoverable carbon reserve capacity of the world's agricultural and degraded soils is estimated to be between 21 to 51 Gt of carbon (FAO, 2022).

The role played by agriculture in restoring soil absorption capacities and specific techniques are presented in the next section. The next section will also focus on the challenge of quantifying and monitoring the amount of carbon absorbed and stocked in sound and biomass.

3.1 Carbon Farming Techniques

The IPCC (2022b) underlines the important role that Agriculture can play in the mitigation and adaptation challenge to climate change. The mitigation potential from agriculture by 2030 is estimated to be more than 5500 MtCO2 per year at global level, and more than 20% of the absorption potential lies in OECD countries, while 10% lies in EIT countries and around 70% of this potential in other countries, mostly developing ones. Considering the creation of a global carbon credit market for the agricultural sector, the economic potentials is equally important, as it is estimated to absorb between 1500-1600 MtCO2-eq/yr at carbon prices of 20 US$, reaching an absorption power of 4000-4300 MtCO2-eq/yr for a 100 US$ price. (Smith et al., 2007).

As just presented, agriculture plays an important role, both ecologically and economically. For these reasons, for decades the literature has been devoted to research on sustainable and beneficial agricultural practices, with increasing institutional and political support, as shown in chapter 2. The aim of this section is therefore to present the concept of carbon faming and which its main techniques are.

According to the Technical Handbook "Establishing and implementing results-based carbon sequestration mechanisms in agricultural soils in the EU", carbon sequestration in agricultural soils refers to the management of carbon pools, carbon circulation and greenhouse gas fluxes at farm level implemented to mitigate climate change. The set of actions implemented to reach this goal are ascribed to carbon farming, which includes therefore both soil and livestock, all carbon sinks in soil, materials, and vegetation together with the fluxes of carbon dioxide (CO_2), methane (CH4) and nitrous oxide (N2O). The latter is among the relevant greenhouse gas fluxes in the agricultural sector identified by the IPCC and therefore considered part of the carbon sequestration in agricultural soils. The processes are illustrated in Figure 10.

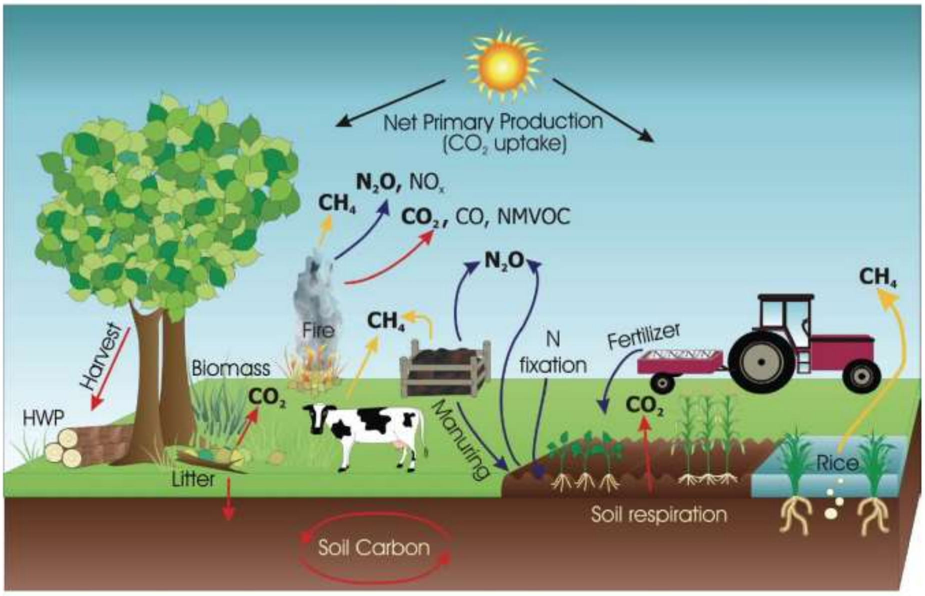

Fig 10: Main sources/absorption and processes related to Greenhouse gas emissions in a managed agricultural land (Source: IPCC 2006)

The application of specific agricultural practices can increase the absorbing capacity of the reference cropland and reduce the amount of carbon dioxide released into the atmosphere. This is confirmed also by the IPCC, which underlines how Laceyagricultural practices can help reducing emissions and meet the ambitious targets defined by the European political agenda.

The concept of Carbon Farming goes hand in hand with the term conservative agriculture and regenerative farming, generally used to describe those management practices that aim to minimize erosion and leaching of nutrients and organic matter, enhance biodiversity and soil health and to sequester carbon (Elevitch et al. 2018). The global approach to this kind of practices, and their potential to provide multiple benefits in addition to emission reduction and carbon sequestration such as improving crop productivity, soil nutrient and biodiversity, is also presented by the IPCC, which identify these agricultural practices as key levers to guide the adaptation of the agricultural sector to climate change while increasing farm profitability and energy efficiency (Perman et al., 2006). On this last point, the literature stresses how following the system approach rather than implementing a single practice allows efficient use of resources and increases biodiversity (Lal, 2016). This is particularly relevant when considering the practical implementation of carbon farming techniques within farms, and the many difficulties a farmer could encounter when faced with the need to change production methods considerably. For this reason, support and training for farmers are key issues to be addressed, as will be explained in detail in the next chapters.

According to the IPCC, the implementation of the rate of soil carbon sequestration and storage can be achieved:

- by decreasing the level of soil disturbance, in order to improve the physical protection of soil carbon in aggregates by acting on tillage practices;
- increasing the mass and quality of plant and animal inputs to the soil;
- improving the microbial diversity and consistency of the soil;
- maintaining a continuous living plant cover on the soil throughout the year.

The implementation of these practices on farms, however, is not always easy and straightforward. Often these practices are incompatible with traditional production systems, they may require high costs for farmers or lead to heavy losses in case of investments made (e.g. in fertilisers or traditional agricultural machinery). Finally, the expected results in terms of improved soil quality, reduced erosion, and increased productivity, which depend on several factors that cannot always be predicted, may occur after some time, leading to significant economic losses for farmers. For this reasons, economic support, incentives and planification are deemed necessary.

One last point needs to be addressed when analysing the phenomenon of the carbon farming. The technical handbook devotes an entire section to the co-benefits of carbon farming, i.e., those benefits that go beyond reducing emissions and increasing the absorptive capacity of agricultural soils. The handbook identifies the following co-benefits: reduction of soil erosion and nutrient leaching; Improved soil functionality and water infiltration; Diversified income flows for farms; Improved animal welfare and correct nutrition; Pollination services; conservation of biodiversity and landscape protection. Co-benefits needs to be assessed in an early stage and be counted in the credit system, as the response to climate change needs to be fully integrated with the response to other pressing environmental and social issues. This poses therefore an important challenge for the monitoring phase (Frascarelli et al., 2021).

The relationship between the type of farming practice implemented, the type of interaction with the carbon cycle, the amount of CO_2 absorbed or saved, the necessary change in management and the co-benefits obtained are all summarised in the following tables.

Table 2: Overview of Carbon Farming Options (Source: European Network for rural development, 2022)

Carbon farming actions		Mitigation mechanism	Per hectare mitigation potential (t CO2-e/ha/yr)	Opportunities for scaling up in the EU
Peatland restoration	Peatland rewetting, subsequent maintenance and management, paludiculture	Avoided emissions	3.5 - 29	Drained peatlands, predominantly in northern MS
Agroforestry	Creation, restoration, and management of woody features in the landscape	Removal	0.03 – 27	
Afforestation	Creation of new woodlands and forests on sites that have not been forested within the last 50 years	Removal	2.39 – 5.7[4]	Throughout the EU, in almost all soil/climatic conditions
Maintain and enhance SOC on mineral soils	Cropland and grassland management (permanent and ley)	Removal and avoided emissions	0.5 -7	
Catch/cover crops	Crops grown between the harvest of one main crop and the sowing of the next (cover crops can be undersown	Avoided emissions	-0.01 – 4.6	
Hedges and woody margins		Removal	0.65 – 3.3	
Conservation of near-natural peatland	Exisiting wetland/ peatland soils	Avoided emissions	0.7 – 2.8[5]	Exisiting near-natural peatlands throughout the EU
Arable conversion to grassland	Conversion of arable land to permanent grassland which is no longer cultivated		0.33 -1.44	

Table 3: Co-benefits, risks and safeguards for selected carbon farming practices (Source: European Network for rural development, 2022)

	Carbon farming actions	Co-benefits for land managers	Societal co-benefits	Risks	Safeguards needed
Managing peatlands	Peatland rewetting / maintenance / management, paludiculture	Potential for paludiculture and/or future income from carbon certification[6]	Biodiversity, flood regulation, water quality	CH_4 emissions (although net GHG benefit), decrease in production	Resilience to climate change impacts, consider effect of displacing production
Agroforestry	Creation, restoration, and management of woody features in the landscape	Diversification of outputs. protects against single crop failure	Improved water retention, microclimate, soil health, biodiversity	Non-native species' impact on biodiversity	No agroforestry on peatlands, consider nature conservation objectives
Afforestation	Creation of new woodland and forests on land in other use (or unused)	Diversification of outputs, potential for future income	Improved microclimate, flood risk management, recreation	Displacement of production (on agricultural land)	No afforestation on peatlands, consider existing nature conservation
		from carbon certification[7]	opportunities, health benefits		values and objectives
Maintain and enhance SOC on mineral soils	Cropland and grassland management (permanent and ley)	Improved water holding capacity and workability of soils, productivity	Improved water retention, soil health, biodiversity	Biochar, off-farm compost impacts on soil health/biodiversity	Restriction on biochar and municipal compost

3.2 Monitoring Systems

As previously mentioned, the adoption of a carbon farming scheme requires a precise measurement and quantification of the results obtained. This is the subject of the so-called Monitoring, Reporting and Verification (MRV) phase, which is particularly delicate since the key challenge at this stage is to quantify with adequate precision the results obtained, avoiding unsustainable costs (Frascarelli et al., 2021). This is stressed also by the Technical Handbook, which identify the key challenge of all outcome-based schemes in the design of MRV systems that can measure with sufficient accuracy the impact of climate actions implemented by farmers at an acceptable cost.

There is no single optimal monitoring approach for all carbon farming schemes, as they do not all cover the same types of practices (Frascarelli et al., 2021), and this variety has led, together with the absence of a clear legislative framework reference, to the proliferation of different public and private MRV protocols appliable to farm management, such as the Australian Government Carbon Farming Initiative; Alberta-Canada Government Conservation Cropping Protocol; USDA's COMET; Verified Carbon Standard Protocols; Gold Standard Soil Organic Carbon Framework Methodology. Each platform focuses on different production systems and different specific management practices; uses different methods and models to quantify and monitor changes in Soil Organic Carbon (SOC) and GHG emissions and applies different approaches and time frames to consider the effects of management practices, and/or is only applicable to specific geographic locations. Moreover, when defining the MRV phase for a result-based carbon farming scheme, it is important to also consider the possibility that the actors involved in the scheme may try to exploit any weaknesses in the scheme to increase their individual gains. This could happen through alteration of input data, falsification of monitoring documents, inflation of the benefits achieved. In the case of the creation of a system of tradable credits, it is also important to provide for the possibility of operators trying to make them count more than once. For this reason, the creation of a transparent, publicly accessible, and possibly unique register is particularly relevant (FAO, 2017).

For the purpose of this thesis, we will focus now on the monitoring phase, presenting its different possibilities and features. The variations of carbon in the soil and biotic pools can be measured through the following types of intervention:

- Direct measurement;
- Modelling;
- Use of instruments (spectral methods, remote sensing, micrometeorological techniques).

There is no single monitoring approach as different carbon farming practices can be adopted (Frascarelli et al., 2021).

Direct measurement involves on-site visits to take soil or biomass samples for laboratory analysis (Frascarelli et al., 2021). It is the most accurate form of monitoring and can be used to calculate variations in carbon stock (e.g. in soil or trees), which can then be translated into removals or GHG emissions. At the same time, it is the most expensive approach, due to the need to do on-site visits, sampling, and laboratory measurements to calculate changes in carbon (Bispo et al., 2017). Moreover, although it is considered the most reliable methodology, the final result depends on the more or less precise compliance with the following steps that must be established through sampling and analysis protocols: 1) the sampling design: stratification, sample location, sample size and composition; 2) sample collection in the field: sampling frequencies, sampling depth, soil core extraction methods; 3) sample preparation; 4) laboratory determinations: SOC and POC concentration, soil density etc. The scientific debate is still open on some of these same parameters, for example about the depth at which samples should be taken, the IPCC recommends that they should be taken at least 30 cm deep while FAO recommends deeper soil sampling even though this requires specific and expensive instruments (Frascarelli et al., 2021).

Modelling comprehends the use of informatic tools based on computer applications, algorithmic model, that can estimate starting from input data the results of the carbon farming activity implemented. Now a day, modelling approaches are mainly used to calculate emission reductions within the livestock sector, but they can also be used to estimate the SOC content in soil, or the carbon stored in tree biomass (Frascarelli et al., 2021). The use of models makes it possible to reduce the high costs of on-site sampling, but they still have disadvantages in terms of the uncertainty of the results, since it is an estimate that is inevitably subject to a level of uncertainty, which can only be corrected by feedback and corrections given by direct measurements.

Proximal sensing and Remote Sensing are the most innovative tools which have been recently adopted to estimate results of carbon farming practices. As a matter of fact, the concentration of organic carbon in soil can be measured using sensors able to capture electromagnetic variations. As a matter of fact, organic mass and mineral elements absorb light in specific wavelengths. Soil parameters can be measured by sensors using signals that correspond to physical soil qualities. The use of proximal sensing (sensors) and remote sensing (satellites or drones) presents various benefits, as the on-site sampling is not requested, punctual estimations are possible, and data are easily collected to create reliable estimation of the SOC presence (Frascarelli et al., 2021). Nevertheless, this last method is allowed by the Protocol for Measurement, Reporting, Verification and Monitoring to Assess Soil Organic Carbon Sequestration and Greenhouse Emissions in Agricultural Landscapes (FAO, 2017), even if is strongly recommended for a local use after verification of the suitability of the sensors applied and calibration of the model with site-specific data.

The Draft report on calculation methods to be applied in estimating quantitatively agricultural and forest carbon sinks and their stability, written within the Life project Carbon Farming scheme, well summarizes the important factors that need to be taken into consideration when estimating carbon pool variations:

- **Accuracy and Precision**, which should both be achieved, reducing as much as possible biases and uncertainty;
- **Possibility to compare different results**, as assumptions methods and data must be transparent and commonly recognised as valid and possibly accepted, so to provide meaningful results between different areas;
- **Completeness,** all the relevant carbon pools should be included as well as the co-benefits generated;
- **Consistency**, meaning that substantial differences should not emerge from the application of different methodologies;
- **Relevance,** meaning that the inevitable trade-off between time, resources, data and methods should be appropriate and justified;
- **Transparency**, as results need to be confirmed by a third party.

Ch. 4: Application of VCM to Carbon Farming (or have we reached r=0?)

As emerges from what has been described so far, in the face of an incumbent problem such as the climate crisis, both individuals and governments are taking actions, and this is having consequences on market actions too. It is also interesting to note how, faced with a situation of necessity, the business world is reacting too, and not only under law-enforcement, but also and above all driven by the market. This is how new opportunities are being created. The concept of carbon markets itself reflects this idea: by making CO_2 a scarce good, or rather its reduction, and since its demand is growing, the conditions are created to stimulate the supply of CO_2 reduction actions, with a consequent reduction of pollution levels.

4.1 Voluntary Carbon Markets for the agricultural sector

The IPCC Report published in April 2022 underlines that carbon removal technologies, among which nature-based solutions and technological solutions, are deemed essential to limit global warming and reach the Paris Agreement Target. On this regard, it is crucial to say that while carbon capture and storage technologies are likely to gain importance only in the long term (Britsch et al., 2022), nature-based solutions such as forestation and soil use are gaining increasing popularity as immediately applicable and capable to bring CO_2 reduction together with a plethora of other connected benefits such as rural development, fostering biodiversity and much more (Liu, 2022).

A report recently released from the World Economic Forum states that, if proper action is implemented at political level, by 2030 agricultural green house gas emissions could be reduced by 6% and the soil could be restored by 16%, adding between €1.9bn and €9.3 billion annually to farmers' incomes. It is now easily understandable why there is a growing willingness to bring carbon farming practices within the standards required to issue credits and then sell them on voluntary markets to realize:

- Extra income for farmers: it is estimated that a credit obtained though the implementation of carbon farming practices could be sold at about €15, meaning an extra €30 per hectare on average. Given that the average profit margin per hectare is about €150, that may be an important contribution for farmers. (Pratty, 2022)
- Production improvement and soil quality: it has been observed that an increase of 1 ton of carbon in the soil of the degraded agricultural land is capable of increasing crop yields by 20 to 40 kilograms per hectare (kg/ha) for wheat, 10 to 20 kg/ha for corn, and 0.5 to 1 kg/ha for navy beans (Lal, 2004)
- Foster the realization of local projects to transform the agriculture sector.

Figure 11 below shows the general structure of the framework which could be implemented to adopt the voluntary carbon market functioning to the carbon farming.

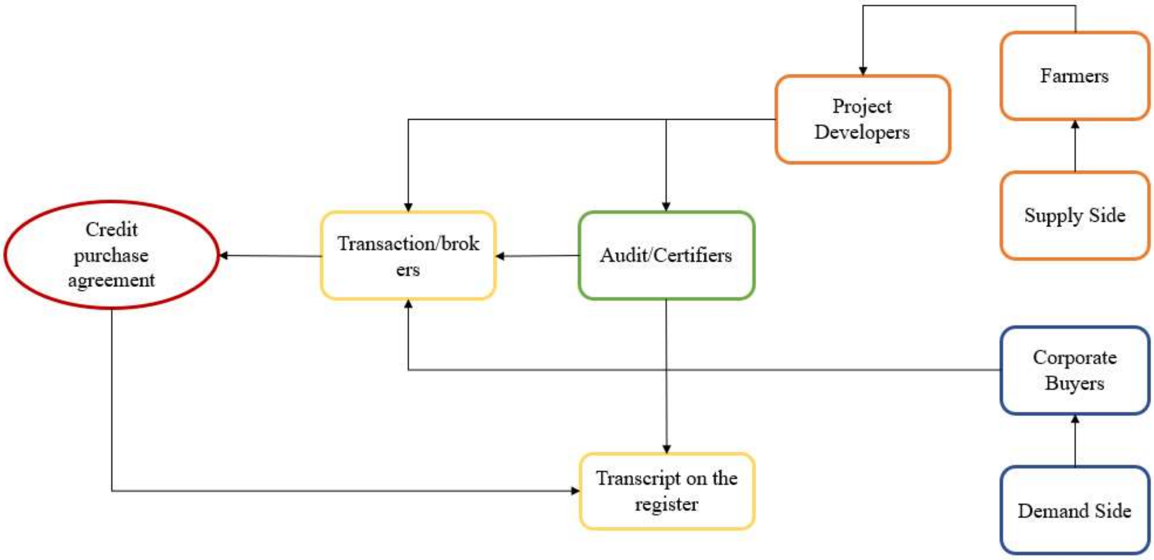

Fig 11: General Structure of VCM applied to Carbon Farming

Farmers represent the starting point of the Soil Carbon Market value chain, since are the ones who, through the implementation of carbon farming agricultural practices foster carbon absorption within their soils. Most of the times, especially in developing countries, farmers partners with project developers to plan, implement and manage the projects. Project developers are also the figures which usually sell the carbon credits obtained, then transferring the revenue to farmers and holding percentages. The Certifiers review, certify and audit the project implementations against internally defined standards; most certifiers have also their own register to keep track of transactions made and allow in theoretically to avoid double counting. Recently the role of brokers, as agents which aggregate, evaluate, and connect buyers with project developers is on the rise. Sometimes, when project developers are large enough can provide both functions. Finally, in most systems the transaction is reported on the register, which should be searchable and transparent (Liu, 2022).

The realization of this type of markets creates several challenges, in terms of the need for innovation and appropriate skills, but especially in terms of regulation. As a matter of fact, there are currently around 160 million dollars' worth of global forest and agricultural carbon credit transactions, and while a legal framework for carbon credits release and monitoring has already been implemented for forestation practices, agricultural carbon credits are still uncovered by any type of regulation, and therefore refer mainly to private standards as the Global Standard or the Verra (Forest Trend's Ecosystem Marketplace, 2020). This fact severely limits market entry by players who fear for their credibility in a fast-growing sector but with unclear rules, and limits the implementation of projects in developed countries, and in the EU, where the social, economic, and environmental situation is quite different from the realities of developing countries on which private standards are often designed (Britsch et al., 2022).

4.2 Relevant legislation for carbon farming and voluntary market in Europe

The European Union has understood the great potential of carbon uptake actions through the implementation of carbon farming practices, and how much these latter may contribute to the achievement of Europe's ambitious environmental goals. In line of this, the Commission has recently launched the work to define the **EU Carbon Farming Initiative**, which aims to develop a set of land use and management practices to reduce emissions from agriculture and sequester carbon in the soil and in the environment. To incentivize carbon uptake and greater carbon circularity, the Commission has considered a regulatory framework for certifying carbon removals based on robust and transparent carbon accounting in order to monitor and verify the authenticity of removals (European Commission, 2022b).

Figure 12 below shows how the EU carbon farming initiative is embedded among other relevant European Policies and fits into the broad plan set out by the Green Deal to achieve climate neutrality by 2050.

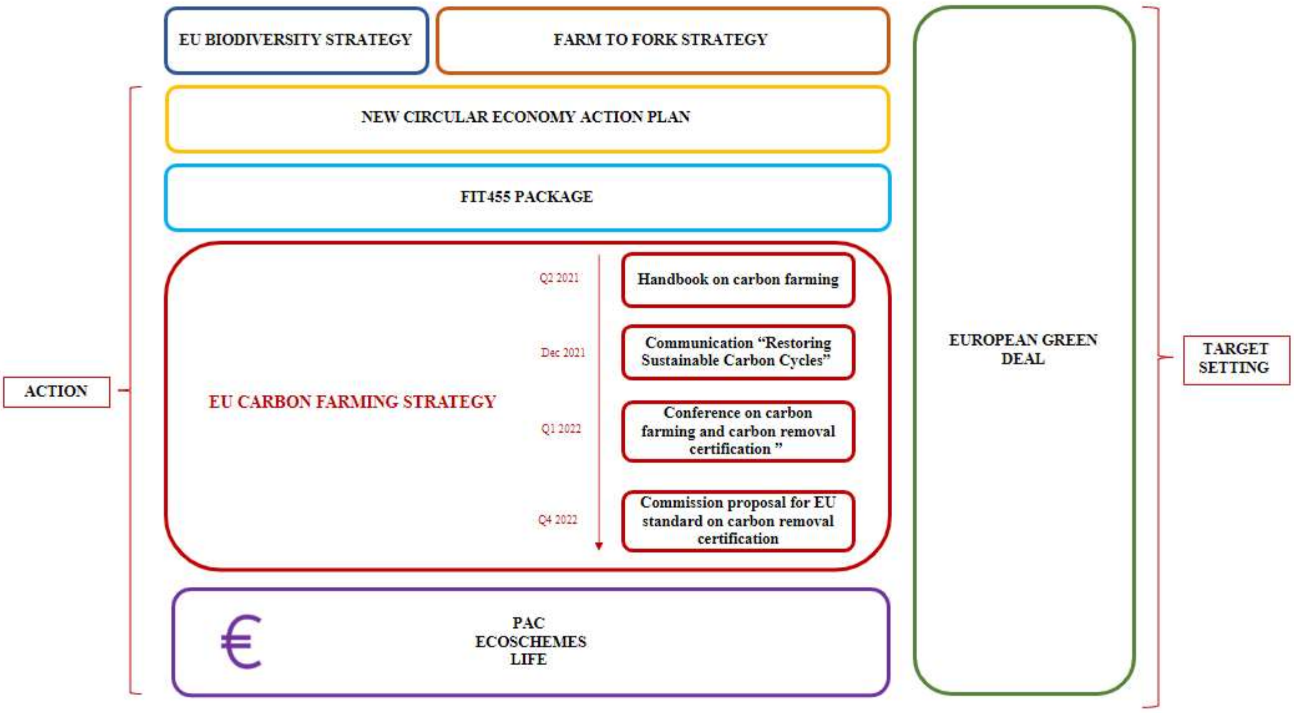

Fig 12: Eu Carbon Farming Strategy in the context of European Policies to reach Climate Neutrality by 2050

In December 2019 the European Commission presented the Communication on the **European Green Deal,** which is conceived as a growth strategy which will transform the European Union into a modern, resource-efficient, and competitive economy, ensuring that:

- no more net greenhouse gas emissions are generated in 2050;
- economic growth is decoupled from resource use;

- no one is left behind.

As it emerges, the Green Deal is an integral part of the Commission's strategy to implement Agenda 2030 and the goals of the United Nations Sustainable Development Goals (Sikora A., 2021), and represents an unprecedented effort, at the Union level, to facilitate the transition toward the common goal of a climate-neutral economy, by reducing carbon emissions by more than half by 2030 and reach carbon neutrality by 2050.

The European Green Deal will cover all sectors of the economy, which are strongly interconnected, including climate, environment, energy, transport, industry, agriculture, construction, and sustainable finance. To achieve a just green transition, the European Commission in 2020 has presented a set of policies and strategies on the following goals:

- Making the EU's climate targets for 2030 and 2050 more ambitious;
- Ensure the supply of clean, affordable, and secure energy;
- Industrial strategy and the action plan on circular economy;
- Building and renovating in an energy and resource efficient manner;
- Accelerating the transition to sustainable and smart mobility;
- Zero pollution objective for an environment free of toxic substances;
- Biodiversity Strategy 2030;
- Farm to fork strategy.

These last two strategies are particularly relevant for the purpose of this thesis. In particular, **the Biodiversity Strategy** foresees the strengthening of protected areas in Europe and the restoration of degraded ecosystems through the strengthening of organic farming, the reduction of the use of pesticides and reforestation (European Commission, 2019).

On the other hand, the **Farm to Fork Strategy** is a ten-year plan which aims to accelerate the transition of the European food system towards a sustainable future by "*addressing comprehensively the challenges of sustainable food systems and recognising the inextricable links between healthy people, healthy societies and a healthy planet"* (European Commission, 2020c). The inclusive approach promoted by the strategy is reflected in the aim to reward farmers, fishermen, and the other actors in the food supply chain who have already implemented the transition to sustainable practices by creating additional opportunities for their activities. The strategy is also implemented considering that the transition to sustainable food systems signifies an important economic benefit (European Commission, 2020b). If it is well planned and implemented, it becomes a key opportunity both for farmers, fishermen, and aquaculture producers as well as for food processors and food service providers.

The development of the strategy, has been outlined around four macro-objectives that relate to:

- Security of food supply;
- Sustainability of the European food supply chain;
- Reduction of food losses and waste;
- Fight against fraud in the food supply chain.

These macro-objectives are declined into specific objectives, one of which is particularly relevant for the work in analysis: the strategy establishes that the Commission will implement a study and consultation phase that will lead to the drafting of a regulatory framework for certifying carbon removals ("carbon credits") by the end of 2022.

To achieve its objectives, the strategy identifies the key tool to support the transition in the agricultural sector: the CAP. As a matter of fact, one of the main objectives of the 2021-2027 CAP is the modernization of agriculture through the development of more sustainable agricultural practices. To achieve and accelerate the transition to a fair, healthy and sustainable food system the implementation of adequate advisory services, financial instruments, and research and innovation is indispensable. Moreover, the new regulatory package marks a radical change in how member states plan and implement this policy, under the banner of the New Delivery Model, the new model gives member states much greater decision-making power than in the past in the management of the CAP. The change is not only procedural but substantive, since with the New Delivery Model the focus is no longer primarily on compliance and competencies, but on results and performance, assessed through a robust monitoring framework, consisting of a series of indicators designed to determine how financial resources are used and by means of interventions aimed at achieving final targets associated with the objectives (Capitanio et al., 2022).

As it emerges, the Green Deal, together with its sectoral articulations as the EU biodiversity strategy and the Farm to fork strategy, define ambitious, even though rather generic, targets which need to be achieved for the entire agricultural sector, and make important promises regarding the development of a legislative framework for the creation of a voluntary market for carbon credits applicable also to the agricultural sector. Afterwards, the commission worked to define, through various implementation plans, the road map to achieve these targets.

Firstly, the “Ready for 55 %: Delivering the EU's 2030 climate target along the path to climate neutrality" has been launched, through which the commission provided a package of proposals to address climate change. Briefly known as “**Fit for 55 package**”, it consists in a set of proposals to amend and update EU regulations and implement new initiatives to ensure that EU policies are in line with the climate objectives agreed within the Green Deal, and in particular the commission aims to increase the annual rate of reduction to reach a 61% emission reduction by 2030. One of biggest change, however, concerns agriculture, which together with forests is included for the greenhouse gas accounting in the land use, land use change and forestry (LULUCF) sector. In this sector, the new target set are also more ambitious: aiming at a greater absorption of CO_2 by natural sinks equal to 310 million tons of CO_2 by 2030, i.e., 35% more than the previous target. Member States will need to preserve and extend their carbon sinks. By 2035 the EU should aim to achieve climate neutrality in the LULUFC sector, including emissions from fertilizer use and livestock farming.

While the initiatives seen so far are mainly aimed at the general transformation of the agricultural sector in line with new and more ambitious targets, a targeted intervention on carbon credits is implemented by the **Circular Economy Action Plan**, through which the Commission will develop a regulatory framework for certifying carbon removals based on robust and transparent carbon accounting, to monitor and verify the authenticity of carbon removals. The plan has been adopted by the commission in March 2020 to address the whole life cycle of products, targeting how products are designed, promoting circular economy processes, encouraging sustainable consumption, and reducing waste. It is in this view that the regulatory framework for lifecycle assessment and carbon estimation is deemed fundamental, as well as carbon accounting and verification.

Within this complex framework, in which directives come from different implementation plans, the EU carbon farming strategy has been launched in 2020 with the promise to deliver a proposal for EU standard carbon removal certification by the end of 2022. It is therefore a work in progress, the commission has initiated a series of technical tables for the publication of the first documents, and in parallel has started a broad participatory process with the actors of the sector and the citizens.

The first document released within this process is the Technical Guidance Manual - creation and implementation of carbon farming mechanisms. The Handbook is based on the results of two round tables carried on during 2019 and 2020 and consists in an accurate review and analysis of existing carbon farming schemes implemented at international and community level, together with a step-by-step guide on how to design and implement carbon farming mechanism and a result-based rewarding scheme. From the reading of the handbook, it emerges clearly that the key challenge in all outcome-based schemes is the design of MRV systems which are able to measure with sufficient accuracy the impact of the climate actions taken by farmers at an acceptable cost.

The second milestone of the road toward the implementation of the EU carbon farming strategy is the **communication on sustainable cycles**, released in December 2021. The communication sets out short- to medium-term actions aiming to address current challenges to carbon farming to upscale this green business model that rewards land managers for taking up practices leading to carbon sequestration, combined with strong benefits on biodiversity. It looks at the development and deployment of natural and technological carbon removal solutions, in line with the objectives of the EU Forest Strategy, the Circular Economy Action Plan, the EU's Long-Term Vision for Rural Areas and the Farm to Fork Strategy.

Finally, the 31st of January 2022 the **Conference on carbon farming and carbon removal certifications** took place, which is part of an extensive consultation process initiated by the commission to gather stakeholder and public opinion on the issue. The conference brought together decision makers and experts from different backgrounds to share their experiences in view of the upcoming EU regulatory initiative on the certification of carbon removals.

The other pillar on which the road map towards the construction of a legislative regime for carbon farming is based is the analysis of the results obtained from pilot projects or initiatives already launched in member states. On this regard, a leading role is played by European and non-European states that have already implemented a national framework and, often, a national credit registry. In this regard, for example, England already implemented the UK WoodLand Code in 2014 (Fitzgerald et al., 2021), while France recently implemented Label Bas-Carbone certification (Label-Bas Carbone, 2022). Both these initiatives are promoted and supported by government agencies, with the collaboration of research centres and private sector representatives.

Finally, Member States will be able to implement pilot carbon farming and monitoring projects on their territory using various European funding sources (European Commission, 2022b):

- through national management of CAP-related funds, even considering that the commission has already included carbon farming among its recommendations to states in the implementation of national CAP strategic plans
- through the application of eco schemes or rural development funds (RDPs)
- through applied European research funds such as Horizon Europe or LIFE

The Executive Vice president Frans Timmermans expressly specified this in the speech announcing the launch of the EU carbon farming strategy, stating: "*Our climate action must first and foremost reduce human-made emissions. But we also need to restore and protect natural carbon sinks, so that we can capture CO_2 from the atmosphere and store it in our soils and forests. Carbon farming offers new income opportunities for farmers. It is an example of how the new Common Agricultural Policy's eco schemes and private funding can reward agricultural practices that help us fight the climate and biodiversity crises" (*European Commission, 2022b).

In Italy there is growing interest in implementing carbon farming projects to release carbon credits, but it is still considered a very niche sector, both among farmers and businesses. In Italy, the tons of CO_2 sold between 2011 and 2019 amount to only 0.6 million for an economic value of about 2 million euros, but that is without considering the projects started in 2020 year in which there are about 50 activated projects (Ballocchi, A. 2021). Even if this is a small amount, compared for example with the fact that in the UK alone, where about 9.6 million tCO_2 have been totally absorbed, the demand is growing and the market is alive, although precisely it needs clear rules. Now a day there is no reference legislation on how to generate, acquire and manage credits on the voluntary market, even if small steps have been implemented. In this context the work of the Nucleo di Monitoraggio del Carbonio of the CREA (National Council for Agricultural Research and Analysis of Agricultural Economics) was initiated. The Nucleo has been created under the coordination of the CREA

Forest Observatory and in collaboration with the TeSAF department, University of Padua, the Euro-Mediterranean Center on Climate Change (CMCC) and the Compagnia delle Foreste and was created with the aim to analyse and monitor the progress of the Voluntary Markets/Funding of Eco-system Services at the national level, with reference to forestry and soil conservation projects for offsetting emissions.

The work of the Nucleo has achieved important results regarding forestation projects, since it coordinated a long process of public discussion involving the main players operating in the voluntary credit market in Italy, which led to the creation of the "Forest Carbon Code" (CFC), which is still limited to forestation and does not consider farming related initiatives (Nucleo Monitoraggio Carbonio, 2014).

With regard to the implementation of the drafting of the Italian National Strategic Plan for the implementation of the CAP 2023-2027 funding it is crucial to note that, to date, no specific interest in carbon farming emerges. However, carbon farming implementation actions still fall secondarily as an activity subject to funding, since some practices are listed among the criteria for enhanced cross-compliance that farmers receiving funding will have to comply with. These are the maintaining of permanent lawns, protection of wetlands and peatlands, minimum ground cover with mulch, minimum tillage, and crop rotation of arable crops (Capitanio et al., 2022).

The above is valid also for the implementation of the Eco schemes. The Italian national strategic plan did not expressly include carbon farming and its monitoring among the selected Eco schemes, as, for example, France did, but it did include the application of certain "good practices" among those eligible for farmer funding. Italy selected the following Eco schemes in its National Strategic Plan:

1. Payment for animal welfare and antibiotic reduction
2. Weeding of tree crops
3. Preservation of olive trees of special landscape value
4. Extensive forage systems with rotation
5. Pollinator-specific measures among these, the second and the fourth are partly covering regenerative and conservative agricultural practices and foresee a direct payment of 120 euro/h and 110 euro/h (Capitanio et al., 2022).

Ch. 5: Objectives and Methodology

The following chapter aims to introduce the experimental part of the thesis, explaining the objectives of the research and the methodology by which it has been carried out.

5.1 Research Objectives

The general objective of this thesis is to explore the potentiality of Voluntary Carbon Markets as a tool to improve agricultural soil quality, foster CO_2 uptake and realize co-benefits moving the broad field of soil governance. More in detail, the present work aims to carry on a **feasibility analysis** of the implementation of an agricultural carbon credit market in the context of the Commission works toward the EU Carbon Farming Strategy, via a stakeholder consultation process aiming to identify the **critical** and **success factors** which need to be considered by the regulator and propose suggestions on this regard. Secondly, the research also aspires to estimate the **trust** that actors have in the regulator, and consequently the predisposition to adhere to this system.

The willingness to pursue simultaneously the analysis considering economic/legislative, technical/agricultural, and ecological aspects is the major novelty of this work, seeking to highlight how the interdisciplinary nature of the analysis allows for a complete picture of the system under analysis, and therefore propose solutions that are as holistic as possible. This three-lenses field of analysis was pursued in both the literature review section and the experimental section, trying to fit these 3 approaches always within society, and thus without excluding the citizen/consumer's point of view and value within this puzzle. Therefore, to provide an analysis as accurate and truthful as possible the achievement of the following sub-objectives is considered essential:

- Conduction of an extensive literature research on the regulatory framework of the carbon credit market analysed in the context of the tools available to the regulator to achieve climate goals. The literature review will also cover the basic concept of carbon cycles to understand how soil can be considered a carbon sink and which are the main agricultural techniques for the implementation of carbon farming.
- Explanation of the challenges presented by the applicable monitoring system to quantify the absorptive capacity of agricultural soil, and the different systems that can be applied.
- Using primary data produce a report to assess the evolution of the EU Carbon Farming Strategy and its implementation in Italy based on information disclosure by different stakeholders. In particular, the study intends to carry out a qualitative research project based on semi-structured interviews with actors in the sector, both supply side and demand side thus involving farmers and agricultural consultants, researchers and consultants, investment fund managers and other entities interested in credit purchase. To provide as complete a picture as possible, the analysis set two other objectives. First to detect the confidence of actors in the market with respect to both European and Italian institutions regarding the

drafting and implementation of the strategy under analysis. Second to include within the analysis also the levers that would push each actor to enter the market, and how these can be used by the legislature to ensure the success of the system.

Through the conduction of the interviews, it is intended to lead the actors to reveal valuable information regarding their conception and needs with respect to carbon farming and the creation of the voluntary market, and through their processing to provide a tool to enable the legislature to identify the space of the best possible compromise between the different economic, social, agricultural and ecological demands.

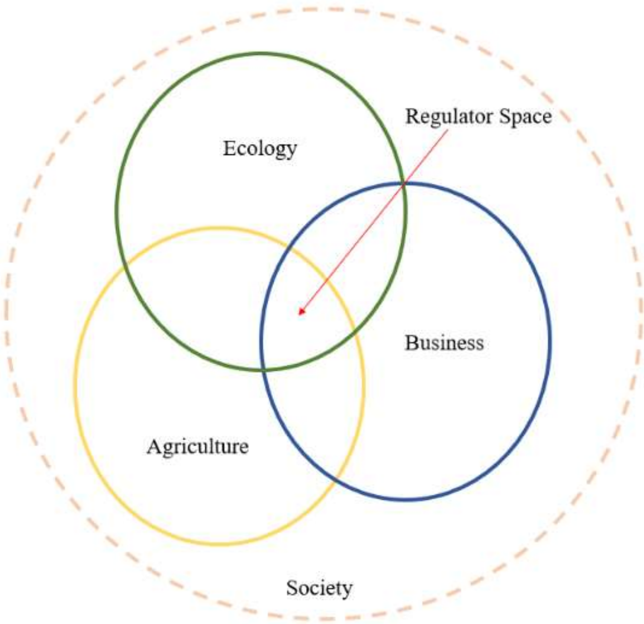

Fig 13: Schematic Representation of Research area's intersection

The choice of this topic has been suggested by Dr. Andrea Cruciani, CEO of the start-up Agricolus at which I interned. In fact, this topic is among the topics on which the R&D department is currently doing research, specifically to identify indicators suitable for building a model to remotely monitor CO2 uptake in agricultural soils. Therefore, the idea is to delve into this topic and study its legislative developments, which will be essential to define in the future the strategy that Agricolus can adopt to implement these monitoring systems and thus enter the industry.

5.2 Methodology

The methodological process implemented in this research work consisted of the following steps:

1. **Identification of the research question:** "*Which are the emerging success and risk factors for the implementation of a Carbon Farming VCM? and how are they considered within the legislative development toward the definition of the EU Carbon Farming Strategy*?"

2. **Identification of the type of actors and profiles best suited to the purpose of the research.**

In particular, the following profiles were selected:

- **Farmers and agronomic experts**: on the supply side as actors in charge of implementing carbon farming practices to obtain credits to be offered in the marketplace;
- **Impact investment managers at financial funds or banks and consultancy companies**: on the demand side. Given the impossibility to directly contact large companies, the analysis focused on the main lever that drives large companies into this market, namely the growing intention of investment funds to invest in companies meeting certain social and environmental standards, and on the conduit that often leads a company to implement offset and credit purchase projects, namely consulting firms specialized in the green transition;
- **Experts and researchers in both ecology and agricultural sciences**: as representatives of the research field within these topics.

A particular effort was put into the research, for each category of respondent, of different attitudes towards environmental and social issues. For this reason, three actors were interviewed among the farmers, including a small organic grain producer, an agronomist engaged at a large winery that is also organic, and finally a consultant agronomist working for a big consultancy company which supports big cooperatives suppliers of large processing companies interested mainly in traditional agriculture.

On the demand side, on the other hand, three actors were interviewed, one representative of an investment fund specialized in renewable energy with extensive experience in the voluntary credit sector and with particular attention to environmental issues and a representative of the bank sector specialized in portfolio investments, thus close to the demand trends of medium and large savers regarding investment choices and consequently on the winning criteria that companies can leverage to obtain investment. The third actor included is a consultancy company specialized in supporting companies to reach sustainability goals, having a broad experience in carrying out climate compensation projects and therefore very close to the point of view of companies wishing to offset their emissions.

Lastly, to include a technical and expert perspective on the ecological and agricultural challenges posed by the implementation of carbon farming two other actors have been included in the analysis, a researcher at the University of Perugia expert in Carbon Farming and a researcher employed by the CREA experts in monitoring systems and for the absorption of CO_2 were interviewed. The figure 14 shows the different positing of the interviewed actors on the three “lenses” adopt for the analysis.

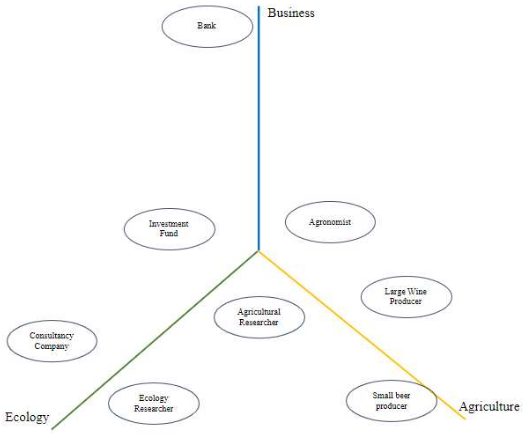

Fig 14: Stakeholder placement

3. Definition of the research method and interview planning

Following the definition of the research question, the intention that emerged has been to bring forward an interpretative qualitative research work instead of a quantitative one. This choice was due mainly because the primary interest of the author is to understand the actors' perception, needs, motivations and pain points against a market system that is still very undefined in several respects. This kind of information usually emerge easily when the actor is free to talk and express his/her thoughts (Lacey, 2007). Secondly, the method has been identified, e.g., the conduction of semi-structured interviews, with the following characteristics:

- The respondents have been engaged in a formal one to one interview, organized mainly remotely and lasting about 30-60 minutes
- The author developed a set of broad open-ended questions representing the general topics which have been covered during the interview
- During the interviews the author followed the pre-packaged guide but caring to leave room for further reflections by the interviewee and following unforeseen paths of the conversation.

The choice to adopt the semi-structured interviews method was driven by the observation that all the factors indicated by Lacey et al., (2007) are present, namely the fact that the research is based on a number between five and ten interviews, that it would be difficult to contact the respondents more than once, and lastly the fact that individual point of view and perception can vary consistently, and therefore there is a need to avoid leading behaviours, which could arise for example in the case of Focus Groups in which various uncontrollable factors can lead to a herd dynamics.

4. Interview implementation and results analysis

The interviews were carried out between the fourth week of April and the first of May.

The analysis of the primary data obtained has been carried on following the framework presented by Lacey et al., (2007) and articulated on the following steps:

- Familiarisation with the data through review;
- Transcription of tape-recorded material;
- Indexing of data for easy retrieval and identification;
- Identification of emerging themes and identification of categories;
- Exploration of relationships between categories;
- Development of theory and incorporation of pre-existing knowledge.

All interviews were recorded, subject to the release of informed consent by the interviewees to allow the data to be re-processed. The data have been presented in anonymous form within the analysis.

5. Levers analysis

To explore and d deepen the role of citizens within the proposed framework it was necessary to adopt a different research methodology, opting for a 'demonstrative quantitative analysis of the identified thesis. Given the impossibility of conducting a survey in the appropriate manner and especially in the appropriate time frame, and reaching a sufficiently heterogeneous and large audience, it was deemed appropriate to resort to the analysis of secondary data, resorting mainly to the datasets of ISMEA regarding the prices of agricultural products and the Bank of Italy regarding the price trends of financial products.

Ch. 6: Results elaboration and discussions

6.1 Analysis of success and risk factors for the implementation of the Voluntary Carbon Market within the EU Carbon Farming Strategy

During the familiarisation phase, which has been carried out analysing the interviews' transcripts, fourteen factors have emerged as recurrent themes on which enough actors (more than two) focused, identifying them as risk or success factors, which need to be taken into consideration when defining a framework for the application of the voluntary carbon market for the carbon farming. These factors are:

1. **Cost and Sophistication of Monitoring Systems (CSMS)**: the correct and effective implementation of the monitoring phase is still very difficult and expensive, an important challenge is represented by the difficult trade-off to be realized between scientific robustness, and usability and affordability of the monitoring system.
2. **Local Specificity of Key Parameters (LSKP):** when adopting the model to carry out the monitoring and assessment phase, it is important to consider that generally, models developed so far for the carbon farming have been tailored on parameters specific to the project implementation location. Moreover, very often these models are developed for research purposes or for pilot projects for CO_2 absorption estimation, thus being scientifically correct but often very elaborated and hence difficult to scale up.
3. **Ecological Approach (EA)**: this factor addresses the adoption of a comprehensive view on the production reality under analysis, and a deep understanding of its whole functioning, and linkages with other realities. This concept has emerged in relation to both credit-creating agricultural production entities, and credit-buying industrial entities.
4. **Multi-disciplinarity of Issues at Stake (MIS)**: the implementation of carbon farming practices, their monitoring, and finally the creation of credits that can be purchased on a voluntary market present numerous challenges attributable to very different fields of study, from agricultural science to economics to finance, without leaving aside ecology and biology.
5. **Fragmentation of Agricultural Sector (FAS)**: in several European countries, and in Italy especially, the agricultural sector is characterized by a high presence of medium/small farms.
6. **Presence of Sector Associations and Cooperatives (PSAC)**: in Europe, and in the Italian reality in particular, the phenomenon of associationism and corporativism in the agricultural sector is very common.
7. **Backwardness of the Agricultural Sector (BWAS)**: the Italian agricultural sector, and especially small entities (SME), often demonstrates a serious state of backwardness with respect to both implemented agricultural practices and the use of technological and innovative support tools.

8. **Spread of Action-Based Rewards (SABR)**: To date, most policy initiatives in agriculture have fostered the green and digital transition of the sector adopting mainly incentives given *ex ante* to actors, either to support needed investments or as reimbursement for expenses incurred.
9. **Additionality Criteria (AC)**: the calculation of the CO_2 uptake that can be rewarded to date is based solely on realized increases over the baseline situation at the beginning of the project.
10. **Private Frameworks already Adopted and Developed (PFAD)**: there are currently private standards that are also being applied to carbon farming, although mostly for projects carried out in developing countries, and which are purchased by companies (e.g., Verra and Gold Standard).
11. **Suspect of Green Washing (SGW):** the absence of a legislative framework, the coexistence of numerous private standards, and a general misinformation of actors have created a curtain of suspicion over the functioning of voluntary carbon markets, which unfortunately have been confirmed in past years by incidents of double sales of credits, fraud on registries, etc.
12. **Carbon Farming Previous Experience (CFPE)**: carbon farming practices are not a recent invention, but mostly draw on traditional practices implemented before the advent of industrial agriculture, and its core principles are at the basis of agroecology and organic farming. To this day, they are often implemented within regenerative and biodynamic approaches to farming.
13. **High Variability of Agricultural Territories (HVAT):** within the European territory, and in the Italian territory itself, there are geographical areas of great variability in terms of climate, conformation, and characteristics of the soil, but also with regards to social and economic structures, such as farm size, types of management, techniques applied, etc.
14. **Growing Awareness in the Business Sector (GABS)**: there is a growing awareness, among small and large productive companies, of the need to limit and compensate for large emissions and to communicate effectively the objectives fixed and the results achieved.

This coding phase led to the identification of themes and emerging concepts, and to the identification of emerging links between the responses obtained in the different interviews. The thematic chart below shows the correspondence between the single identified factor and the respondent who specified it and the category to which he/her belongs.

Tab 4: Factor-Respondent Thematic Chart

	Factor	Agriculture Side			Business Side			Sector Expert	
		Farmer 1	Farmer 2	Agronomist	Consultant	Banker	Investment fund	Agriculture R.	Ecology R.
1	Cost and sophistication of monitoring systems (CSMS)	X		X	X		X	X	X
2	Local specificity of key parameters (LSKP)			X					X
3	Ecological approach (EA)	X	X					X	X
4	Multidisciplinarity of issues at stake (MIS)						X		X
5	Fragmentation of agricultural sector (FAS)		X	X	X			X	X
6	Presence of Sector Association and Cooperatives (PSAC)		X	X	X				X
7	Backwardness of the agricultural sector (BWAS)		X	X				X	
8	Current spread of action-based rewards (SABR)	X	X	X				X	
9	Additionality criteria (AC)		X				X	X	
10	Private frameworks already adopted and developed (PFAD)				X	X	X		

11	Suspect of Green Washing (SGW)	X	X	X	X	X	X	X	X
12	Carbon Farming Previous Experience (CFPE)	X	X	X	X			X	
13	High variability of agricultural territories (HVAT)	X	X	X	X				X
14	Growing awareness in the business sector (GABS)		X	X	X	X	X		

Interesting patterns have emerged observing the relative frequency with which the various factors occurred, both within each category and for the total number of respondents (*Fig. 15*). It can be noted that members within each of the three groups tend to give aligned within-group responses on different issues, showing how the factors of greatest importance differ. For the respondents within the agriculture group, the most important factors are HVAT, CFPE, SGW and SABR; for the business are GABS, SGW and PFAD; for the ecological observatory are SGW, FAS, LSKP and lastly CSMS.

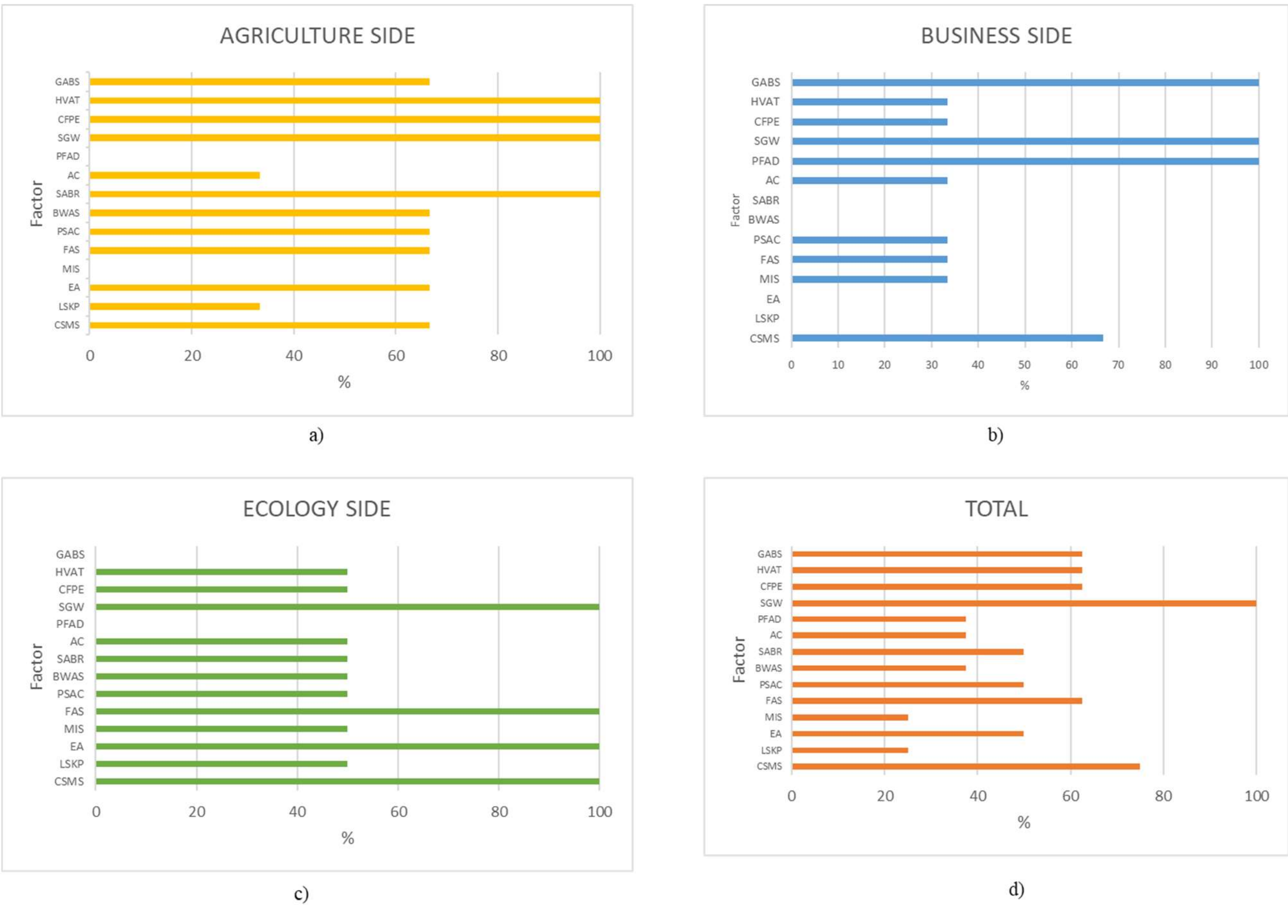

Fig. 15: Percentage of factor's mention within each group and in total

Figure 15 shows the areas of intersection between the responses given by the different groups, to best bring out the cross-cutting nature of the identified factors and the commonalities of interest. Interestingly, most of the factors are shared by all 3 groups, showing that despite different roles and even different approaches the actors show interest in common topics, and this is a major strength of the legislator who must identify these common factors as areas of special interest and focus. The central position is occupied by the Suspect of Green Washing (SGW) factor, which was reported by all respondents, emphasizing that the action taken by the Commission to legislate on the issue is necessary and appreciated by all groups.

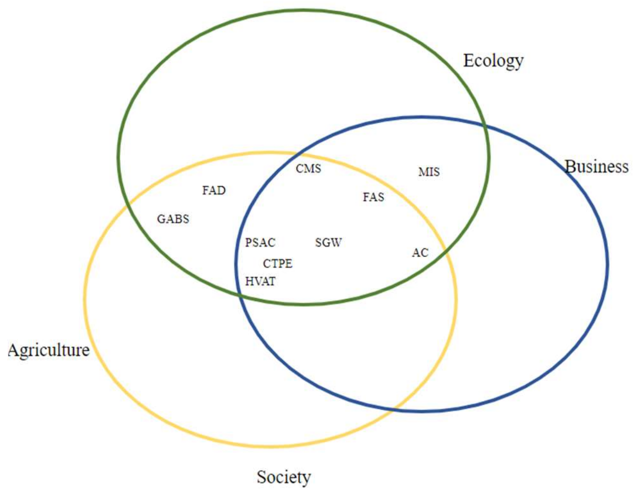

Fig. 16: Intersections between the factors identified

The following step foreseen was the categorization of the different factors. Given the structure of the interviews, which included two separate questions for identifying risk and success factors, it is immediately possible to categorize the emerging themes as:

A. **Success Factors**, i.e., factors are able to increase the successful implementation of the system, and therefore that need to be emphasized and propelled by the regulator, in this case the European proposing legislator and the Italian receiving and implementing legislator.

A. **Risk Factors**, which could jeopardize the proper implementation of the system and therefore need to be addressed with special attention by the legislature.

Table *5* shows the classification identified. It is interesting to note that all respondents spontaneously expressed concordant views on the nature of the different factors. On this regard, a brief clarification is necessary regarding the categorization of the Additionality Criteria (AC), as it is the only factor that was characterized by the respondents in opposition to what was found in the literature. In fact, the need to identify a starting point in implementing CO_2 uptake projects was recognized as necessary by the 3 respondents who reported it, but at the same time its adoption as understood in the literature was found to be detrimental to the implementation of projects in developed countries as it makes it difficult to engage actors who already farm with high standards of sustainability.

Tab 5: Categorization of identified Factors

Factor	**TYPE**
Cost and sophistication of monito.ring systems (CSMS)	RISK
Local specificity of key parameters (LSKP)	RISK
Ecological approach (EA)	SUCCESS
Multidisciplinarity of issues at stake (MIS)	SUCCESS
Fragmentation of agricultural sector (FAS)	RISK
Presence of Sector Association and Cooperatives (PSAC)	SUCCESS
Backwardness of the agricultural sector (BWAS)	RISK
Spread of action-based rewards (SABR)	RISK
Additionality criteria (AC)	RISK
Private frameworks already adopted and developed (PFAD)	SUCCESS
Suspect of Green Washing (SGW)	RISK
Carbon Farming Previous Experience (CFPE)	SUCCESS
High variability of agricultural territories (HVAT)	RISK
Growing awareness in the business sector (GABS)	SUCCESS

Combing the results relative to the frequency of respondents who emphasized the importance of the factor and the categorization of the factor, it is possible to evidence a relationship between the category of factor and its relevance in terms of frequency detected in the total number of respondents. This is plotted in Fig. 17 below, in which the vertical axis shows the relative frequency of responses (in percentage values) and the horizontal axis the categorical variable risk or success.

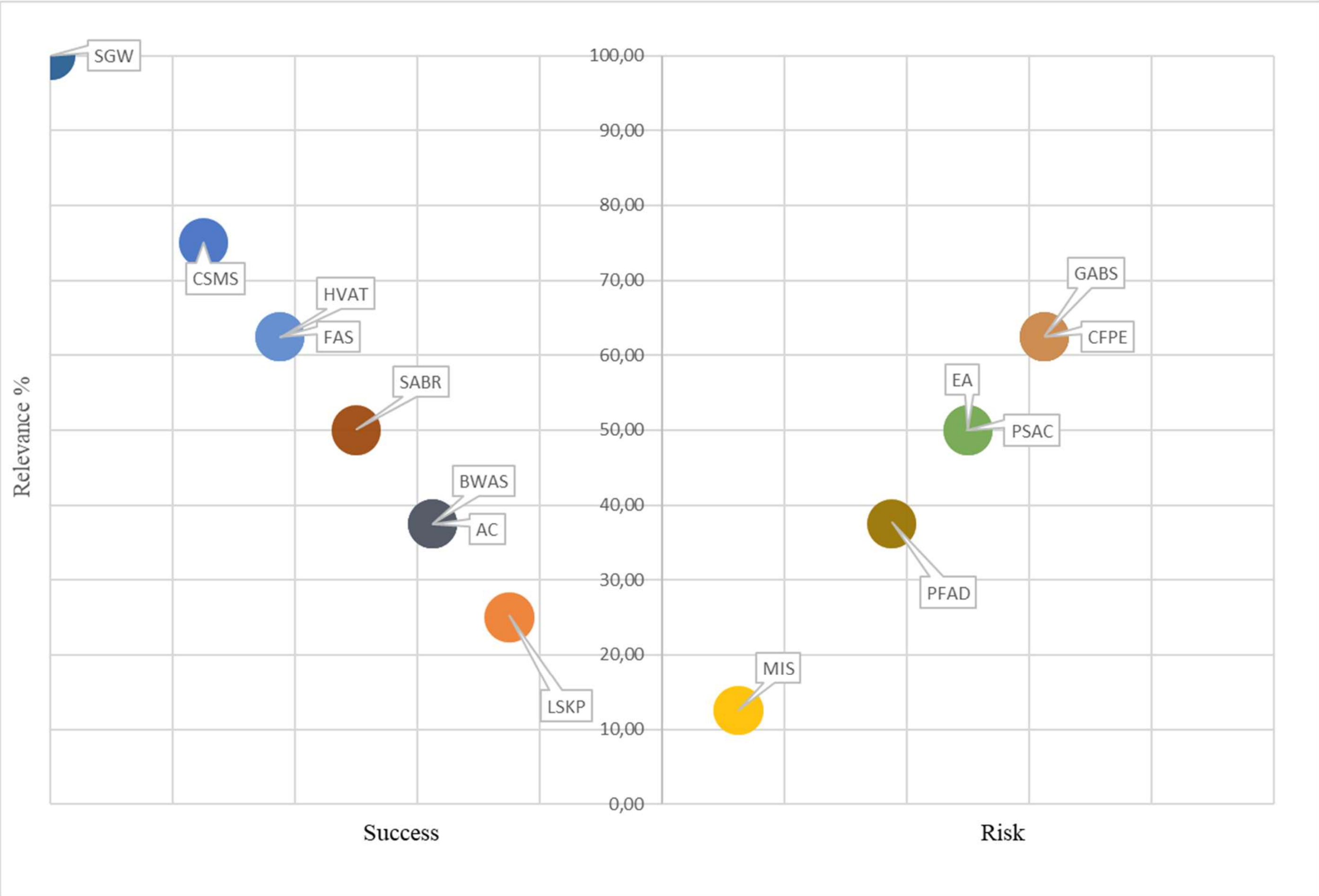

Fig. 17: Relevance and Categorization of the identified Factors

This allowed for an indicative clustering of the factors, dividing the factors thus arranged into three clusters, i.e., distinguishing the factors with relevance below 33.3% (Low), with relevance between 33.4% and 66.6% (Medium) and finally the factors with relevance higher than 66.7% (High). It is possible to distinguish:

- **Success factors with high relevance**, which have a high level of transversality among the areas explored, potentially placing themselves as strategic levers on which to act to achieve a good level of satisfaction among the different groups and push their participation in the market. These are a) the presence of previous experience in the field of carbon farming (CFPE), and b) the growing awareness in the business sector (GABS).

- **Success factors with medium relevance**, which are a) the possibility to adopt a holistic ecological approach to business and farm management (EA), and b) the presence of cooperatives and sector associations (PSAC). These factors showed a slightly lower relevance but are still considered important by the respondents.

- **Success factor with low relevance**: two success factors have been identified by only two respondents, namely a) the multidisciplinarity of the issues at stake (MIS), which, if correctly contemplated within the preparatory works for the legislative design secure higher chances of successful implementation of the legal and policy framework, and b) the presence of private frameworks (PFAD) which have already developed and are already used by actors in the markets. The latter can be considered a success factor because it can provide useful knowledge, and at the same time ensure the presence of buyers if a good alignment between the systems is adopted.

- **Risk factor with high relevance**, which need to be particularly considered by the legislator, which must take decisive actions and implement adequate mitigation strategy. These risks, which have been underlined by the majority of the respondents, are a) the high cost and sophistication of the monitoring systems (CSMS), b) the high fragmentation of the agricultural sector (FAS) which, being characterized by numerous small businesses, makes it challenging to make large investments, achieve high levels of technology or have and innovative approach to agronomic management and finally, c) the high variability of the territories (HVAT), both geographical and social, which makes it difficult to identify a suitable framework for different situations, from the practical implementation of agricultural practices to the more complex identification of the relevant legal framework.

- **Risk factors with medium frequency**, which are a) the spread of the action-based rewards (SABR) and therefore the consequent established habit for many farmers of receiving *ex ante* funding to support investment and b) the additionality criteria (AC), that establishing additionality with respect to the practices implemented before the development of the project risks hindering the participation of the farmers already adopting regenerative practices.

- **Risk factors with low frequency**, which have been identified as a) the local specificity of the key parameters needed to implement a correct monitoring and evaluation of the CO2 intake (LSKP) and b) the backwardness of the agricultural systems (BWAS).

Tab. 6: Factor's Clustering

Category/Relevance	High	Medium	Low
SUCCESS	Carbon Farming Previous Experience (CFPE)	Ecological approach (EA)	Multidisciplinarity of issues at stake (MIS)
	Growing awareness in the business sector (GABS)	Presence of Sector Association and Cooperatives (PSAC)	Private frameworks already adopted and developed (PFAD)
RISK	Cost and sophistication of monitoring systems (CSMS)	Spread of action-based rewards (SABR)	Local specificity of key parameters (LSKP)
	Fragmentation of agricultural sector (FAS)	Additionality criteria (AC)	Backwardness of the agricultural sector (BWAS)
	High variability of agricultural territories (HVAT)		
	Suspect of Green Washing (SGW)		

During the interviews, for each one of the factors identified interesting reflections and suggestions emerged, which are outlined in table 7.

Tab. 7: Suggested Actions

Factor	**SUGGESTED ACTION**
Cost and sophistication of monitoring systems (CSMS)	Adoption of innovative monitoring systems based on remote sensing.
Local specificity of key parameters (LSKP)	Define one common methodology and procedure based on scientific consensus, leaving then the singular realities to develop specific algorithms based on local characteristics of the parameters needed.

Ecological approach (EA)	The application of an ecological approach is suggested by the actors, to be applied both to the factories and to industrial / corporate realities. Overall, it allows to have a holistic view on all the productive production processes, as far as agricultural realities are concerned, and to combine the quantification of CO_2 absorbed with a Life Cycle Assessment analysis on all the products of the companies in order to be able to issue credits only on surpluses of absorbed CO_2. For corporate entities, it is recommended in order to allow offsetting by credit only on non-highly abatable issues or as an intermediate process towards achieving net zero.
Multidisciplinarity of issues at stake (MIS)	The creation of interdisciplinary working groups is suggested, for the definition of guidelines, both at European level and in the phase of receiving directives. Furthermore, it is recommended to implement initiatives to involve stakeholders, especially agricultural producers, to avoid the direct imposition of regulations.
Fragmentation of agricultural sector (FAS)	The presence of small producers both at EU and Italian level could seriously compromise the capacity of farmers to implement carbon farming strategies, support the investments of monitoring and certifying it. On this regard, the presence of agronomists and business consultants is strategic, and their role should be recognised and empowered. Moreover, the presence of cooperatives and sector associations can play an important role in leading the projects and supporting the costs of monitoring and certification.
Presence of Sector Association and Cooperatives (PSAC)	The diffusion in Europe and in Italy, especially in the northern regions, of cooperatives and sector associations is considered an important success factor to reach small producers and unify the efforts and economic resources of the sector. For this reason, it is important to define their role, their power vis-à-vis with farmers (for example in terms of withholding taxes on the revenues generated by credits) and avoiding the creation of corporatism to the detriment of other realities.
Backwardness of the agricultural sector (BWAS)	It is important to foster education and engagement of both farmers and agronomist consultants on the topic of carbon farming, and on its benefits for the production and the functioning of the Voluntary Carbon Market. On this regard the funds allocated to the transversal pillar of the CAP called AKIS (Agricultural Knowledge and Innovation Systems) could play a fundamental role.

Current spread of action-based rewards (SABR)	It is important to overcome the habit many farmers have of receiving action-based rather than result-based funding. On this regard, it is important to act on two fronts: on the one hand, guaranteeing credit prices high enough to motivate the farmer to implement the practices and undergo monitoring, on the other hand, pushing for a cultural transformation of the sector towards a more entrepreneurial mentality, which is already rather widespread in the countries of northern Europe, but struggles to establish itself in Italy.
Additionality criteria (AC)	It is important to act on two fronts: on the one hand, guaranteeing credit prices high enough to motivate the farmer to implement the practices and undergo monitoring, on the other hand, pushing for a cultural transformation of the sector towards a more entrepreneurial mentality, which already rather widespread in the countries of northern Europe, it struggles to establish itself in Italy. In this perspective, recognizing a "neutral" and universal baseline applicable to all farms and considering the impact and absorption of the entire agricultural production could be an action that can be implemented.
Private frameworks already adopted and developed (PFAD)	One of the major challenges of the EU Commission is to try to put an institutional umbrella on realities that in part already exist, even if they are limited to developing countries. Gathering the experience gained from private standards and achieving continuity with what has already been achieved will allow players who already operate in the market to implement projects and purchasing credits to continue to operate and lead the new market.
Suspect of Green Washing (SGW)	On this regard all the respondents agree that there is an urgent need of clarification, standard definition and guidelines assessment at the institutional level, to allow the Voluntary Carbon Market to overcome its reputation as a palliative and ploy for major polluters. This would allow this instrument to truly become a tool capable of supporting the ecological and inclusive transition of both the agricultural sector and credit-buying companies. A particular attention should be dedicated to the definition of correct projects implementation, both on the farm side for the release of credits and on the business side for the purchase of the lowest possible number of credits, and if possible, for a limited period of time.
Carbon Farming Previous Experience (CFPE)	An important issue is the utilization of acquired knowledge and experience of lead farmers: in this perspective is essential to facilitate the spread of carbon farming practices even among traditional and small-scale farmers.

High variability of agricultural territories (HVAT)	The regional variations, both within Europe and within Italy itself, represent a challenge that can be solved only by identifying the correct trade-off between the universality of the monitoring method to be used (especially when models based on remote sensing data) and the ability to reflect the specificity of the biological, chemical and physical parameters of reference. On the other hand, it is also important to consider the diversity of the agricultural production and management frameworks, which especially in Italy sees the presence of numerous small / medium producers and few large-scale producers. In this regard, it is important to consider the limit that financing in agriculture often has, excessively dependent on the size of the agriculture enterprises, penalizing small producers, for whom the transition can have high costs and little possibility of financing.
Growing awareness in the business sector (GABS)	The growing interest of the business / production sector in sustainability standards is an important factor that must be encouraged. In this regard, the importance of creating a high and transparent standard should be underlined, in order to protect companies from reputational risks. Furthermore, the importance of pushing this lever is emphasized through information and knowledge spread. Also, supporting companies and consultancy activities in identifying effective methodologies to communicate their efforts and results achieved to the public, and above all to investors, is an important aspect to implement.

6.2: Actor's trust evaluation

The second pillar of the interviews was the analysis of the perception respondents regarding the capacity of both EU institutions and Italian institution to achieve their goals in terms of legislative developments, ability to respond to the demands of the various stakeholders, and, most importantly, to implement and enforce the framework when in its final form.

Regarding the answer received by the respondents belonging to the ecology area it has emerged that:

- there is high trust for what concerns the framework implementation at the EU level, the main challenge being the possibility, at this level, to guarantee the presence of a multi-disciplinarity and international approach.
- On the other hand, at the national level the implementation of the European guidelines seems a main drawback, because Italy has not identified Carbon Farming as a priority in its strategic plan and this is seen as an obstacle. Moreover, the implementation of this type of actions requires strong political decisions, and this is considered a main lack of the Italian system. Bureaucracy is also an issue: the

agriculture sector is highly regimented, and overlaps with the existing legislation is highly likely to occur (for example, in Italy it has not been defined yet how to account for income from the sale of credits).

Similar perception emerged from the interviews carried on with representatives of the finance and business world, which underlined that

- there is a relatively high trust for EU level, and there is a wide belief that EU action will be effective and comprehensive, given the high request and pression of the markets and society, especially in Norther Countries.
- At the national level, there is confidence that Italy will implement the necessary practices to comply with the European system, especially driven by the benefits that the implementation of th inis system would bring to the agricultural sector (and here it is interesting to note that trade associations are already moving intensively on this issue). This confidence is however linked, for two out of three respondents, to the ability of the EU to deliver a comprehensive and exhaustive framework, to limit somehow the discretion of Member States in its implementation.

Agricultural representatives, on the other hand, report slightly different views, although the perceptions stem from the observation of the same causes:

- At the Eu level, as a matter of fact, there is a general trust on its implementation but greater suspicion regarding the ability to identify a scheme suitable for different national realities. The greatest fear, presented by two out of three respondents, is that the system will be defined by taking as an example and model the countries of Northern Europe, which are further along in implementing similar practices, but have very different geographical, productive and economic realities.
- At the national level the major idea regarding the national implementation of a carbon farming and Voluntary Carbon Market System scheme is that Italy will implement them basically copying other countries. This could lead to the implementation of a scheme capable of responding well to the needs of large-scale domestic producers, at the expense of small producers who risk being underrepresented. A great deal of confidence in this respect is placed in the associations and cooperatives.

In general, the actors have greater confidence in institutions at the European level than in Italian institutions, with some interesting cases, such as one that almost reaches the point of hoping for the non-action and non-involvement. It is interesting to note, however, that institutions and local governments are also the best identified figures to respond to the fears expressed regarding the ability to involve the interested stakeholders, creating systems capable of responding to needs, and above all guaranteeing the protection of small producers with respect to large-scale realities.

6.3 Citizens as a lever: consumer and saver role

One last step needs to be done to complete the analysis presented till now.

As a matter of fact, till now the analysis carried out focused only on the answers given by representatives of the three critical areas for the implementation of the Voluntary Carbon Market System applied to carbon farming, in order to identify which are the critical and success factors for its implementation. On one hand, this analysis allows to identify what areas and issues need to be addressed in the preparation of the legislation and its implementation, but on the other hand it would be an error isolating this analysis from the broader social context. One last important voice needs to be added to the chorus of the actors queried within the framework of this thesis work: the citizen's one.

As a matter of fact, to provide a complete picture of the issues at stake, it is crucial to also analyse the role that citizens, and society as a whole, play in the creation and functioning of the system described so far. The main conclusion emerging on this regard is that citizens play a central role and can be defined the main lever for the very existence of the voluntary carbon market, being the ultimate reasons for which both farmers and companies are willing to enter into it. Fig. 17 shows the reasoning and the data underling this statement.

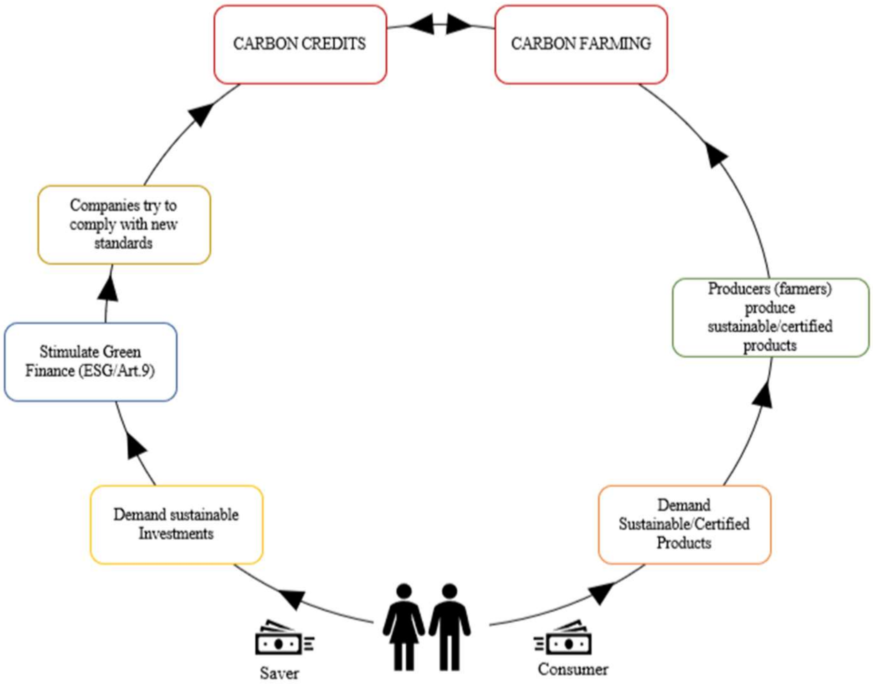

Fig. 17: Citizen's Role

The starting point is the role of citizen in society, which can be generalised in three main roles:

- Voter: in democratic societies, the citizen has the power to influence the political willingness to fight climate change.
- Consumer: through the demand of specific products, the citizen stimulates the company's action on supplying goods in response to new emerging needs;
- Saver: through investments choices, move the choice of financial institutions and investments funds.

It is evident that this is a closed and self-reinforcing circle, where beliefs and awareness of the citizens is amplified through vote in political actions, which can directly influence both business and financial institutions towards the creation of standards and compliance. In turn, financial institutions can influence business through investment decisions, while business has a huge power of influence by means of lobby and communication/advertising on public.

The results of the action of citizen as voters has partly been explored in chapter two, where the political tendency to reach climate neutrality has also been demonstrated, especially at the European level. What needs to be addressed now is how a growing demand for sustainable certified food products is pushing a considerable number of agricultural enterprises and consortia to change their production practices, even radically, towards more sustainable models. Data concerning organic production, currently the only regulated and certified sustainable production system at European level for the food sector (Aprile et al., 2012), can demonstrate this. The graph in Fig. 18, plotted based on ISMEA data of monthly average prices of wholesale food products relative to the month of July 2021, shows how organic products are on average considerably more expensive, on average 26% more. However, consumers are now well prepared to bear these higher prices, so much so that since 2012 in Italy the number of households consuming organic food products has increased by 10 million with a growing trend, with an increase of 5% only from 2020 to 2021 (Sgambato, E., 2021).

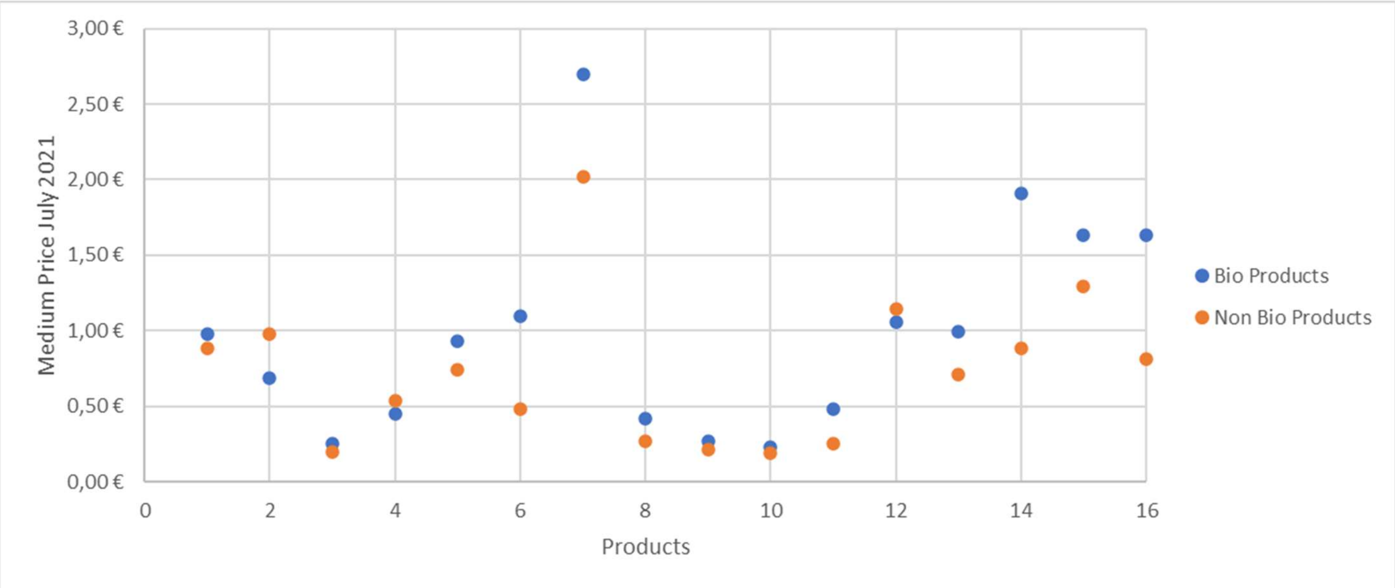

Fig. 18: Price comparison food products (Data Source: Ismea, 2022)

Demand for sustainable food products is clearly on the rising, and therefore the possibility to increase market power is a good lever for farmers to implement sustainable practices and, as it has happened already for organic farming, the same could happen for carbon farming. On this regard it is important to notice that this could work only, or has better chance to work, if a certification and adequate controls are defined at the EU level, and an adequate information campaign is implemented also toward citizen.

The same general logic can be applied to the analysis of the citizen 'role as saver. The Global Sustainable Investment Alliance reports that in 2020 the world market dimension for financial activities considered "sustainable", and therefore compliant with the ESG standards, was valued 35.300 million US dollar, equal to 36% of the total managed savings worldwide, and that these number showed an increase of more than 15% compared to 2018. This trend is confirmed also at the Italian level, where Banca d'Italia reports that by the end of 2020, 17% percent of Italian and foreign mutual fund shares held by households were ESG funds, with a total estimated value of 116 billion euros. The estimate is based on a definition of "ESG funds" that includes not only funds that declared themselves to be ESG in the prospectus, but also those to which Morningstar assigned a sustainability score of 4 or 5 (the rating ranges from 1, least sustainable, to 5, most sustainable) and funds to which Morningstar assigned low risk related to pollutant emissions (Low carbon designation) (Banca d'Italia, 2022).

6.4 Results Discussion

The final step of the analysis concerns the comparison between the synthesis of the results obtained and the process implemented so far by the European Commission for the development of the EU Carbon Farming Strategy. The table below shows the list of the identified factors, their categorization based on the relevance found among the respondents and the level of consideration implemented at European level. This last point was made with reference to the literature review carried out in the first chapters and to the results that emerged during the Conference on Sustainable Carbon Cycles, which has been organised by the European Commission to bring together decision makers, experts and technicians coming from several sectors to share experiences, knowledge and view toward the creation of the upcoming EU Carbon Farming Strategy.

Tab 8: Identified Factors and present consideration at EU level

High Success | Medium Success | Low Success | High Risk | Medium Risk | Low Risk

Factors	Presence in European legislative development
Cost and sophistication of monitoring systems (CSMS)	Challenge recognised, work in Progress - consultation with stakeholders and technical working tables are currently working
Local specificity of key parameters (LSKP)	Challenge recognised, work in Progress - consultation with stakeholders and technical working tables are currently working
Ecological approach (EA)	Absence of specific intention in this regard
Multidisciplinarity of issues at stake (MIS)	Well addressed and action implemented - Multidisciplinary working tables and broad stakeholder consultations.

Fragmentation of agricultural sector (FAS)	Challenge recognised, work in Progress - consultation with stakeholders and technical working tables are currently working
Presence of Sector Association and Cooperatives (PSAC)	Absence of specific intention in this regard
Backwardness of the agricultural sector (BWAS)	Well addressed and action implemented within the new PAC and specifically the AKIS Pillar
Spread of action-based rewards (SABR)	Challenge recognised, work in Progress - consultation with stakeholders and technical working tables are currently working
Additionality criteria (AC)	Absence of specific intention in this regard
Private frameworks already adopted and developed (PFAD)	Absence of specific intention in this regard
Suspect of Green Washing (SGW)	Well addressed and implemented through the willingness to implement a transparent and reliable framework. Still, this is applied mainly to the farm/agriculture side and not on the business side.
Carbon Farming Previous Experience (CFPE)	Well addressed and implemented through the presentation of successful case studies in the Technical Handbook.
High variability of agricultural territories (HVAT)	Challenge recognised, work in Progress - consultation with stakeholders and technical working tables are currently working
Growing awareness in the business sector (GABS)	Well addressed and implemented through the engagement of companies within the consultation phase and in conferences.

Lastly, it is important to notice that the EU Commission has also started a consultation process regarding the creation of a carbon label, a further step that was only hinted at in the Communication on Sustainable Carbon Cycles, but which is gaining increasing importance. This demonstrates how the European Union has understood the importance of exploiting certifications as a tool of transparency but also as a lever to effectively transfer information to citizens in a simple and transparent way. However, it is important to underline that now the attention regarding certification is only developed on the agricultural production side, while there is still no clear intention detected to include credit purchasers within a definitive framework for planning the abatement of internal emissions, compensation for residual quotas and certification and control over the efforts implemented.

Resuming on the research question initially identified, and thus whether the EU Carbon Strategy is positioning itself as a breakthrough strategy for the agricultural sector, and how it responds to the different actor's needs identified through the applied three-dimensional approach, the great transformative potential of carbon farming and its economic financing through the creation of the VCM clearly emerges. As a matter of fact, the analysis shows that both success and risk factors with high frequency have either already been addressed with practical actions or are present in the debate at the European level. Nevertheless, it is important to underline the high transformative potential above mentioned can be fully exploited only if a holistic and ecological approach is adopted, not incurring in the error of isolating the single implementation of carbon farming practices from the Lifecycle Assessment of the whole production within a single farm.

What stated above is true also regarding the business world: it would be an error to consider the acquisition of carbon credits as a universal placebo capable of offsetting all emissions from production activities. It is essential that companies' access to the market is also regulated, that ambitious and transparent requirements for commitment to climate neutrality are defined, and that the purchase of credits is presented as a temporary and transitional solution.

Ch. 7: Conclusions

The analysis presented clearly shows the European commitment to stop climate change without compromising the economic growth and social well-being of its inhabitants. However, the way to find the right compromise between ecological optimum and social optimum is an extremely slippery ground, and above all with regard to the implementation of the EU Carbon Farming Strategy, the road is still long.

On this regard, some conclusive considerations can be made, looking at the legislative development in its entirety and taking into consideration what emerged from the exploratory research. Firstly, the importance of the project phase needs to be further emphasized and defined at the legislative level, both on the side of the farmer, who must define a carbon farming project and the related monitoring and assessment phase, and on the side of the corporate credit buyers, which must define an internal strategy to reduce emissions related to its production activity and identifying the minimum timeframe and optimal offsetting methods. The EU Commission must focus more on this point, otherwise the Voluntary Carbon Market System risks to be perceived only as a system generating profit for farmers and green advertising for companies, and this would not only be a risk, but also a great waste of resources and opportunities.

The EU also needs to pay closer attention to the role of citizens as a lever within the system, investing resources and skills building awareness and education, both as consumers and savers. This also involves the creation of a clear, transparent, recognizable, and well-sponsored certification both for products resulting from carbon farming and for companies committed to offsetting their emissions through credits deriving from carbon farming projects.

In this, Italy faces a double challenge: being a country in which the agricultural sector has an important economic importance, and which owes an important part of its value to the multi-functionality of agriculture but which at the same time struggles to stay on for sustainable production and innovation in the sector, Italy can derive important benefits from the implementation of this system. Moreover, it can count on a series of important levers such as the presence of important category associations that are already very interested in the topic, and a great attention by citizens to the quality and recently also to the sustainability of food. However, the delay with which the administrative spheres are approaching these issues, ultimately represented by the absence of specific intentions for carbon farming in the new strategic plan of the CAP, and long-standing problems linked to bureaucracy and the difficulty of Italian politics in agreeing definite positions, are limits that must be addressed quickly and decisively.

In the end, what clearly emerges is the need of profound transformations, that are not limited to individual sectors but are occurring systematically throughout our economy toward achieving climate neutrality by 2050. On this regard, the implementation of the EU carbon farming strategy would represent, under a certain perspective, the collapse of the last holdout, if not practical at least conceptual. Soil, land, private property par excellence, brings out its universal dimension: soil depletion is a common problem, and a political will to find a common solution emerges. The difficult and challenging trade-off between ecological optimum and social optimum, which cannot disregard the private optimum of the landowner, is thus realized in such an extremely complex instrument as the creation of the voluntary credit market, powerful because in potency it has great capacity to influence the actions of actors and overcomes the sectoral isolation of the transition policies made so far, but that it does not exempt itself from the great risk of becoming, as a market, a mere instrument of profit. This is the greatest risk, which only careful and all-encompassing monitoring and regulation of all interests at stake-economic, social, and environmental interests-can avoid.

One last thought needs to be addressed to the current economic and political situation, and the outrageous war in eastern Europe we are assisting to. It is well documented that both the inflation, caused by the conjuncture of economic growth and scarcity of energy resources, and the global food crisis caused by grain deadlock in Ukrainian ports have both major repercussions on the complex interactions between the agricultural sector, the business world, and the environment. Food products prices will increase consistently, mostly in African Countries, exacerbating the situation of malnutrition in the poorest segments of the population (Amref, 2022). At the same time, in the business sectors investors are reacting to the crisis disinvesting from the riskiest and most uncertain funds, with an across-the-board decline inevitably leading to a cooling of the economy (MorningStar, 2022). Reasoning with respect to the model presented in Chapter 1, we are in fact in a situation where the social discount rate has soared due to the crisis, and this is likely to lead to a renewed focus on productivity and mere economic efficiency at the expense of environmental balance. The main hope on this regard is that the crisis demonstrates how much it is necessary and urgent to rethink our economic and productive model from the ground up. In this perspective, a truly effective and integrated implementation of carbon farming should look at the entire agricultural sector, and act as a pivot of transformation not limited to the implementation of specific and isolated agricultural practices but aiming to increase the resilience and sustainability of the sector. In a holistic and integrated way.

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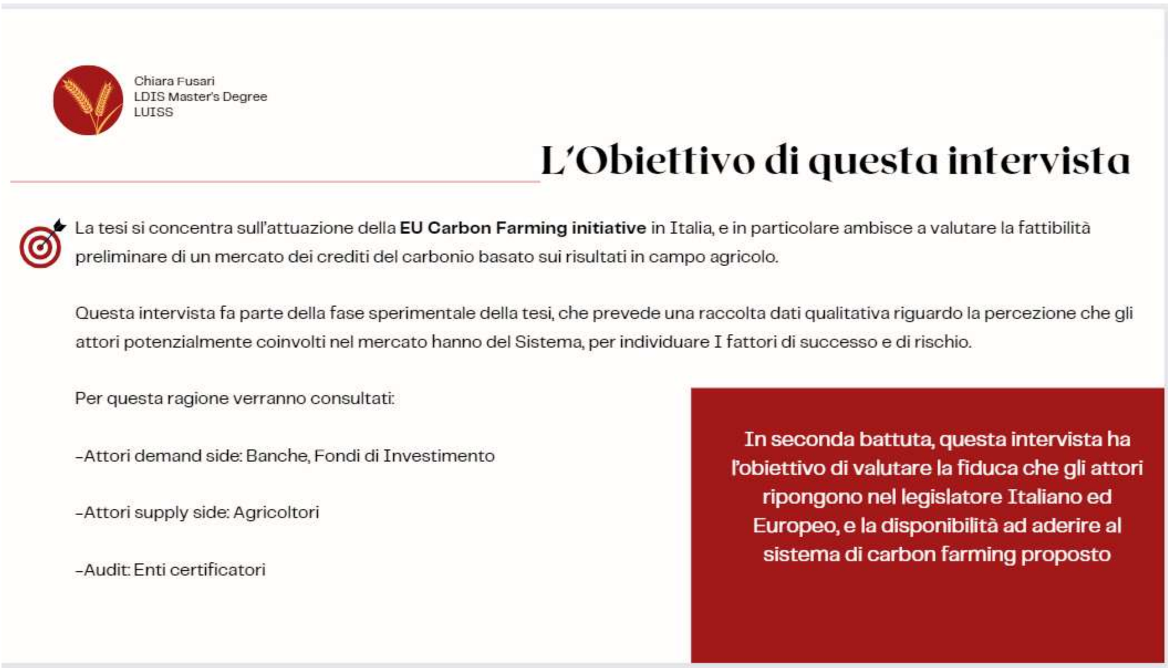
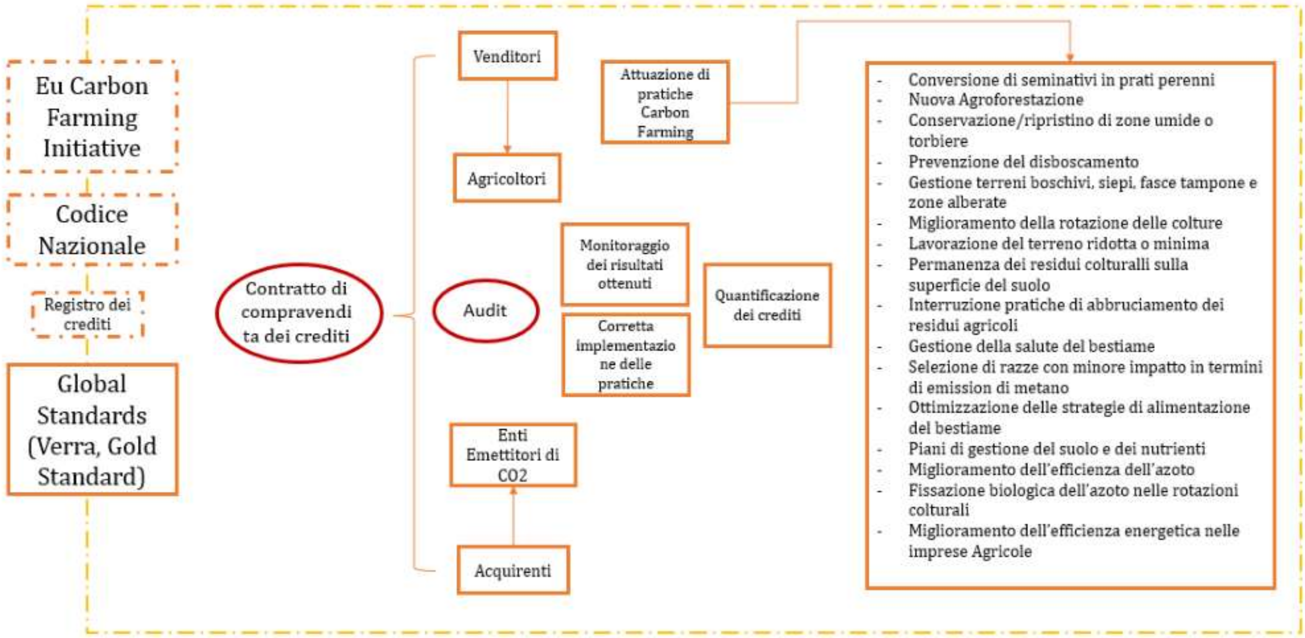
ANNEX:


Chiara Fusari
LDIS Master's Degree
LUISS
INTERVISTA
Analisi di fattibilità preliminare sull'attuaizone di un Mercato Volontario dei Crediti del Carbonio per il settore agricolo


Chiara Fusari
LDIS Master's Degree
LUISS
L'Obiettivo di questa intervista
La tesi si concentra sull'attuazione della EU Carbon Farming initiative in Italia, e in particolare ambisce a valutare la fattibilità preliminare di un mercato dei crediti del carbonio basato sui risultati in campo agricolo.
Questa intervista fa parte della fase sperimentale della tesi, che prevede una raccolta dati qualitativa riguardo la percezione che gli attori potenzialmente coinvolti nel mercato hanno del Sistema, per individuare I fattori di successo e di rischio.
Per questa ragione verranno consultati:
-Attori demand side: Banche, Fondi di Investimento
-Attori supply side: Agricoltori
-Audit: Enti certificatori
In seconda battuta, questa intervista ha l'obiettivo di valutare la fiducia che gli attori ripongono nel legislatore Italiano ed Europeo, e la disponibilità ad aderire al sistema di carbon farming proposto

Il Mercato Volontario dei Crediti del Carbonio



Scenario

Il mercato presentato si presta ad essere attuato in qualche modo al vostro scenario?

Quali sono I fattori che considereresti chiave nel valutare l'adesione al mercato presentato?
Quali sono invece I fattori di rischio che non vi farebbero entrare in questo mercato?

Analisi

Quanta fiducia riponete nelle istituzioni Europee riguardo la creazione di un quadro normativo di riferimento in materia?

Quanta fiducia riponete nelle istituzioni Italiane riguardo la creazione di una legge di riferimento nazionale in maniera?

Summary:

Introduction

This is a thesis about soil, and how humanity is literally in danger of losing the earth beneath its feet.

For millennia, soil has been humanity's primary concern, as first source of food and subsistence, but this has changed drastically in the last 50-year, when soil lost its centrality in the political agenda and public debate, especially in the privileged Western World. As a matter of fact, our society has been simply convinced that hunger had been defeated by increased yields and productivity, and this implies mechanical tillage of soil by huge tractors, adding ever-increasing quantities of industrial fertilizers. Thanks to the chemical and technological innovations brought by the Green Revolution of the 1970s, developed countries were able to increase agricultural productivity by leaps and bounds, feeding a growing population, which has increased dramatically by 7 billion in the last 200 years, and is expected to consistently grow in the future (IlSole24Ore, 2017), with an estimated increase in cultivated land of more than 539 million hectares, an area which is comparable to twice the size of India (Liu, 2022). Yet, in recent decades, as the productivity of agricultural soils and the entire complex ecological system related to agricultural production is greatly threatened by climate change, productivity started to decline. Climate Change is caused by the greenhouse effect produced by an excessive presence of CO_2 and other Green House Gases (GHG), generated by human activities, among which livestock breeding and intensive farming. Data show that the total amount of carbon in the atmosphere has increased by 30%, and science agrees in linking this increase with the dangerous warming of our planet because of an increased greenhouse effect, altering temperatures and seasonality which are essential to ensure adequate crops growth (Esa, 2022). At the same time, fertilizers abuse, and intensive practices have led to soil depletion, deterioration of water quality and desertification, with a huge economic impact: the sum of the total nutrients loss in soils brings an estimated economic loss of around $200mln annually and has high costs to human health and environmental impact, estimated at $400 billion per year (FAO, 2022). In front of this scenario, agriculture is both a cause and a solution, on one hand accounting for more than 10% of total global anthropogenic emissions of greenhouse gases (IPCC, 2022), on the other hand being an essential ally for its CO_2 uptake potential. As a matter of fact, soil can be restored though carbon farming practices, and the recoverable carbon reserve capacity of the world's agricultural and degraded soils is estimated to be between 21 to 51 Gt of carbon (FAO, 2022).

The looming climate and food emergency has led to a collective awareness, which has resulted in several crucial initiatives in responding to the emergency. At global level, in 2015 the ONU launched the Agenda 2030 for Sustainable Development, which aim to lead people, companies and institution's action in achieving the 17 Sustainable Development Goals, broken down into 169 specific targets with related indicators (UN, 2015a). Among these, the health status of the soil is one of the three indicators used to monitor the achievement of SDG 15: *"Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage* *forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss".* Also in 2015, the Paris Agreement was signed by 55 countries, presenting for the first time at the global level an action plan aimed at limiting global warming by defining the long-term goal of keeping the earth's atmosphere warming below 2 degrees (UN, 2015b). On this regard, the European Commission decided to foster the role of the agricultural sector launching a new plan, which is expected to finally give consistency to what numerous Common Agriculture Policy (CAP) and previous strategies have not reached yet: push for a broad and deep transformation of the agricultural sector, surpassing the era of intensive and impactful practices, to attain a similar productivity, but based on different cycles and techniques. This work of thesis aims to fill this gap, taking the opportunity offered by the legislative developments proposed by the European Union regarding the implementation, by 2023, of the EU Carbon Farming Strategy, and the attempt to foster its adoption through the creation of a Voluntary Carbon Market (VCM) to enable farmers to transform the CO_2 absorbed in agricultural soils into credits that can be sold on a voluntary market open to companies wishing to offset their own emissions. Parallel to political engagement, research is also moving more confidently on the topic of soil health and carbon farming. What is emerging is that soil governance has been relegated to the more technical aspects of cultivation for too many years. On this regard, technical, political, and economic aspects of soil use and management need to be stressed and merged holistically, to derive a new multidisciplinary theory of soil governance (Juerges et al., 2018). The same has been recently stated also by L. Montanarella, prominent expert of Soil Science and founder of the Fao's Soil Partnership, which stressed the importance to study and manage soil with a holistic and transversal approach (Montanarella, 2012). This is the background to this thesis, which aspires to answer the following research question: "*Which are the emerging success and risk factors for the implementation of a Carbon Farming VCM? and how are they considered within the legislative development toward the definition of the EU Carbon Farming Strategy*?"

To answer this question, an explorative qualitative research has been carried out, based on an extensive literature review, which sought to combine theoretical concepts, relating to the environmental economics approach to pollution target identification exposed in chapter 1 and related policy instruments presented in chapter 2, with a focus on market instruments and voluntary carbon markets. The literature review focused also on the technical and ecological area linked to the functioning of biological and ecological systems of the carbon cycle and the challenge of their monitoring which are presented in chapter 3, concluding with an analysis of the political approach implemented at European level in chapter 4. The general background highlighted by the literature review has supported the explorative research, which aims to give a novel multidisciplinary perspective of the issue of soil governance based on the creation of a VCM, through the conduction of several interviews with different actors of the sector, representing both the demand and supply side of the possible VCM. Given the novelty of the topic explored, and the time constraints, this thesis goal is to provide an initial exploration of the issue, reporting and analysing information and data stemming from different stakeholders (e.g., farmers, consultants, investors and agriculture and ecology experts). The explorative analysis presented aims to identify interesting factors and to propose a comprehensive reading of the legislative unfolding, which will need to be subjected to more extensive validation, such as through surveys to validate the identified factors within a larger audience.

Literature Review:

The literature review aims to explore core concepts of the different fields.

Initially, the analysis has focused on a model of dynamic efficiency in environmental economics presented by Perman et al., (2011), which lends itself very well to present the difficult role of the decision maker in dealing with environmental issues. As a matter of fact, the model shows that there is a discrepancy between ecological and social optimum, meaning that while global warming is a threat to humanity, immediately eliminating the cause, that is, reducing CO_2 emissions to zero, is impossible because of the high social and economic costs. At the same time, this solution would also not be decisive because of the permanence of greenhouse gases in the atmosphere, which are absorbed at various rate according to biological and chemical characteristics of the ecosystems. The regulator has the difficult task of identifying the amount of emissions that can be abated without generating excessive burdens on society, striking a delicate balance that depends on several factors including: the willingness of society to bear the costs of the ecological transition (defined as the social discount rate), the ability of the ecosystem to absorb the CO_2 already emitted (identified as the parameter alpha, which can be increased through carbon farming practices), and the ability of companies to internalize the shadow price of emissions, and thus take on the burden of lost production or its transition (which is actually accomplished through the creation of the carbon credit market).

Explored how the emission targets are identified and which is the role that both carbon farming and the carbon markets can play the analysis moved to the instruments available to reach those targets. There are three main categories of instruments: a) **Institutional approaches to facilitate internalization of externalities**, which consists of the implementation of actions to improve already existing social or institutional ways to contain environmental damage such as specification of liability, facilitation of bargaining, development of social responsibility through education; b) **Command and Control Instruments**, which allow regulators and environmental agencies to exercise a direct control over polluter subjects; c) **Market instruments**, which operates altering the relative prices faced by economic agents though the creation of taxes on emissions emitted of subsidies for emissions saved. This latter category also includes the institution of **carbon markets**, which can be defined in very general terms as a system in which, within a specific legislative framework, polluting entities can purchase units of CO_2 or other GHG absorbed by other actors (CarbonCredits, 2022a). Carbon Markets have been established in 1997 with the Kyoto Protocol. Carbon Markets can be distinguished among mandatory compliance markets and voluntary , which fall entirely under the control of the policy maker which identifies the maximum level of emissions deemed socially acceptable, identifies polluting firms that must reduce their emissions, and allocates the amount of emissions "available" among polluting entities in the form of permits or credits to pollute (with the possibility for virtuous entities within the scheme to sell the amount of CO_2 saved to less polluting ones). The voluntary carbon market on the other hand have evolved over time as voluntary systems which enable pollutant subjects to offset their emissions by the acquisition of carbon credits generated by projects or initiatives which remove or decrease the GHG emissions from the environment (Kreikbich et al., 2021). The main difference that needs to be underlined is the fact that companies engage in this second scheme on their own, often as part of Corporate Social Responsibility initiatives or industry program. VCM are a fast-growing reality, and their contribution to meeting climate goals is becoming increasingly evident (Kreikbich et al., 2021). The Bank of America Global Research underlines in its report that the segment will go through a 50-fold expansion in demand by 2050. This will especially be the case for some hard-to-abate sectors, including construction, aviation, shipping, and metals, for which the technology to reduce emissions is lagging, meaning that other methods are needed to make progress at decarbonising (Bank of America, 2021). Still their implementation is rather complex, Britsch et al. (2022) underlines the importance of the reference framework, and how it should always indicate:

- The requirements to be met when creating a project willing to emit carbon credits. The main requirements are additionality the project, securing of permanent drop of emissions and exclusive claim, while other requirements can be established such as social or environmental benefits, often in line with the SDGs.
- The monitoring system adopted.
- The verification method and the metrics adopted to issue the carbon credit. These credits are usually (but not always) recorded in a register.

The dominant global standards are the Verra and the Gold Standards, both issued by private entities, but different local and public standards are emerging too, especially regarding pilot projects or national frameworks. To date, there are numerous standards with even substantial differences, however, most are beginning to converge, driven by requests for increasing uniformity from member companies, on the following parameters used to evaluate carbon farming projects (Liu, 2022):

- Realness: the effective absorbent of GHG is adequately measured
- Additionality: the absorbent is increased by project activities financed by carbon finance scheme
- Transparency: there is a third-party verification and information is clear and accessible
- Leakage: the project foresees mitigation of risks emerging during the activities
- Permanence: the carbon sequestered during the project is stored permanently (even if there is no accordance of a time framework)
- Completeness: the information is released regarding all the aspects of the project
- Ownership: the owner of the carbon offset is immediately identified
- Accuracy: the measurement is as specific and punctual as possible

- Conservativeness: the evaluation of the project is based on conservative assumptions in case of uncertainty.

Given the voluntary nature of VCM, and the multitude of voluntary markets the various players can rely on each one with different standards, their expected grow raises material concerns for companies and regulators as the increase in demand, which also brings with it an increase in prices, will create a number of challenges are beginning to emerge for both companies and the regulator: in terms of reputational credibility and economic impact for the former, and in terms of the necessary transparency and impact on pollution effective absorption for the latter (Britsch et al. 2022).

Once the more purely economic areas of the topic have been addressed, aspects related to the operation of carbon farming and its monitoring were also explored. **Carbon Farming**, which falls into the category of nature-based solutions, refers to the management of carbon pools, carbon circulation and greenhouse gas fluxes at farm level, implemented to mitigate climate change. The capacity of agricultural soil to absorb and store carbon dioxide depends on the rate of carbon cycle in the given ecosystem. As a matter of fact, if rate of photosynthesis, through which the plant transforms sunlight, water, and atmospheric carbon dioxide (CO_2) into carbohydrates and oxygen, is higher than total respiration rate, though which carbon moves from the plants back to the atmosphere, the ecosystem stores more carbon than it emits. In this case we refer to soil and biomass as **carbon pool**. Rate of respiration and rate of photosynthesis depends on several environmental, climatic, soil characteristic and species-specific factors (Bispo et al., 2017), and many other biotic factors intervene in this process such as plant input and soil organisms, weather (temperature and precipitation) and soil mineralogy (soil physio-chemical properties) (Luo et al. 2017).

According to the IPCC, the augmentation of the rate of soil carbon sequestration and storage can be achieved in several ways, such as decrease the level of soil disturbance, in order to improve the physical protection of soil carbon in aggregates by acting on tillage practices; increase the mass and quality of plant and animal inputs to the soil; improve the microbial diversity and consistency of the soil; maintain a continuous living plant cover on the soil throughout the year.One last point needs to be addressed when analysing the phenomenon of the carbon farming. The technical handbook devotes an entire section to the co-benefits of carbon farming, i.e., those benefits that go beyond reducing emissions and increasing the absorptive capacity of agricultural soils, such as reduction of soil erosion and nutrient leaching; Improved soil functionality and water infiltration; Diversified income flows for farms; Improved animal welfare and correct nutrition; Pollination services; conservation of biodiversity and landscape protection.

The adoption of a carbon farming scheme requires a precise measurement and quantification of the results obtained. This is the subject of the so-called Monitoring, Reporting and Verification (MRV) phase, which is particularly delicate since the key challenge at this stage is to quantify with adequate precision the results obtained, avoiding unsustainable costs (Frascarelli et al., 2021). The variations of carbon in the soil and biotic pools can be measured through several methodologies, such as soil sample analysis, modelling, or most recently the adoption of modelling combined with spectral methods, remote sensing, micrometeorological techniques. The use of these methods still involves a strong trade-off between economic efficiency and reliability of results, and the continuing progress of research in the field of remote monitoring, which emerges as the most efficient solution but with potential for improvement regarding effectiveness, bodes well.

A report recently released from the World Economic Forum states that, if proper action is implemented at political level, by 2030 agricultural greenhouse gas emissions could be reduced by 6% and the soil could be restored by 16%, adding between €1.9bn and €9.3 billion annually to farmers' incomes. It is now easily understandable why there is a growing willingness to bring carbon farming practices within the standards required to issue credits and then sell them on voluntary markets, and on this is based the EU Carbon Farming Strategy.

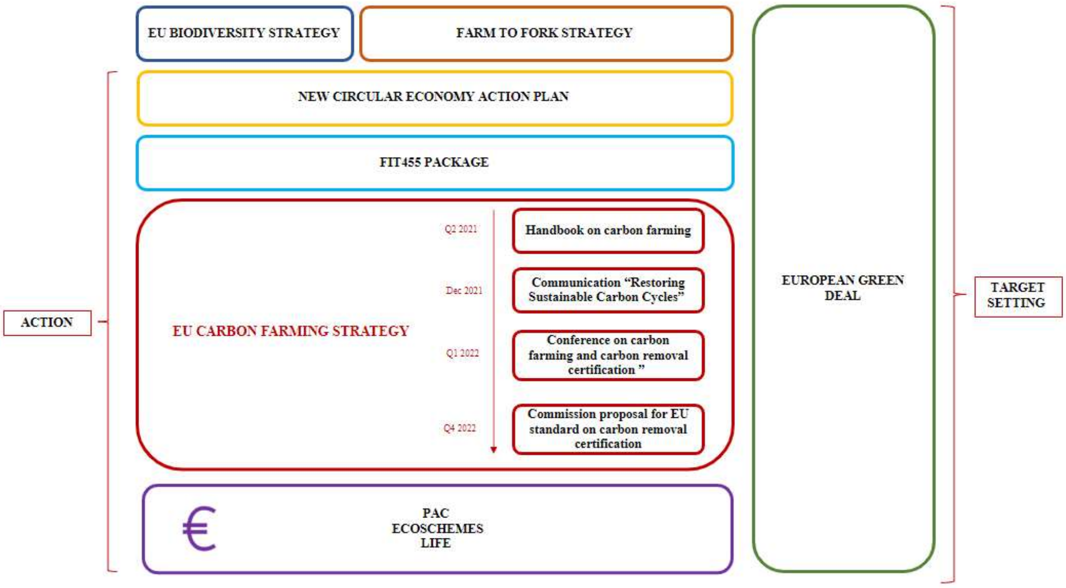


Fig 12: Eu Carbon Farming Strategy in the context of European Policies to reach Climate Neutrality by 2050

The EU Carbon faming initiative is meant to foster the achievement of the Green Deal's goal and is an articulation of what has been defined in both the EU Biodiversity Strategy and the Farm to Fork strategy. It consists in a series of intermediate steps: the release of a preliminary study condensed in the Technical Handbook "Establishing and implementing results-based carbon sequestration mechanisms in agricultural soils in the EU", the Communication on Sustainable Carbon Cycles released in December 2021, the Conference on Carbon Farming and Removal Certifications which took place on January 2022. Regarding the implementation of the drafting of the Italian National Strategic Plan for the implementation of the CAP 2023-2027 funding it is crucial to note that, to date, no specific interest in carbon farming emerges. However, carbon farming implementation actions still fall secondarily as an activity subject to funding, since some practices are listed among the criteria for enhanced cross-compliance that farmers receiving funding will have to comply with.

Results Analysis and Discussion:

The analysis of the results followed the methodology for qualitive research proposed by Lacey et al., (2007). During the familiarisation phase with the collected information fourteen factors have emerged as recurrent themes on which a sufficient number of actors focused, identifying them as risk or success factors, which need to be taken into consideration when defining a framework for the application of the voluntary carbon market for the carbon farming. These factors are:

- **Cost and Sophistication of Monitoring Systems (CSMS)**: the correct and effective implementation of the monitoring phase is still very difficult and expensive, an important challenge is represented by the difficult trade-off to be realized between scientific robustness, and usability and affordability of the monitoring system.
- **Local Specificity of Key Parameters (LSKP):** when adopting the model to carry out the monitoring and assessment phase, it is important to consider that generally, models developed so far for the carbon farming have been tailored on parameters specific to the project implementation location. Moreover, very often these models are developed for research purposes or for pilot projects for CO_2 absorption estimation, thus being scientifically correct but often very elaborated and hence difficult to scale up.
- **Ecological Approach (EA)**: this factor addresses the adoption of a comprehensive view on the production reality under analysis, and a deep understanding of its whole functioning, and linkages with other realities. This concept has emerged in relation to both credit-creating agricultural production entities, and credit-buying industrial entities.
- **Multi-disciplinarity of Issues at Stake (MIS)**: the implementation of carbon farming practices, their monitoring, and finally the creation of credits that can be purchased on a voluntary market present numerous challenges attributable to very different fields of study, from agricultural science to economics to finance, without leaving aside ecology and biology.
- **Fragmentation of Agricultural Sector (FAS)**: in several European countries, and in Italy especially, the agricultural sector is characterized by a high presence of medium/small farms.
- **Presence of Sector Associations and Cooperatives (PSAC)**: in Europe, and in the Italian reality in particular, the phenomenon of associationism and corporativism in the agricultural sector is very common.
- **Backwardness of the Agricultural Sector (BWAS)**: the Italian agricultural sector, and especially small entities (SME), often demonstrates a serious state of backwardness with respect to both implemented agricultural practices and the use of technological and innovative support tools.
- **Spread of Action-Based Rewards (SABR)**: To date, most policy initiatives in agriculture have fostered the green and digital transition of the sector adopting mainly incentives given *ex ante* to actors, either to support needed investments or as reimbursement for expenses incurred.

- **Additionality Criteria (AC)**: the calculation of the CO_2 uptake that can be rewarded to date is based solely on realized increases over the baseline situation at the beginning of the project.
- **Private Frameworks already Adopted and Developed (PFAD)**: there are currently private standards that are also being applied to carbon farming, although mostly for projects carried out in developing countries, and which are purchased by companies (e.g., Verra and Gold Standard).
- **Suspect of Green Washing (SGW):** the absence of a legislative framework, the coexistence of numerous private standards, and a general misinformation of actors have created a curtain of suspicion over the functioning of voluntary carbon markets, which unfortunately have been confirmed in past years by incidents of double sales of credits, fraud on registries, etc.
- **Carbon Farming Previous Experience (CFPE)**: carbon farming practices are not a recent invention, but mostly draw on traditional practices implemented before the advent of industrial agriculture, and its core principles are at the basis of agroecology and organic farming. To this day, they are often implemented within regenerative and biodynamic approaches to farming.
- **High Variability of Agricultural Territories (HVAT):** within the European territory, and in the Italian territory itself, there are geographical areas of great variability in terms of climate, conformation, and characteristics of the soil, but also with regards to social and economic structures, such as farm size, types of management, techniques applied, etc.
- **Growing Awareness in the Business Sector (GABS)**: there is a growing awareness, among small and large productive companies, of the need to limit and compensate for large emissions and to communicate effectively the objectives fixed and the results achieved.

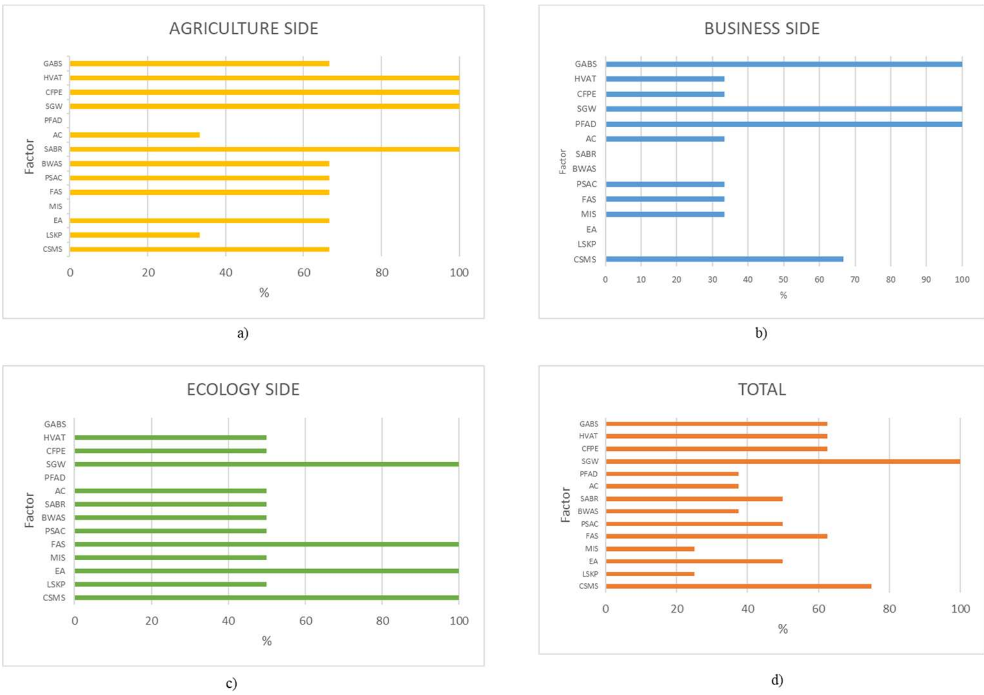


Fig. 15: Percentage of factor's mention within each group and in total

Figure 15 shows the areas of intersection between the responses given by the different groups, to best bring out the cross-cutting nature of the identified factors and the commonalities of interest. Interestingly, most of the factors are shared by all 3 groups, showing that despite different roles and even different approaches the actors show interest in common topics, and this is a major strength of the legislator who must identify these common factors as areas of special interest and focus. A central position is occupied by the Suspect of Green Washing (SGW) factor, which was reported by all respondents, emphasizing that the action taken by the Commission to legislate on the issue is necessary and appreciated by all groups.
The following step of the analysis was the categorization of the different factors. Given the structure of the interviews, which included two separate questions for identifying risk and success factors, it is immediately possible to categorize the emerging themes as success or risk factors (respectively right axes of fig. 17 and left axes of figure 17). Combing then the results relative to the frequency of respondents who emphasized the importance of the factor and the categorization of the factor, it is possible to evidence a relationship between the category of factor and its relevance in terms of frequency detected in the total number of respondents. This is plotted in Fig. 17 below, in which the vertical axis shows the relative frequency of responses (in percentage values) and the horizontal axis the categorical variable risk or success.

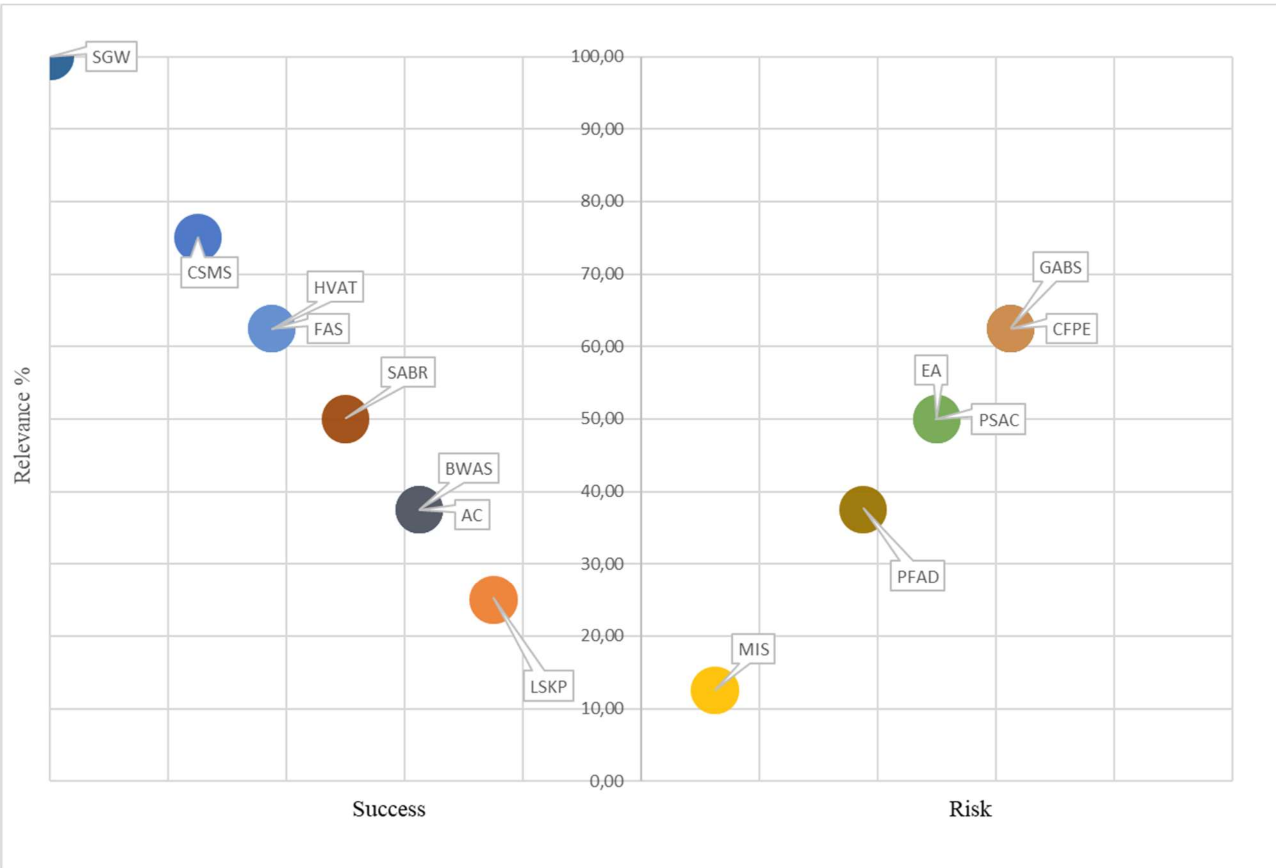


Fig. 17: Relevance and Categorization of the identified Factors

This allowed for an indicative clustering of the factors, dividing the factors thus arranged into three clusters, i.e., distinguishing the factors with relevance below 33.3% (Low), with relevance between 33.4% and 66.6% (Medium) and finally the factors with relevance higher than 66.7% (High). It is possible to distinguish:

- **Success factors with high relevance**, which have a high level of transversality among the areas explored, potentially placing themselves as strategic levers on which to act to achieve a good level of satisfaction among the different groups and push their participation in the market. These are a) the presence of previous experience in the field of carbon farming (CFPE), and b) the growing awareness in the business sector (GABS).

- **Success factors with medium relevance**, which are a) the possibility to adopt a holistic ecological approach to business and farm management (EA), and b) the presence of cooperatives and sector associations (PSAC). These factors showed a slightly lower relevance but are still considered important by the respondents.

- **Success factor with low relevance**: two success factors have been identified by only two respondents, namely a) the multidisciplinarity of the issues at stake (MIS), which, if correctly contemplated within the preparatory works for the legislative design secure higher chances of successful implementation of the legal and policy framework, and b) the presence of private frameworks (PFAD) which have already developed and are already used by actors in the markets. The latter can be considered a success factor because it can provide useful knowledge, and at the same time ensure the presence of buyers if a good alignment between the systems is adopted.

- **Risk factor with high relevance**, which need to be particularly considered by the legislator, which must take decisive actions and implement adequate mitigation strategy. These risks, which have been underlined by the majority of the respondents, are a) the high cost and sophistication of the monitoring systems (CSMS), b) the high fragmentation of the agricultural sector (FAS) which, being characterized by numerous small businesses, makes it challenging to make large investments, achieve high levels of technology or have and innovative approach to agronomic management and finally, c) the high variability of the territories (HVAT), both geographical and social, which makes it difficult to identify a suitable framework for different situations, from the practical implementation of agricultural practices to the more complex identification of the relevant legal framework.

- **Risk factors with medium frequency**, which are a) the spread of the action-based rewards (SABR) and therefore the consequent established habit for many farmers of receiving *ex ante* funding to support investment and b) the additionality criteria (AC), that establishing additionality with respect to the practices implemented before the development of the project risks hindering the participation of the farmers already adopting regenerative practices.

- **Risk factors with low frequency**, which have been identified as a) the local specificity of the key parameters needed to implement a correct monitoring and evaluation of the CO2 intake (LSKP) and b) the backwardness of the agricultural systems (BWAS).

The second pillar of the analysis conducted aspires to estimate the level of trust actors have in the legislators, both at the Italian and European levels. This step is considered fundamental of the assessment of the possible implementation of the Carbon Farming system and the willingness of the actors to join it, as voluntary implementation is envisaged at this stage. In general, from the conducted interviews it emerges that actors have greater confidence in institutions at the European level than in Italian institutions, with some interesting cases, such as one that almost reaches the point of hoping for the non-action and non-involvement. It is interesting to note, however, that institutions and local governments are also the best identified figures to respond to the fears expressed regarding the ability to involve the interested stakeholders, creating systems capable of responding to needs, and above all guaranteeing the protection of small producers with respect to large-scale realities.

Finally, to obtain as complete and comprehensive a picture as possible, the role of the citizen was also considered and analysed, in its dual function as a consumer, and thus with a power to influence production (including of food products) and as a saver, with power to influence the allocation of savings as sustainable and socially responsible investments. Due to the nonexistence of certification on carbon now, consumer attitudes toward organic certification, to date the largest recognized European-level initiative available (Aprile et al., 2012), was considered as example. Analysis of secondary data (Ismea, 2022). shows that despite the higher price of certified products, Italian and European consumers demonstrate an increasing propensity to purchase bio products. The same general logic can be applied to the analysis of the citizen 'role as saver. The Global Sustainable Investment Alliance reports that in 2020 the world market dimension for financial activities considered "sustainable", and therefore compliant with the ESG standards, was valued 35.300 million US dollar, equal to 36% of the total managed savings worldwide, and that these number showed an increase of more than 15% compared to 2018. This trend is confirmed also at the Italian level, where Banca d'Italia reports that by the end of 2020, 17% percent of Italian and foreign mutual fund shares held by households were ESG funds, with a total estimated value of 116 billion euros.

Having gathered all this information, several possible findings emerge by comparing it with the literature review and in particular with the legislative development to date. The table 8 shows the list of the identified factors, their categorization based on the relevance found among the respondents and the level of consideration implemented at European level. This last point was made with reference to the literature review carried out in the first chapters and to the results that emerged during the Conference on Sustainable Carbon Cycles, which has been organised by the European Commission to bring together decision makers, experts and technicians coming from several sectors to share experiences, knowledge, and view toward the creation of the upcoming EU Carbon Farming Strategy.

Tab 8: Identified Factors and present consideration at EU level

High Success | Medium Success | Low Success | High Risk | Medium Risk | Low Risk

Factors	Presence in European legislative development
Cost and sophistication of monitoring systems (CSMS)	Challenge recognised, work in Progress - consultation with stakeholders and technical working tables are currently working
Local specificity of key parameters (LSKP)	Challenge recognised, work in Progress - consultation with stakeholders and technical working tables are currently working
Ecological approach (EA)	Absence of specific intention in this regard
Multidisciplinarity of issues at stake (MIS)	Well addressed and action implemented - Multidisciplinary working tables and broad stakeholder consultations.
Fragmentation of agricultural sector (FAS)	Challenge recognised, work in Progress - consultation with stakeholders and technical working tables are currently working
Presence of Sector Association and Cooperatives (PSAC)	Absence of specific intention in this regard
Backwardness of the agricultural sector (BWAS)	Well addressed and action implemented within the new PAC and specifically the AKIS Pillar
Spread of action-based rewards (SABR)	Challenge recognised, work in Progress - consultation with stakeholders and technical working tables are currently working
Additionality criteria (AC)	Absence of specific intention in this regard
Private frameworks already adopted and developed (PFAD)	Absence of specific intention in this regard
Suspect of Green Washing (SGW)	Well addressed and implemented through the willingness to implement a transparent and reliable framework. Still, this is applied mainly to the farm/agriculture side and not on the business side.

Carbon Farming Previous Experience (CFPE)	Well addressed and implemented through the presentation of successful case studies in the Technical Handbook.
High variability of agricultural territories (HVAT)	Challenge recognised, work in Progress - consultation with stakeholders and technical working tables are currently working
Growing awareness in the business sector (GABS)	Well addressed and implemented through the engagement of companies within the consultation phase and in conferences.

Lastly, it is important to notice that the EU Commission has also started a consultation process regarding the creation of a carbon label, a further step that was only hinted at in the Communication on Sustainable Carbon Cycles, but which is gaining increasing importance. This demonstrates how the European Union has understood the importance of exploiting certifications as a tool of transparency but also as a lever to effectively transfer information to citizens in a simple and transparent way. However, it is important to underline that now the attention regarding certification is only developed on the agricultural production side, while there is still no clear intention detected to include credit purchasers within a definitive framework for planning the abatement of internal emissions, compensation for residual quotas and certification and control over the efforts implemented.

Resuming on the research question initially identified, and thus whether the EU Carbon Strategy is positioning itself as a breakthrough strategy for the agricultural sector, and how it responds to the different actor's needs identified through the applied three-dimensional approach, the great transformative potential of carbon farming and its economic financing through the creation of the VCM clearly emerges. As a matter of fact, the analysis shows that both success and risk factors with high frequency have either already been addressed with practical actions or are present in the debate at the European level. Nevertheless, it is important to underline the high transformative potential above mentioned can be fully exploited only if a holistic and ecological approach is adopted, not incurring in the error of isolating the single implementation of carbon farming practices from the Lifecycle Assessment of the whole production within a single farm.

What stated above is true also regarding the business world: it would be an error to consider the acquisition of carbon credits as a universal placebo capable of offsetting all emissions from production activities. It is essential that companies' access to the market is also regulated, that ambitious and transparent requirements for commitment to climate neutrality are defined, and that the purchase of credits is presented as a temporary and transitional solution.

Conclusions

The analysis presented clearly shows the European commitment to stop climate change without compromising the economic growth and social well-being of its inhabitants. However, the way to find the right compromise between ecological optimum and social optimum is an extremely slippery ground, and above all regarding the implementation of the EU Carbon Farming Strategy, the road is still long.

On this regard, some conclusive considerations can be made, looking at the legislative development in its entirety and taking into consideration what emerged from the exploratory research. Firstly, the importance of the project phase needs to be further emphasized and defined at the legislative level, both on the side of the farmer, who must define a carbon farming project and the related monitoring and assessment phase, and on the side of the corporate credit buyers, which must define an internal strategy to reduce emissions related to its production activity and identifying the minimum timeframe and optimal offsetting methods. The EU Commission must focus more on this point, otherwise the Voluntary Carbon Market System risks to be perceived only as a system generating profit for farmers and green advertising for companies, and this would not only be a risk, but also a great waste of resources and opportunities.

The EU also needs to pay closer attention to the role of citizens as a lever within the system, investing resources and skills building awareness and education, both as consumers and savers. This also involves the creation of a clear, transparent, recognizable, and well-sponsored certification both for products resulting from carbon farming and for companies committed to offsetting their emissions through credits deriving from carbon farming projects.

In this, Italy faces a double challenge: being a country in which the agricultural sector has an important economic importance, and which owes an important part of its value to the multi-functionality of agriculture but which at the same time struggles to stay on for sustainable production and innovation in the sector, Italy can derive important benefits from the implementation of this system. Moreover, it can count on a series of important levers such as the presence of important category associations that are already very interested in the topic, and a great attention by citizens to the quality and recently also to the sustainability of food. However, the delay with which the administrative spheres are approaching these issues, ultimately represented by the absence of specific intentions for carbon farming in the new strategic plan of the CAP, and long-standing problems linked to bureaucracy and the difficulty of Italian politics in agreeing definite positions, are limits that must be addressed quickly and decisively.

In the end, what clearly emerges is the need of profound transformations, that are not limited to individual sectors but are occurring systematically throughout our economy toward achieving climate neutrality by 2050. On this regard, the implementation of the EU carbon farming strategy would represent, under a certain perspective, the collapse of the last holdout, if not practical at least conceptual. Soil, land, private property par excellence, brings out its universal dimension: soil depletion is a common problem, and a political will to find a common solution emerges. The difficult and challenging trade-off between ecological optimum and social optimum, which cannot disregard the private optimum of the landowner, is thus realized in such an extremely complex instrument as the creation of the voluntary credit market, powerful because in potency it has great capacity to influence the actions of actors and overcomes the sectoral isolation of the transition policies made so far, but that it does not exempt itself from the great risk of becoming, as a market, a mere instrument of profit. This is the greatest risk, which only careful and all-encompassing monitoring and regulation of all interests at stake-economic, social, and environmental interests-can avoid.

One last thought needs to be addressed to the current economic and political situation, and the outrageous war in eastern Europe we are assisting to. It is well documented that both the inflation, caused by the conjuncture of economic growth and scarcity of energy resources, and the global food crisis caused by grain deadlock in Ukrainian ports have both major repercussions on the complex interactions between the agricultural sector, the business world, and the environment. Food products prices will increase consistently, mostly in African Countries, exacerbating the situation of malnutrition in the poorest segments of the population (Amref, 2022). At the same time, in the business sectors investors are reacting to the crisis disinvesting from the riskiest and most uncertain funds, with an across-the-board decline inevitably leading to a cooling of the economy (MorningStar, 2022). Reasoning with respect to the model presented in Chapter 1, we are in fact in a situation where the social discount rate has soared due to the crisis, and this is likely to lead to a renewed focus on productivity and mere economic efficiency at the expense of environmental balance. The main hope on this regard is that the crisis demonstrates how much it is necessary and urgent to rethink our economic and productive model from the ground up. In this perspective, a truly effective and integrated implementation of carbon farming should look at the entire agricultural sector, and act as a pivot of transformation not limited to the implementation of specific and isolated agricultural practices but aiming to increase the resilience and sustainability of the sector. In a holistic and integrated way.