Framework of possible business models for the implementation of a carbon demonstrator

Mathieu Nogues, Mirabelle Husson, Grousset Paul, Suzanne Reynders, Jean-Francois Soussana

© P. Van Hilf – Shutterstock.com

RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

INRAE

ADEME
Agence de l'Environnement et de la Maîtrise de l'Energie

Framework of possible business models for the implementation of a carbon demonstrator

Territorial demonstrators of soil carbon sequestration

Final report - deliverable 2/3

ACKNOWLEDGEMENTS

The authors would like to thank the external experts who made valuable contributions: Laure Bamière, Catherine Brocas, and Anne-Marie Joliet.

QUOTE FROM THIS REPORT

Nogues, M., Husson, M., Grousset, P., Reynders, S., & Soussana, J.-F. (2021). Framework of possible business models for the implementation of a carbon demonstrator: Territorial demonstrators of soil carbon sequestration. INRAE INRAE; LISIS; NATAÏS. https://doi.org/10.15454/FC2Z-7D70-EN

SUMMARY

ABSTRACT

The objective of this study was to analyse the different business models and value chain of a carbon demonstrator, as well as the barriers, support and knowledge needs encountered by stakeholders while taking into account the legal and economic framework specific to each. The study was carried out in France and Europe, and also in Australia and Canada (Alberta) where soil carbon markets are well developed. In this study, the following business models were studied: financing of carbon storage by an agri-food company in its value chain, aggregation of carbon credits by a third-party organisation, aggregation of credits by a platform and citizen financing of carbon storage projects.

As a result of this study, many business models are emerging or are already well established. Some projects finance the adoption of carbon-storing practices in order to contribute to the fight against climate change and improve the quality of agricultural soils. Others join forces with aggregators (associations, companies, cooperatives) which not only allow them to benefit from economies of scale (administrative costs, monitoring, verification) but also to facilitate access to the carbon credit system for farmers. Some platforms serve as carbon credit marketplaces to facilitate the sale and purchase of credits.

While the number of business models and projects is proliferating, it seems that project owners are having difficulty finding buyers. The question therefore arises as to the advantage of acquiring this type of credit. Indeed, if the purchase of these products depends on the will of the financiers and these emission reductions are neither tradable nor refundable, then the main interests lie in the communication that can be made by the purchasing companies and in the preservation of their value chain in the face of climate change.

Some economic data were not obtained in this study, making it difficult to fully analyse the costs and benefits of farmers adopting these practices. In order to ensure the widest possible adoption of these carbon-storing practices, it is important that farmers receive a reward commensurate with the risks and investments made (material and immaterial). It would therefore be interesting to analyse their return on investment in more detail.

In this study, economic models based on low-carbon food labels have not been studied. It would be interesting to develop this aspect at a later stage.

1. Introduction

The objective of this deliverable is to analyse the different business models of carbon demonstrators. A carbon demonstrator is based on a value chain that may involve farmers, aggregators, buyers, technical and scientific organisations and a certifier. The remuneration of the stored carbon can be done in several ways, such as the financing of a company integrating farmers in its value chain, the sale of carbon credits, thanks to a certification affixed to a food product or by using carbon storage to promote a financial product (see the Ecotree case).

1.1. The voluntary carbon market in Europe

The voluntary carbon market is an open market that allows individuals or private actors to market or sell CO_2e credits. The purchase of these credits is not compulsory and depends on the willingness of companies, local authorities or individuals to offset some or all of their emissions. This is a growing market because it allows companies to develop rigorous policies based on private or national labels.

An increasing number of projects are being carried out in this framework in order to remunerate the reduction of emissions or even the storage of carbon. In order for a project to be accepted by one of the existing labels, it is necessary that it meets various criteria. It must:

- **Be additional**, i.e. the amount of CO_2e reduced/stored is greater than would have been achieved without the development and funding of this project
- Measure and verify the amount of CO_2e avoided/stored
- **Guarantee the uniqueness of the carbon credits** issued. Any emission reduction or storage must only be counted once by a label. One credit issued = 1 tonne of CO_2e stored/avoided.
- Be transparent and allow verification of sequestered/avoided CO_2e emissions.

1.2. The development of the voluntary carbon market

The *Voluntary Carbon Market (*VCM) is still very new. Indeed, the first voluntary carbon registry, *the Environmental Resources Trust (* renamed *America Carbon Registry* in 2007), was launched in the United States in 1996 and the first carbon certificates were issued in 1997 by the "Scolel'te" project and sold to the World Bank and the *Formula 1 Association*. Gradually, other national registries and private labels were created [2] such as:

- **In 2001:** the California Climate Action Registry (which will split in 2009 into *the Climate Registry* and *the Climate Action Reserve*)
- **In 2003:** the launch of the Gold Standard (GS) by WWF and several international NGOs to ensure the integrity and development of the voluntary market
- **In 2005:** the *Climate Action Reserve* adopts the first protocol (Forest Project Protocol v1.0) which introduces forest management into the carbon market
- **In 2007:** the Verified Carbon Standard (VCS) by the International Emissions Trading Association (IETA), The Climate Group and the World Business Council for Sustainable Development. A key feature of the VCS programme was the introduction of the VCS AFOLU buffer system which took into account the risks of storage failure to ensure the permanence of credits
- **In 2008:** the Plan Vivo standard and the Plan Vivo Foundation to award Plan Vivo certificates
- **In 2011:** The *Woodland Carbon Code* is a standard developed and managed by the UK government and applies only within the UK. The code applies global standards combined with UK-specific legislation and was the first domestic project endorsed by the *International Carbon Reduction and Offset Alliance* (ICROA)

Between the late 1990s and 2016, the voluntary carbon market has evolved from a new market developing new rules and standards to a consolidated market that has evolved its practices and successfully engaged the private sector. New types of projects (forestry, energy, etc.) increasingly linked to sustainable development are emerging and developing over a wider geographical range. The ratification of the Kyoto Protocol in 2005 launched a wave of project investments aimed at reducing greenhouse gas (GHG) emissions in developing countries and the development of the first rules to ensure the integrity of the voluntary carbon market.

In 2012, the end of the first commitment period of the Kyoto Protocol, coupled with the financial crisis of 2008, drastically reduced the demand for emission credits in the *European Union Emissions Trading Scheme* (EU ETS) and the price of these credits also fell. Many project developers are now choosing the voluntary carbon market. In 2016, the development of the carbon tax in Colombia is also a key step in the development of the VCM for two reasons. First, Colombia is the first government to allow private organisations to buy carbon credits instead of paying the carbon tax. Secondly, the Colombian government is the first government to accept in its regulatory framework the set of rules and procedures established by the *Gold standard* and the VCS programme, which are leaders in setting the VCM standards.

Finally, in 2016, the ratification of the Paris Agreement and the adoption of the Sustainable Development Agenda by the United Nations represent a new era for climate protection. These two events are strong calls to action for the protection of the planet and the environment and set clear targets for the signatory countries. Indeed, the parties to the Paris Agreement have committed to collectively achieving carbon neutrality in the second half of the 21st century. Each signatory country must also communicate its planned contributions to the fight against global warming and take domestic measures to mitigate these emissions. From this period onwards, corporate demand for carbon credits is increasing and the issuance of credits in the VCM has been growing strongly from 2017 to 2019 (see Figure 1). Between the launch of the VCM and the end of 2019, the market had reached more than 608 million tonnes of CO_2e in terms of emission reductions or removals.

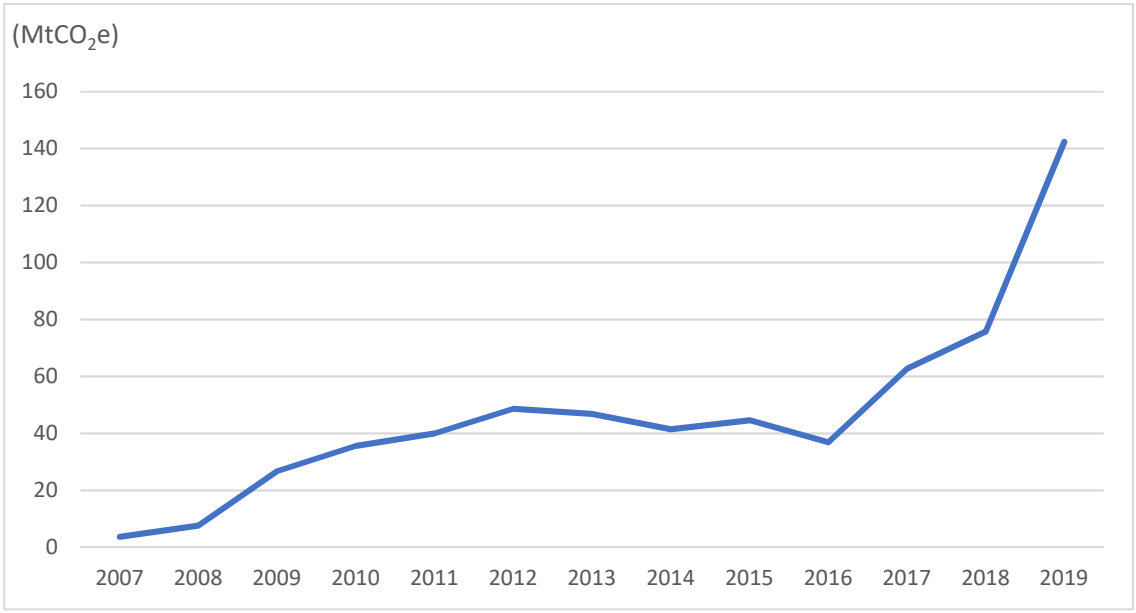


Figure 1: Emission reductions ($MtCO_2e$) in the voluntary market worldwide (source: France Stratégie, 2020)

1.3. The value of voluntary carbon in Europe

The costs of carbon credits depend on various factors such as:

- **The types of practices implemented**: some agricultural practices such as hedge planting for example are more expensive than others.

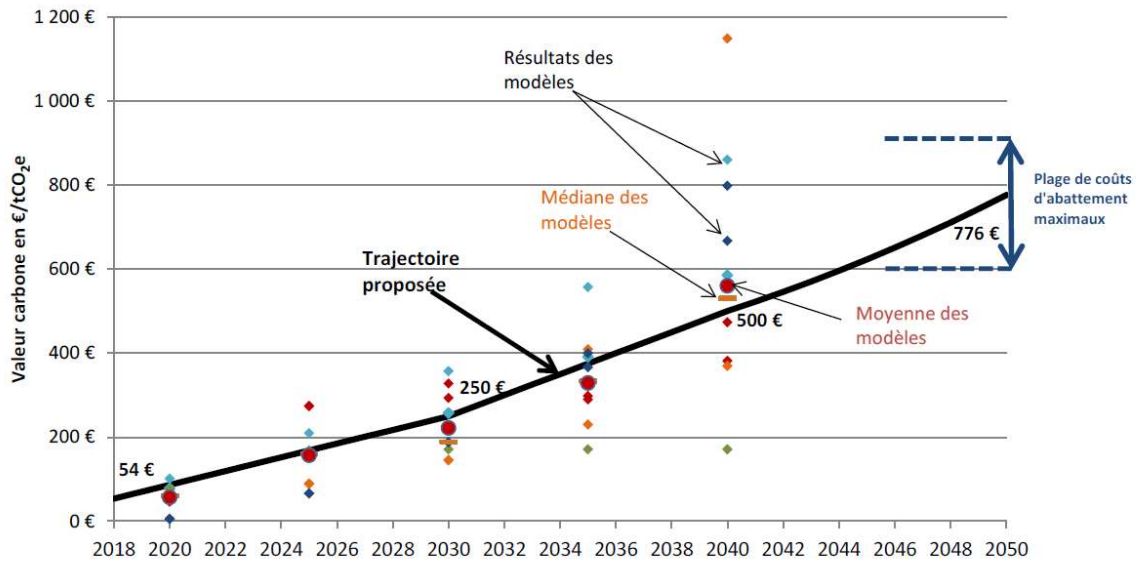
- **The area** where projects are carried out: carbon credits sold in developing countries are cheaper than in Europe.
- **Buyers' preferences,** which may depend on the location of credit production, type of activity, co-benefits.
- **The type of transaction**: credits purchased in large quantities will tend to be sold at a lower price than credits purchased in small quantities.

European projects are on average smaller than international carbon projects. They have higher prices with an average of 13€/t CO_2e (prices between 6€/t CO_2e and 110€/t CO_2e) in Europe against 6€/t CO_2e on the international markets (prices between 0.4€/t CO_2e and 72€/t CO_2e)[1].

1.4. The tutelary value of carbon

The tutelary value of carbon corresponds to the value of climate action, i.e. the value given to the avoidance of the emission of one tonne of CO_2 equivalent. It is intended to serve as a reference in the design of decarbonisation policies for all sectors. The definition of the tutelary value of carbon makes it possible to sort out the most relevant actions to be implemented. All actions or projects whose cost would be lower than this value would therefore be prioritised. According to the report of the commission chaired by Alain Quinet [4], this value is 87 euros per tonne of CO_2e in 2020 (see Figure 2), i.e. 319 €/tC . It would be €250/tCO_2e in 2030, €500/tCO_2e in 2040 and €775/tCO_2e in 2050. Post-2050, the tutelary value would then be considered constant.

Figure 2: evolution of the shadow value of carbon (source: France Stratégie)



As the tutelary value of carbon may today still be lower than the cost of some agricultural projects, the very rapid increase in this value over the next few years should make it possible to demonstrate the interest of a large proportion of agricultural projects.

[1] Gabriella CEVALLOS, Valentin BELLASSEN, Julia GRIMAULT, Domestic carbon standards in Europe, 2019: https://www.i4ce.org/download/domestic-carbon-standards-in-europe/

1.5. The potential and cost of carbon storage in French soils

The 4 ‰ initiative launched by France at the Paris conference, proposes to increase annually the carbon stock present in the world's soils by 0.4% in order to contribute to the emission reduction target. The current organic carbon stock in French soils is estimated at 3.58 Gt (or 13,400 $MtCO_2$) of carbon for the 0-30cm horizon [5]. An increase of 4‰ per year in soil organic carbon stock would offset 12% of French annual GHG emissions. The "4 for 1000 France" study conducted by INRAE in 2019 at the request of ADEME and the Ministry of Agriculture and Food estimated, through agronomic and economic modelling, the additional storage potential and the cost associated with nine agricultural practices. With the calculation method used in this study, it is estimated that, with no change in land use or agricultural and forestry products, the total carbon stocks of French agricultural soils increase by 2.3‰ per year with a high uncertainty (-0.2 ‰ to +3.2 ‰ per year). However, this increase is offset by land use changes such as soil artificialisation and grassland reversal which have a negative effect on French soil carbon storage. Figure 3 shows a contrasted value of carbon stock across the territory due to land use, climate and soil type.

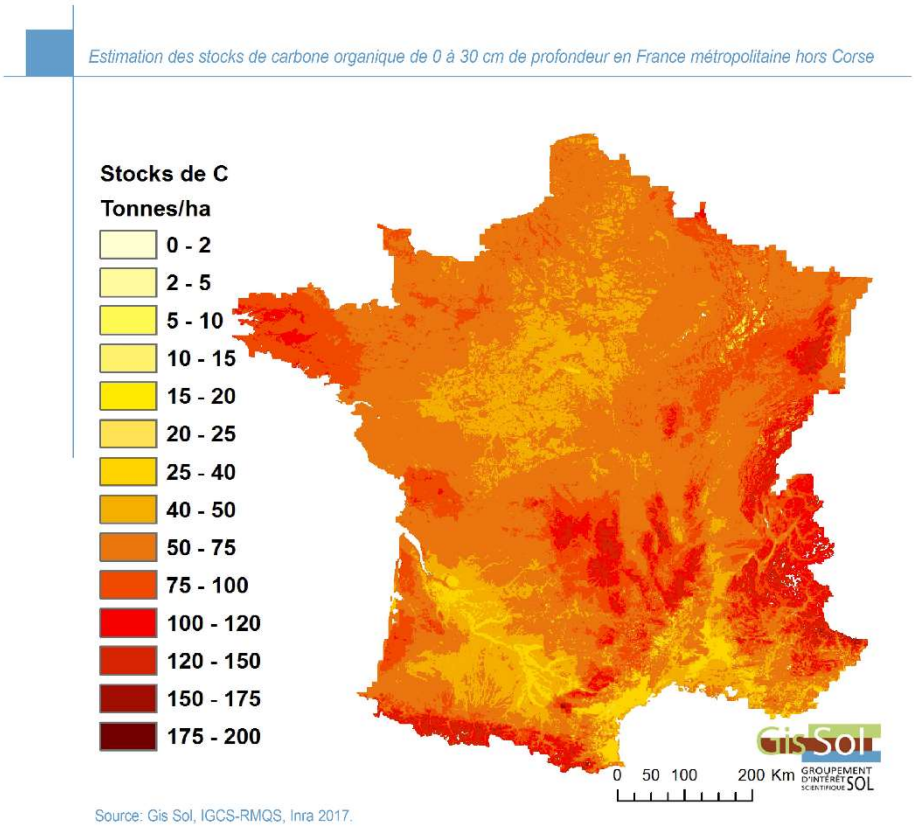


Figure 3: Estimation of organic carbon stocks in the top 30 centimetres of soils in mainland France (excluding Corsica) (Data available via: Manuel Martin, 2019, "La carte nationale des stocks de carbone des sols intégrée dans la carte mondiale de la FAO", https://doi.org/10.15454/JCONRJ, Portail Data Inra, V1)

On French territory:

- Forest soils account for 38% of the total stock and tend to store carbon.
- Permanent grasslands account for 22% of the total stock and carbon storage is stable or slightly increasing.
- Temporary grasslands and field crops account for 26.5% of the total stock. In Europe, it is estimated that arable soils have suffered an average de-stocking of 170 kgC/ha/year for the period 1967-2007.
- The remaining 13.3% of the total stock is stored in various types of tenure.

The implementation of nine storage practices was studied as part of the 4 for 1000 study (simulation over 30 years, under the current climate, without any change in land use and without any profound transformation of farms). These practices would allow an additional annual storage of +1.9‰ for all land uses combined on the 0-30 cm horizon. Additional storage is mainly possible in arable crops and to a lesser extent in permanent grasslands. For forests, no agricultural practice allowing for more carbon storage could be identified by this study. The objectives for forests would therefore be to maintain existing carbon stocks as well as the practices that enable their maintenance. On 0-100 cm, under the assumption of additivity of practices:

- 87.4% of the additional storage could be achieved in field crops through the implementation of five practices (see Table 1). The establishment of plant cover is the practice that has been identified as having the highest additional storage in France.
- 10.3% of the possible additional storage could be achieved in permanent grassland. This could be achieved through moderate intensification by using fertilisers or by encouraging the return of residues and manure to the soil by extending grazing rather than mowing.
- The remaining 2.3% of the additional storage would be achievable in the vineyard through grassing practices

Stockpiling practices	AMT	Technical unit cost	The entire soil profile		Mitigation cost (All emission items included: N_2O, CH_4, C)	CO_2e subtracted from the atmosphere throughout France, taking into account the GHG balance
			Additional storage of C	Storage cost		
	(Mha)	(€/ha/year)	(tC/ha/year)	(€/tC)	€/tCO_2e	($MtCO_2e$/year)
Extension of intermediate crops	16,03	39	0,215	180	51	-11,79
Direct seeding	11,29	13	-			
New organic resources	1,46	22,6	0,098	231	70	-0,47
Insertion and lengthening of temporary grasslands	6,63	91	0,214	424	90	-5,99
Intra-plot agroforestry	5,33	118	0,391	302	22	-28,28
Hedges	8,83	73	0,031	2 322	59	-10,91
Moderate intensification of permanent grasslands	3,94	28	0,213	130	(*)	0,04
Replacement of mowing and grazing in permanent grassland	0,09	73	0,362	203	88	-0,09
Grassing of vineyard inter-rows **Permanent**	0,15	-26	0,464	-56	-17	-0,23
Winter	0,41	-15	0,300	-51	-14	-0,45

Table 1: Summary of storage costs per practice, averaged over the whole soil profile, and mitigation costs, taking into account the whole GHG balance. (*) As the moderate intensification of permanent grasslands has a net emitting balance, the mitigation cost is not indicated. (Pellerin, Bamière et al., Rapport de l'étude 4/1000, INRAE, 2019).

The additional storage potentials, implementation bases and associated costs vary according to regions and practices. In order to achieve the 4 per 1000 target, existing stocks must be maintained where they are high (forests, peatlands, permanent grasslands) and increased where they have been reduced (especially in arable farming), which gives storage practices a high potential. This study has therefore demonstrated the importance of encouraging the maintenance of permanent grasslands, wetlands and forests that store large quantities of carbon and of stopping the artificialization of soils.

The application of the 9 practices studied in this study, (simulated over 30 years, under current climate and CO_2 concentration, without any change in land use and without any structural transformation of farms), would allow all land uses combined an additional annual storage of +1.8‰. Most of the additional storage potential is in arable soils, where additional storage could reach an annual increase of +5.1‰.

1.6. Barriers and obstacles to the development of voluntary carbon projects

According to a study carried out by the OECD in 2017 (Wreford, Ignaciuk and Gruère, 2017) summarising the importance of barriers to the adoption of environmentally friendly agricultural practices, there are many barriers to the adoption of climate-friendly agricultural practices. The importance of these barriers may depend on specific circumstances such as socio-economic characteristics, cropping systems, existing infrastructure, environmental conditions, regulations and institutions. These barriers exist at different levels: at the farm level, at the sector level or at the national or international policy level. In this report the barriers have been assessed according to their strength but also according to the scientific consensus obtained from the literature.

The most important barriers perceived by this study are:

- **Barriers related to current performance or to the perceived effects of adopting more environmentally friendly practices on performance**: farmers fear a decrease in their harvests or an increase in the risks to the productivity of their plots.
- **Information and awareness-raising on decision-making and risk management in the context of climate change**: Uncertainty about climate change may discourage the adoption of long-term changes (e.g. planting windbreaks, building shelters to protect animals from heat stress). In addition, climate change may be perceived as a much less urgent problem than those related to the day-to-day management of a farm.
- **Climate and environmental policies and the functioning of the sector** are also identified, because while some of them favour the move to action, others create new barriers. For example, decisions taken at the level of the sector and contractualisation schemes may represent obstacles. Similarly, certain agricultural policies may encourage the adoption of practices that are incompatible with climate protection.

These barriers would play a key role in the adoption of more environmentally friendly measures. Other barriers would also be important, such as:

- **The cost of adopting new practices**: indeed, the purchase of new machinery and associated technologies, the establishment of plant cover, can represent significant barriers to the adoption of new practices.
- **Hidden and transaction costs**: oversimplification of the costs associated with these projects could explain the non-adoption of new measures. Thus, learning and implementing new techniques, MRV costs, private transaction costs which are often fixed and independent of farm size and constitute a barrier to participation in carbon markets, are also barriers to be taken into account.
- **Limited access to credit**: the availability of credit may be limited if the implementation of practices leads to a decrease in harvest or profits. This can therefore be a barrier beyond the farmer's control.
- **Social and cultural factors**: farmers identify strongly with their work and it is difficult for them to dissociate themselves from their practices and their farms. These occupational characteristics can have a strong influence on the decision to change their practices and adopt more environmentally friendly measures. For example, resistance to change has been found to deter conventional tillage users from adopting conservation tillage.

All of these barriers can be seen as obstacles that need to be reduced in order to promote the adoption of these practices. There is also a third type of barrier, which is highly dependent on local practices and contexts, and whose importance depends on the structures and policies of each country. These are:

- **Land tenure**, as non-owners are less likely to make investments and take a long-term view. Farmers who own their own land are in a better position to generate carbon credits.
- **The availability of and access to infrastructure** that allows irrigation, for example.

One of the barriers to the development of the Low Carbon Label is also the lack of buyers of carbon credits. This can be explained by the lack of compensation obtained following the sale. Indeed, apart from the satisfaction of contributing to the fight against global warming and possible communication actions by companies on their ecological contribution, buyers of carbon credits do not receive any other type of compensation. **Indeed, the credits purchased have no asset value and cannot be sold or traded.** This was defined within the framework of the French carbon certification : Label Bas Carbone (LBC) to avoid the development of fraud or

speculation on the credits that could have been made and harm the development of this label (this was the case in particular in the case of VAT fraud on carbon quotas).

1.7. The different models of carbon demonstrators

In order to have a vision of the different existing economic models (non-exhaustive list), different models of carbon demonstrator have been studied (see following table)

Table 2: Economic models and associated case studies presented in this deliverable

Business model	Case study
Financing carbon storage by an agri-food company in its value chain	- The example of Nataïs
Aggregation of carbon credits by a third party	- France Carbone Agri Association (FCAA) - The Australian Emissions Reduction Fund - The carbon market in Alberta
Aggregation of credits by a platform	- Soil Capital - Svensk Kölinlagring
Citizen financing of carbon storage projects	- Citizen financing of carbon storage projects

2. Financing carbon storage by an agri-food company in its value chain

2.1. Presentation of the model

In the case of carbon storage financing by an agribusiness company in its value chain, the carbon credits generated by farmers are contractually transferred to the same company. Farmers then have the dual role of storing carbon in the soil and selling their agricultural production to the company concerned.

In order to generate carbon credits, it is necessary that the practices correspond to a methodology of a certification such as the Low Carbon Label, Gold Standard or VCS. It also requires that the company has systems in place to measure and verify the carbon in the soil and that this stored carbon is verified by an external audit. These credits can then be sold to companies that wish to voluntarily offset their emissions (the agri-food company then acts as an aggregator) or retained if the company wishes to improve its GHG balance (see Figure 4).

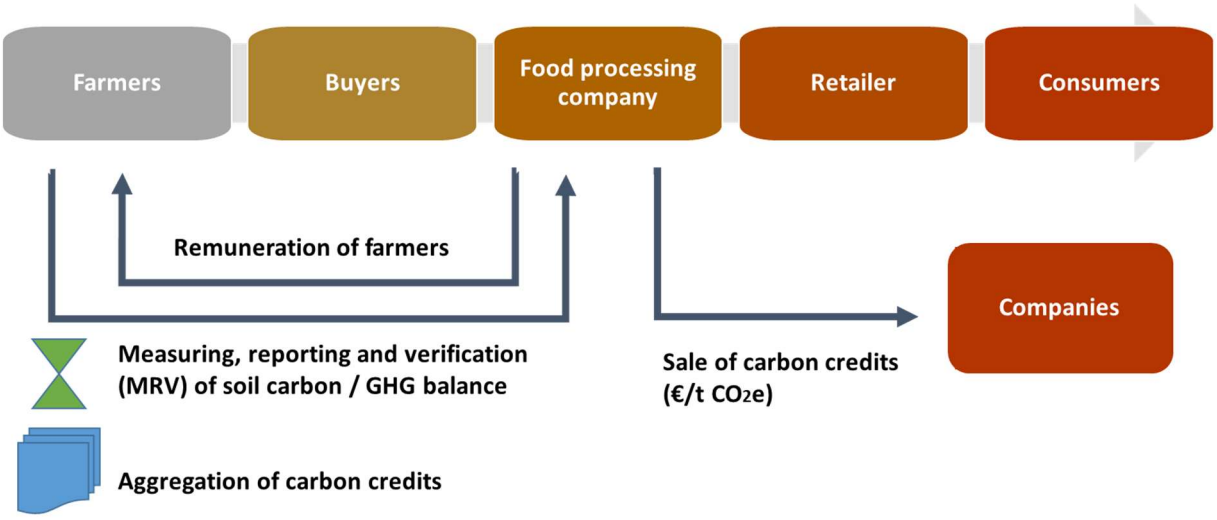


Figure 4: Aggregation of carbon credits by an agri-food company

2.2. The example of Nataïs

Nataïs was chosen to be the focus of this study for several reasons. Firstly, Nataïs is a well-known company, the European leader in popcorn production and represents 95% of the French market. This company works with 250 farmers who produce popcorn on 7,000 hectares, which represents a significant population and study area.

Secondly, through technical and financial support, Nataïs has been encouraging its partner farmers to plant cover crops on their plots for several years. As we have seen from the 4 for 1000 study, this is the practice with the greatest potential for increasing soil carbon storage in France.

Finally, it is a company that has good relations with INRAE. Indeed, Nataïs is one of the four pilot projects of the KIC project, coordinated by INRAE since 2019, which aims to increase carbon storage in agricultural soils, to enhance the value of this stored carbon and to put in place the measurement elements to quantify and verify the storage of this carbon. Nataïs is currently the coordinator of the Naturellement Popcorn project, which aims to develop a sustainable, top-of-the-range popcorn industry and to enhance the value of each of the players in the value chain. Nataïs is using its own funds to finance the carbon storage carried out, but is not yet using it. Work is underway to study the commercialization of carbon credits. Although the commercialization aspect cannot be studied in detail here, a great deal of data is available to help understand the organisation of the upstream part of this value chain.

2.2.1. Presentation of the company Nataïs

Nataïs was founded by Michael Ehmann in 1994 in the Gers. Today, the company is the European leader in the popcorn market. Two products are marketed, bulk popcorn and bagged popcorn, which in 2019 generated an annual turnover of 51 million euros. To ensure 90% of the necessary production, Nataïs has developed a network of 250 partner farmers located in south-west France (the remaining 10% being produced in South Africa).

In order to promote carbon storage in agricultural soils, Nataïs works mainly in two areas:

- Improving farming techniques to promote successful plant cover and associated carbon storage,
- Encouraging farmers to plant plant cover in their fields by demonstrating the agronomic interest of these practices and through a financial contribution (called a carbon premium here).

This network is monitored by a team of 6 engineers who make up the Nataïs agronomic partnership team. This team of engineers monitors the partner farmers and also assists producers in the agro-ecological transition of their practices, particularly with regard to plant cover. To financially encourage this transition, **a sectoral premium** has been introduced (see table 4). The validation of certain criteria on their popcorn plots guarantees the 250 farmers an increase in the purchase price of popcorn. Thus, for the implementation of sustainable agriculture, a farmer can receive up to 11 €/t of popcorn produced (see table n°2), including 7 €/t for the establishment of plant cover (1 point = 1 additional €/t).

Table 3: 2020 annual contract premium for conventional popcorn producers at Nataïs

Type	Pillar	Criteria	Condition	Points
Technical	Securing the harvest	Sowing date	Before 15 April inclusive	8
			or	**or**
			Between 16 April and 20 April included.	4
	Weedkilling	Inter-row spacing	Sowing at 60 cm or less	3
	Fertilization	Bio-stimulants	Bio-stimulant (BASFOLIAR KELP P / PHYLGREEN KUMA)	4
	Sustainable farming	Irrigation	The producer has a connected irrigation control tool in at least one popcorn plot and technical support (capacity, tensiometers)	4
			or	**or**
			Paying service for management assistance (irre-lis, water balance, etc.)	2
		Soil fertility	Soil cover planted before winter with duration of planting beyond 4 months	7
Involvement	Geolocation of the plots		Geolocation of plots on Clip&pop done before 15/05	2
	Reply mail, letter and document		Answer within the time limit	2

2.2.2. The Naturally Popcorn Project

The Naturellement Popcorn project has a budget of €7.4 million and will last 6 years. It is financed by the Programme d'investissements d'Avenir (PIA), managed by the Secrétariat général pour l'investissement (SGPI) and operated by Bpifrance. Its aim is to develop a sustainable, high-end popcorn industry and to enhance the value of each of the players in the value chain. This project brings together 5 partners: Nataïs, STMS, Agro d'Oc, UMR AGIR (INRAE) and CESBIO. This project is structured around 4 main areas:

- Use natural flavours in the manufacture of popcorn to meet consumer expectations
- Improve the environmental and health qualities of products by replacing palm oil with sunflower oil
- Offer consumers transparency and traceability throughout the chain by developing a tool based on the data collected by the producer's management tool
- To improve the sustainability of farming systems by developing the use of agro-ecological practices through :
    - The introduction of varieties better adapted to an agro-ecological transition,
    - Support for the implementation of practices that improve soil fertility through intermediate cover,
    - Improving water management,
    - The development of a remuneration to farmers for the carbon sequestered by plant cover on their maize fields.

The aim of this project is to provide the consumer with a healthy product while at the same time moving agricultural practices towards an agro-ecological approach. The remuneration granted to the farmers makes it possible to finance part of this transition.

2.2.3. Commitments between Nataïs and the farmers on the pilot plots

In order to test the new model of remunerating farmers according to the amount of carbon stored by the intermediate cover crops, Nataïs is working with 40 of the 250 farmers in its network. In 2019, these 40 farmers have been using plant cover for decades and others who are just starting to use cover crops. Each year, the farmers in the pilot plots and Nataïs sign an agreement that is mutually binding. The purpose of the agreement is to define the conditions for monitoring and compensation for the pilot plots as part of the Naturellement Popcorn project. Farmers wishing to be part of this network can propose one or more pilot plots to Nataïs, each plot being at least 5ha in size. Thus, for the year 2019-2020 (these elements may change from one year to the next), the farmer undertakes to provide Nataïs with:

- A set of technical information on the pilot plots (type of crop and date of previous harvest, tillage carried out, technical information on the management of the intermediate crop and the popcorn crop),
- Access to the plot for project partners to take samples,
- Not to communicate the results to any person outside the Nataïs network without prior authorisation.

In return, the Nataïs company undertakes to:

- Carry out at least one biomass sampling on each cover and carry out this sampling as close as possible to the date of destruction of the cover. In 2019 and 2020, the biomass samples taken before destruction were used both to calculate the amount of the carbon premium (see I.b) and to parameterise the model developed by CESBIO. In 2021, the premium will be calculated using the first carbon balance method developed by CESBIO.
- Communicate the results of the monitoring of these pilot plots to all the partners in this network.
- Compensate farmers for their involvement in the network and according to the amount of carbon stored by the plant cover.

2.2.4. The Nataïs scaling strategy

Nataïs' long-term objective is to extend this carbon storage strategy to all the farmers in its network. In 2019, 46% of farmers in the Nataïs network did not plant any plant cover before growing popcorn. These changes in practice must be made gradually in order to maintain the sustainability of farming systems. Farmers must therefore be provided with support, adapted to their level of knowledge and their cropping systems. Three groups were therefore defined to offer support to improve carbon storage (see Table 4).

Table 4: Groups formed by farmers according to the implementation of plant cover and associated objectives

	Composition of the group	**Objective of the group**
Group n°1 (46% of farmers in the network)	Farmers who do not include intermediate cover in their cropping practices.	Adopt the establishment of plant cover in a sustainable way and with simplified cover itineraries.
Group 2	Farmers who have recently started to integrate plant cover and who have not yet fully mastered this technique.	To master the technique of plant cover in order to maximise biomass production and the associated carbon storage by optimising their establishment and destruction.
Group 3	Farmers who have mastered the use of plant cover in combination with a simplified cultivation system for several years.	Establish double cover (summer cover then winter cover) or relay cover to optimise biomass production. Double cover is used for plots in rotation, for example wheat/popcorn. After the wheat harvest, a summer cover is planted during the summer and then destroyed to make way for the winter cover. The relay cover is a cover planted after the harvest of the wheat with species which, because of their

		diversity and spread of growth, will take turns until the popcorn is sown in the spring. This group will serve as an example for groups 1 and 2.

Nataïs' aim is to gradually move Group 1 into Group 2 and Group 2 into Group 3 so that all Nataïs partner farmers are in Group 3 and are successful in establishing plant cover to store carbon.

2.2.4.1. Strategy for Group 1

One of Nataïs' objectives is to convince the 46% of farmers in its network who do not use plant cover of the usefulness of this practice so that it is adopted. To this end, communication on the benefits for soils and crops is regularly carried out, but for some farmers, the workload and technical difficulties involved are still too great. To overcome this barrier, Nataïs is trying to convince these farmers through experimentation so that they can see for themselves the benefits of this practice. To this end, Nataïs has produced a technical guide for setting up a small area of plant cover (confidential document).

Every winter, Nataïs' team of advisory engineers can visit farmers who are introducing plant cover. Particular attention is paid to farmers who are new to this practice. In order to support beginners, a sponsorship scheme is envisaged between a beginner farmer and a farmer who has been using plant cover crops for years.

2.2.4.2. Strategy for Group 2

A significant number of farmers planting cover crops have cover crop systems that can be improved to store more carbon. Nataïs first ensures that these farmers have mastered the fundamentals of bean cover mentioned for group 1. In addition, Nataïs plans to visit these farmers once a year to support them in improving their practices.

To go further with these producers, it is interesting to test the establishment and interest of mixtures for winter cover crops (phacelia and faba bean), and to support the producer during the destruction phase of the cover crops so that the destruction is carried out as late as possible (which allows maximum biomass production). Nataïs considers that the support provided to farmers and the exchange of experience through various communication channels are effective.

Six members of this group planted a summer cover during the 2018-2019 year which seems to be a good way to create additional biomass. On average these covers produced 3.26 tonnes DM/ha which is higher than the annual average of winter covers for the year 2019-2020. It would be interesting for farmers in group 2 to plant this type of cover to increase carbon storage on their plots. To support them, Nataïs plans to hold a meeting to present the summer cover to farmers and the technical elements to be adopted for its successful implementation.

2.2.4.3. Strategy for Group 3

Between 5 and 10 farmers in the network have mastered the establishment and destruction of their plant cover crops, optimising the creation of their biomass. Some also plant summer cover crops. These are the people who encourage the adoption of plant cover crops within the network by setting an example for other farmers. It is with these farmers that Nataïs carries out trials to optimise biomass production (and carbon storage) by testing winter cover crops or developing summer cover crops. It is also around these that Nataïs will organise meetings with other farmers to use them as models.

2.2.5. Barriers, solutions and support needs of farmers

In order to determine the barriers, solutions and support needed to adopt plant cover, a questionnaire was proposed to Nataïs' partner farmers. This questionnaire was adapted from the one designed for European and international farmers in the CIRCASA project (*Coordination of International Research Cooperation on Soil Carbon Sequestration in Agriculture*). CIRCASA had designed two questionnaires (Deliverables D2.1 https://www.circasa-project.eu/Document-library/Deliverables), for farmers and for other stakeholders (scientists, agricultural advisors, associations, industries, etc.) in order to better understand the different points of view

of each stakeholder with regard to carbon sequestration in agricultural soils: knowledge of the soils, techniques used, farmers' motivations and barriers encountered, opinions on the potential and limitations of soil organic carbon management for climate (adaptation and mitigation), agricultural production and socio-economic aspects. The questionnaire also aimed to gain a better understanding of how soil carbon management measures could be implemented, the barriers that may hinder this implementation and the knowledge gaps that need to be filled. This questionnaire was disseminated from April 2020 onwards on several occasions within the Nataïs network of popcorn farmers, including in a 'technical flash' newsletter sent to farmers by email.

The questionnaire received 19 responses and was distributed to 250 Nataïs popcorn growers. Half of the responses were from Nataïs pilot farms, which were already well advanced in the use of plant cover. The results are therefore not representative of the sample of farmers working with Nataïs but may provide some insight into the barriers, solutions and support needs of farmers.

2.2.5.1. Presentation of the sample surveyed

The following are some of the characteristics of the sample interviewed:

- All the farmers interviewed were male and their age was evenly distributed between 18-39 (6/19), 40-54 (7/19) and 55-74 (6/19).
- The majority of the farmers interviewed are in conventional farming (15/19), a minority are in organic farming or in a hybrid system (the questionnaire did not offer the option "soil conservation agriculture" only "conventional farming", "organic farming" and "hybrid system").
- The main farming system of the farms is cereal and oilseed farming (18/19) and maize is the main summer crop of the farm (15/19). A majority of farmers (10/19) grow their popcorn on an area between 20 and 50 hectares and less than 20 hectares (7/19).
- A majority of farmers sow green cover crops (17/19), which appears to be considerable, but this should be nuanced as half of the responses obtained concern pilot farms

The following figure (Figure 5) also shows that the areas on which plant cover is sown account for a significant proportion of the farms' areas:

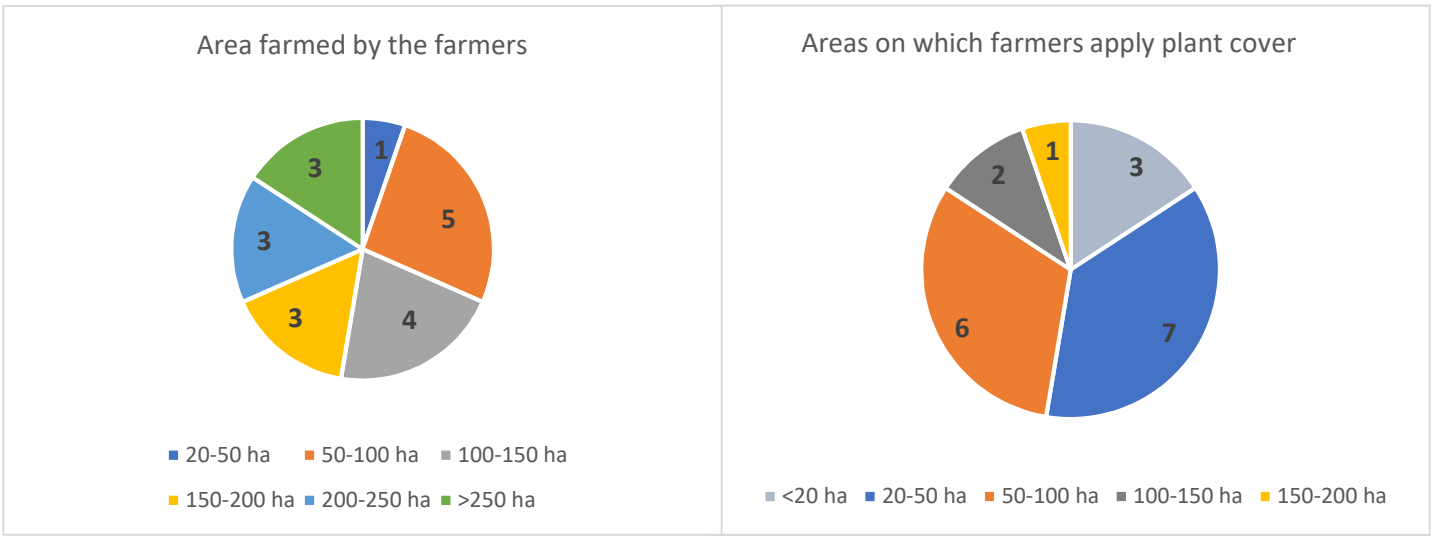


Figure 5: Comparison between the number of hectares farmed by the farmers in the sample and the area on which plant cover is sown.

An important element obtained from these questionnaires is that out of the 19 farmers, 15 do not know the organic carbon content of their soils. Despite this lack of knowledge, a significant number of farmers (8/19 responses) consider that this content is higher than other soils in the region.

The farmers who responded to the questionnaire consider that the increase in soil organic carbon content is important. Indeed, they consider that it:

- Improves soil quality (17/19),
- Increases yield stability (15/19),
- Improves soil bearing capacity (15/19),
- Increases biodiversity (15/19)
- Limits soil erosion (15/19).

8 out of 19 consider it to increase yields to a small extent, while 9 out of 19 consider it to increase yields to a large extent. [2]

2.2.5.2.Actions implemented by these farmers to store carbon

In Table 5, a correlation is observed between the actions implemented to store carbon and those considered effective in increasing soil organic carbon content for the following management options (in green in the table):

- Crop residue management
- Low/minimum tillage
- No-till
- The use of intermediate crops
- Buffer strips and uncultivated areas

On the other hand, some options are little used despite the interest that farmers have in them for carbon storage. This is the case for:

- Use of organic amendments (compost, manure, etc.)
- Introduction of temporary grassland in the rotation
- Management of permanent grasslands (optimised grazing)
- Agroforestry in crops
- Agroforestry in grasslands
- Agroforestry in mixed agro-pastoral systems
- Protection and prevention of erosion (e.g. hedges, contour lines, windbreaks)

Table 5: Distinction between management options already implemented by farmers and those they consider effective in storing carbon

Management options	Already implemented	Considered effective in increasing soil organic carbon content
Crop residue management	18/19	19/19
Low/minimum tillage	14/18	15/19
No-till	17/19	18/19
The use of organic amendments (compost, manure, etc.)	8/19	18/19
The introduction of temporary grassland in the rotation	3/18	14/19
The use of intermediate crops	19/19	19/19
Management of permanent grasslands (optimised grazing)	0/18	12/19

[2] It is difficult to have figures, as the evolution of yields is explained by multiple factors. The primary interest is not generally yield, but rather a search for uniformity of results on the plot (especially if the soil is very heterogeneous) and regularity of results, even in the case of stressful climatic phenomena, for example.

Buffer strips and uncultivated areas	12/19	12/19
Agroforestry in crops	1/19	12/19
Agroforestry in grasslands	0/19	12/19
Agroforestry in mixed agro-pastoral systems	0/19	8/19
Biochar	0/19	2/19
Re-wetting / irrigation of organic soils	2/19	3/19
Protection and prevention of erosion (e.g. hedges, contour lines, windbreaks)	4/19	15/19

However, not all these practices are always relevant depending on the cropping system and the context of the farm. It would be interesting to study in more detail the cases where these practices are relevant but where barriers hinder their implementation.

2.2.5.3. Constraints to the adoption of soil organic carbon management practices

To determine the importance of constraints to the adoption of soil organic carbon management practices, farmers were given a choice between: 'Not important', 'Important', 'Very important', 'Don't know'. According to this survey, the most important constraints for farmers (important and very important) are:

- Non-remunerated carbon sequestration (e.g. public funding, carbon credit)
- Economic risks for investments in a context of economic volatility
- Lack of funding to access technology and technical machinery/tools
- Lack of training and support from advisory structures for practice changes (see Table 6)

Table 6: Most important constraints (important and very important) perceived by farmers

Most important constraints (important and very important) perceived by farmers	**Feedback from farmers on these constraints**
Unpaid carbon sequestration (e.g. public funding, carbon credit) (18/19)	Apart from the aid provided by Nataïs, none of the farmers interviewed thought they could benefit from additional public or private aid to sow plant cover and store carbon.
Economic risks for investments in a context of economic volatility (17/19)	-
Lack of funding to access technology and technical machinery/tools (15/19)	-
Lack of training and support from advisory structures for practice changes (14/19).	It was also mentioned that farmers are mainly aware of plant cover and not of carbon storage.

A large proportion of farmers (14/19) also consider that having rented land is not an important barrier[3].

2.2.5.4. Solutions to enable the adoption of soil organic carbon management practices :

Finally, the solutions considered most important to enable the adoption of soil organic carbon management practices (very important and important added together) are:

- Payments for environmental services (19 out of 19), which would contribute to the adoption of these practices
- The development of a carbon credit market (19 of 19)

[3] No popcorn plots are currently grown in agroforestry

- Other financial support for the transition to soil organic carbon management practices (e.g. loans or investment grants) (18 of 19)
- Increasing public awareness (17 out of 19)
- Information for policy makers on where and how to implement a soil organic carbon sequestration policy (17 of 19)
- The improvement of individual support to encourage the implementation of carbon sequestration practices (17 out of 19), which directly raises awareness among farmers to adopt this approach.

Farmers consider that the carbon footprint indicator developed by Nataïs is a good initiative (9/19, the others did not comment or are waiting to see their results) and that it works very well. **Some expressed the wish that this initiative could be developed over a larger area at farm level**.

2.2.5.5. Information needed for the adoption of carbon management practices:

Regarding the additional information needed to increase the adoption of soil organic carbon management practices, farmers consider that further research is needed on economic and technical aspects (see Table 7).

Table 7: Additional information needed to increase adoption of soil organic carbon management practices

Additional information needed to increase adoption of soil organic carbon management practices	**Feedback from farmers on this necessary information**
Economic analysis of these practices (e.g. effects on yields and income) (12/17)	"A strong financial incentive would give a strong impetus to the adoption of these practices, and would help farmers understand that this is an opportunity and not a penalty.
Information on financial or technical support options (e.g. where to access loans and grants) (12/17)	"The French state should communicate to the public about the good practices implemented by farmers and support farmers financially as Nataïs does. »
Decision-making tools (10/17)	N/A
Management at farm level (e.g. choice of cover crops or cover tools or tools to be used) (10/18)	- Now that cover crop integration is well developed, some farmers are interested in studying in more detail the establishment of different species and varieties within the same species. - Similarly, the development of training courses on carbon aspects should be developed in agricultural colleges - The quality of the training offered by Agro d'Oc was also mentioned by the farmers

2.2.6. The development of a carbon premium by Nataïs

As part of Nataïs' support to pilot farmers, interviews were conducted to determine the costs of plant cover. During the interviews with farmers, two main obstacles were mentioned by the farmers:

- **The acquisition of a new technique** that requires an effort to adapt production systems (Nataïs is already working to remove this barrier as seen above).
- **The importance of the cost to the farmer** of establishing a plant cover (cost of seeds, cost of establishment and cost of destruction)

Nataïs is already helping to remove this second barrier by developing a premium granted to any farmer in its network who plants a cover crop. With this premium set at €7/t of popcorn delivered to Nataïs, a farmer with an average yield of 6 tMS/ha can expect to receive a premium of €42/ha. However, although this premium is an incentive to adopt plant cover, it does not quantitatively take into account the biomass production and carbon storage associated with it. A carbon premium based on biomass production and therefore the success of plant cover crops would encourage farmers to invest more in the success of this practice. The pilot producers in the Nataïs network have benefited from this carbon premium since 2018/2019. This has enabled them to be encouraged in their carbon storage practices but also to test this premium on a small scale in order to determine the fairest price to adopt. Several criteria are taken into account when setting the price. It is necessary that:

- **The price set is attractive to the farmer**,
- **The carbon premium is higher than the value of the value of the chain** when the cover is successful and productive,
- **The price should be sustainable for Nataïs**, so that Nataïs has the capacity to maintain this price while sustaining its own business.

2.2.6.1. Evaluation of the costs of plant cover

In order to understand the attractiveness of this practice for farmers, it is first necessary to understand the costs involved in planting cover crops. To this end, a survey was conducted by Paul Grousset, a Nataïs employee, with each producer to assess the costs associated with the purchase of seeds, their planting and the destruction of the cover crops. This cost analysis only took into account practices specific to the plant cover. For example, a large number of farmers use a rotary harrow to cover their plots at the end of the winter, which in some cases also allows them to destroy the winter cover. This cost is not taken into account in this calculation. The total cost of establishing plant cover was therefore calculated from three types of costs:

- **The cost of seed:** The cost of seed was determined accurately for farmers buying their seed. For those who produce their own seed, the loss of not selling the seed was also estimated based on this year's minimum purchase price. For the network in 2019/2020, the average seed cost is **€46.63/ha** (with an average of €40.16/ha for faba bean and €50.42/ha for buying faba bean + phacelia). The results of the 2019/2020 year did not demonstrate the interest of phacelia implantation, more precise follow-ups would be set up in the next years to study its relevance.
- **The cost of implementing the practices:** the cost depends on the method used. On-the-fly implantation costs on average **23.64€/ha** and the seed drill method costs averagly **38.18€/ha.** These results do not allow for a direct decision on the superiority of the first method over the second, as planting with a drill produces an average of 1 tonne of additional biomass per hectare. These results make it easier for the farmer to make decisions according to the objectives he wishes to achieve. However, some farmers in the network achieve very good results with on-the-fly implantation. The highest amount of biomass produced in 2019/2020 is 4.09 t DM/ha and the best result obtained with a on-the-fly implantation method is 3.89 t DM/ha. An interesting option to reduce establishment costs while maintaining high biomass production could therefore be to build on the experience of these farmers to transfer their specific knowledge of on-the-fly implantation to the rest of the network.
- **The cost of destruction:** the efficiency of the destruction of the cover crop is important because it must not disturb the maize planting. For 2019/2020 several strategies have been adopted (see figure n°6)

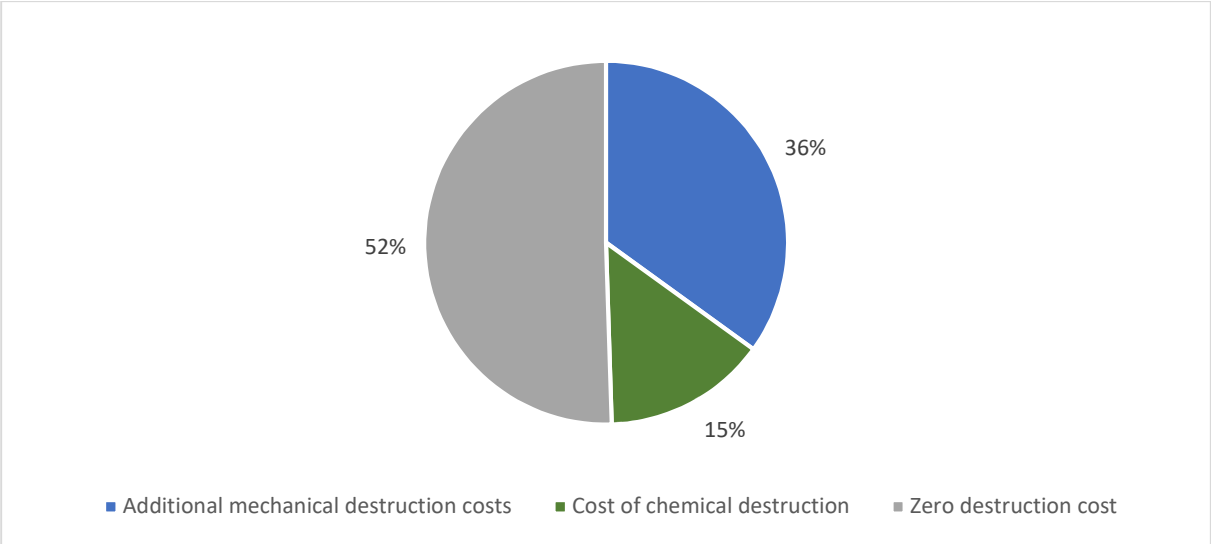


Figure 6: proportion of farmers in the network by type of destruction in 2019/2020.

As shown in the previous figure, 52% of farmers have a zero destruction cost because the destruction of their plant cover is carried out by an activity (soil recovery in a clay context with rotary harrowing / preparation of the deepest part in a sandy-silty context) that would have been carried out even without the presence of plant cover.

For this destruction, 36% of the farmers decided to carry out an additional mechanical destruction to ensure an optimal destruction of the cover crop. This was particularly the case when the cover crop was very developed (height over 60 cm) and when it is recommended to roll or grind the cover crop before tillage or seeding.

The 15% of farmers who carried out chemical destruction incurred an additional cost because it was an additional application of herbicide solely for the purpose of destroying the plant cover. These are farmers who have little experience (1 to 2 years) and who feel that this secures the destruction of the plant cover. The use of herbicide is also associated with the use of tillage tools. Here are the different average costs of destroying cover crops:

- Chemical destruction: 17,90€/ha
- Additional mechanical destruction: 30.83 €/ha

Chemical destruction is therefore cheaper than additional mechanical destruction. However, for hollow-stemmed species such as faba beans and phacelia, mechanical destruction is very effective and does not require additional chemical destruction.

Adding up these different costs, the average cost of plant cover in **the pilot farm network in 2019/2020 is €93.44/ha, broken down as follows: seeds represent about 50% of the total cost, planting 35% and destruction 15%.**

This price is however an average and some farmers manage to achieve much lower costs as shown in the following figure 7.

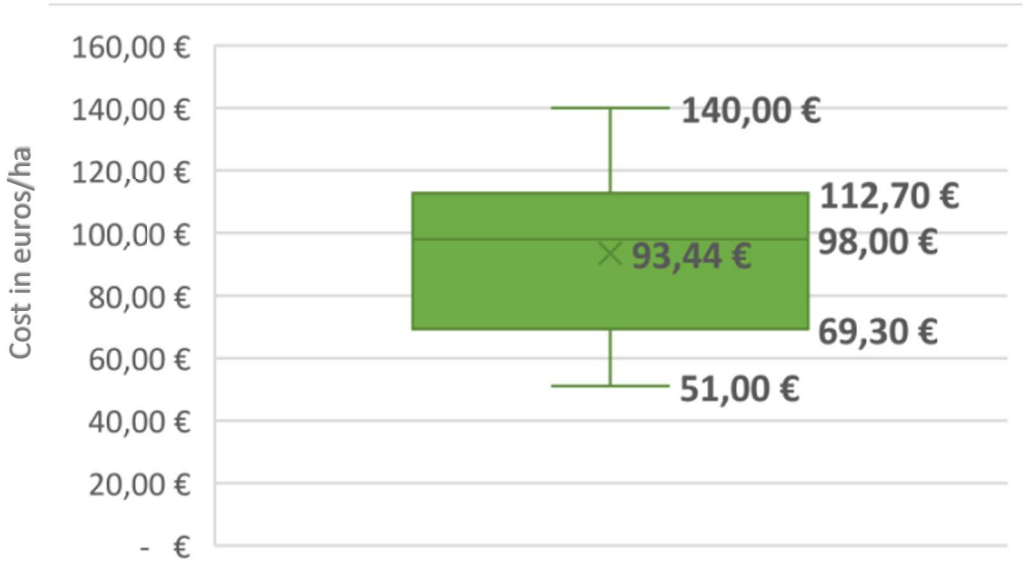


Figure 7: cost breakdown of winter cover in the pilot farm network -2019/2020

These cost results are independent of the success of the cover and the experience of the farmer. Several strategies developed by farmers emerged from this study:

- Some are developing very simplified systems with significant biomass results and few resources invested (simple bean cover planted at the time of the theft and no additional destruction costs),
- Others are investing in a more efficient cover crop system (seed mixing, planting with a drill),
- Another part of the farmers secures the destruction of the cover crop by carrying out an additional tool work on the soil so that a large quantity of residue does not hinder the work of a seed drill that would not be adapted.

2.2.6.2. Estimating the carbon stored for the carbon premium

The amount of carbon stored is calculated using remote sensing of the amount of biomass produced at the plot level. To construct this measure, CESBIO is working on the SAFY-CO2 carbon storage measurement model, which will allow the quantity of biomass produced by a plot to be reliably defined in order to define the quantity of carbon stored associated with it (see Yogo et al. 2021; Deliverable I of this project). To develop this model, CESBIO needed georeferenced biomass quantity data (associated with a GPS point). The creation of a network of pilot farms in 2019 bringing together Nataïs partner farmers wishing to improve their carbon footprint using plant cover crops has made it possible to carry out sampling on plant cover crops (since 2019) and on popcorn (since 2020). Nataïs coordinates the sampling on the farms and the analysis of the results. This makes it possible to provide the data needed for the CESBIO to assess carbon storage and also to provide the farmer with an indicator of the success of his cover crops.

In 2019/2020, farmers in the pilot network were paid by:

- **The pilot plot network bonus:** 200 euros were allocated to each farm participating in the first year of the pilot farm network

- **The carbon premium:** the carbon premium depends on the quantity of CO_2 captured and stored (i.e. sequestered) in the soil (1kg of CO_2 containing 0.2727 kg of C). The quantity of CO_2 captured and stored by the pilot farmers is estimated according to the method developed by CESBIO (see figure 8). In this model, the total biomass is calculated from the dry above-ground biomass and the root biomass (which is estimated at 20% of the dry above-ground biomass). Half of the mass of this biomass is considered as captured carbon and 20% of the captured carbon is stored in the soil. This final amount is used to calculate the carbon premium received by the farmer according to the price defined by Nataïs for each tonne of carbon stored.

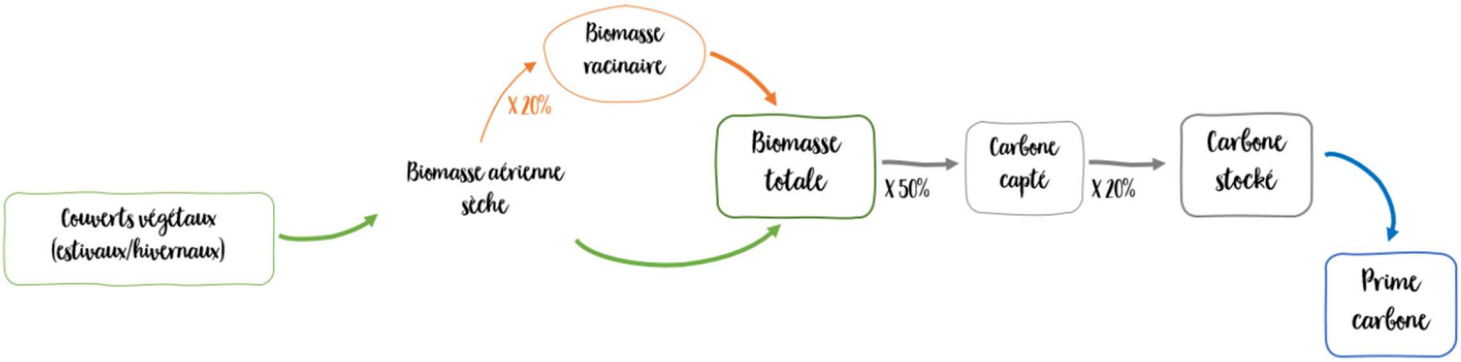


Figure 8: Diagram of the conversion of above-ground biomass taken from the plant cover into a carbon premium - Nataïs

Example of calculation: for a dry above-ground biomass of plant cover of 5tMS/ha and a root biomass of 1tMS/ha, the total dry biomass is 6tMS/ha. The carbon equivalent captured is therefore 3tC/ha and the carbon equivalent stored in the soil is 0.6tC/ha. In 2019/2020, the farmers in the pilot farm network stored an average of 0.45t of carbon per hectare, i.e. 1.63t of CO_2 sequestered per hectare. This storage takes into account the 2019 summer cover (for 5 farmers) and the 2019/2020 winter cover. These payments to farmers will be made in early 2021.

2.2.6.3. The definition of carbon pricing by Nataïs

Nataïs used 5 criteria to define a carbon price. These are:

1. **The attractiveness of the carbon premium compared with the sector premium:** Farmers in the Nataïs pilot farm network can choose between the sector premium and the carbon premium. Producers who produce little biomass can therefore benefit from the sector premium of €7/t of popcorn delivered (which represents €42/ha for an average yield of 6tMS/ha). Nataïs' objective is therefore to determine an amount for the carbon premium so that the carbon premium is more attractive than the sector premium for a large number of farmers in the pilot farm network. Farmers therefore receive an average of €42/ha for an average cost of €93/ha for planting cover crops. There are several reasons for the farmers' interest:
    - Producers work with Nataïs primarily for the popcorn contract and not just for payment for the cover crops. It is one of the only company to finance plant cover, so there is an interest even if the carbon premium does not currently cover all the costs of the cover;
    - Producers do not use plant cover only to receive the premium but also out of a conviction of the importance of protecting their soils;
    - The margin for popcorn is higher than the margin for consumer corn.

2. **Biomass creation through plant cover**: in order to encourage farmers to have productive biomass creation that store a significant amount of C, it is necessary to find a fair price to have an acceptable cost for society and an incentive cost for the producer
3. **The attractiveness of the carbon premium in relation to the cost of cover crops:** the average plant cover crop costs €93.44/ha, so the carbon premium must compensate for these costs to a certain extent, depending on the quantity of biomass created.
4. **The average price of carbon on the carbon market:** Nataïs must also take into account the average price of a tonne of CO_2 to remain consistent with the carbon markets. Today, the price of a tonne of CO_2 is trading at around €25 and could rise to €40 according to some specialists in this sector. If this is the future remuneration of farmers for the establishment of plant cover, it is necessary that the current remuneration of farmers be indexed to this price so that the remuneration is stable and transparent for farmers.
5. **The budget allocated to the carbon premium:** to set up this carbon premium, Nataïs has set aside a maximum budget of 30,000 euros from its own funds. This budget will be used to finance the additional cost to be paid to farmers on the pilot farms compared to the cost of sector premium. For example, if a farmer was to receive €42/ha for the sector premium and ended up receiving €50/ha for the carbon premium, the difference (€8/ha) would be covered by this budget.

In line with these 5 criteria, Nataïs has set the price of the carbon premium for 2019/2020 at €45 per tonne of CO_2 sequestered sustainably.

- **The attractiveness of the carbon premium compared to the industry premium:** by setting this price at €45 per tonne of CO_2 sequestered, 51% of farmers in the pilot farm network will benefit from the carbon premium rather than the industry premium.
- **Biomass creation through plant cover**: the first farmer to benefit from the carbon premium produces an above-ground biomass of 2.21t DM/ha, which corresponds to the network average.
- **The attractiveness of the carbon premium in relation to the cost of cover crops:** with such a fixed price, the carbon premium should compensate on average 48% of the average cost of planting cover crops (93.44 €/ha) and two farmers would have their costs of planting cover crops completely covered by this premium.
- **The average price of carbon on the carbon market:** The amount of the premium remains very close to the €40/t of stored CO_2 expected in the coming years.
- **The budget allocated to the carbon premium:** With this price defined, the budget used by Nataïs to remunerate the 40 pilot farms in 2019/2020 is 19,733.45 euros, which is well below the 30,000 euros planned. Nataïs could therefore have chosen to increase the value of the tonne of CO_2 stored in order to make it more attractive, but Nataïs must also remain consistent in its valuation of the carbon stored. Indeed, if in the future Nataïs were to enter the carbon market and the value of the carbon were to be much lower, then the remuneration paid to farmers could fall. Consequently, it seems to Nataïs more prudent and strategic to take the opportunity to increase the value of the carbon premium rather than reduce it.

In the long term, Nataïs aims to extend the use of this premium to all the farmers in its network, representing a total of 7,000 hectares[4]. In order to be able to offer this premium to its entire network, Nataïs is currently considering different types of financial support to help it achieve this ambition. Two solutions are currently being considered:

- **The EU-ETS market:** Nataïs would resell the carbon equivalent quotas purchased from farmers. This would be a way for Nataïs to offset the costs of the carbon premium set up within its network, while at the same time enabling farmers to be paid for planting cover crops (45 euros compared with 40 euros per tonne of CO_2 on the carbon market in the coming years). Moreover, the widespread use of this approach would make it possible to reduce the costs of the industry premium, which cannot be valued on an external market.

[4] Nataïs produces popcorn on 7,200ha, but the plots with plant cover represent about half. The carbon footprint will be calculated for the entire network of producers, whether covered or not.

- **The low-carbon label:** the development of the field crop methodology is still in progress and Nataïs is participating in discussions concerning the creation of this label. Labelling of the Naturellement Popcorn project would make it possible to obtain remuneration correlated to carbon storage in agricultural soils.

2.2.7. Perspectives of Nataïs

Using the technical and financial tools described above, Nataïs intends to support the change in practices of the producers in its network and encourage the storage of CO_2 in agricultural soils. To achieve this, Nataïs also benefits from the support of a solid base of around 10 pioneering and driving farmers within the pilot farm network, which provides reassurance about the stability and sustainability of the project.

During 2019/2020, 17 farmers in the pilot farm network left the network because they had stopped growing popcorn or were unable to plant cover crops this year. These departures were offset by the arrival of 10 producers, which demonstrates the attractiveness of the project supported by Nataïs. In order to encourage this dynamic, Nataïs supports these farmers in changing their practices, offers them trials that interest them, communicates their actions in a positive way both internally and externally and builds loyalty among these farmers through the carbon premium. The development and maintenance of this carbon premium seems essential to the attractiveness and continuity of this project. Indeed, some farmers are attracted to this network for agronomic reasons, others for financial reasons. A final group of producers still needs to be convinced of the value of the network and the need to change their practices. Nataïs will therefore continue its policy of communicating the benefits of plant cover, supporting producers even more effectively in changing their practices and continuing to offer an attractive and sustainable carbon premium for the company. In two years, the Naturellement Popcorn project has succeeded in developing a solid project thanks to a strong network of producers and relevant support from partners (Agro d'Oc, INRAE (CESBIO, UMR AGIR) and STMS). The objective for the remaining four years of the project will be to expand the project by supporting a larger number of producers in the adoption of plant cover.

2.2.8. Review of the NATAIS model

Table 8 - Review of the Nataïs case

Application cases	- Field crop farms producing popcorn
Points to watch out for	- **Financing of carbon storage from the company's own funds:** Currently there is no valuation of stored carbon apart from the satisfaction of encouraging carbon storage in the soil. - **The cost of planting cover crops is much higher than the carbon premium:** the average cost of planting cover crops is twice as high as the carbon premium. However, it should be remembered that Nataïs is one of the only companies to offer this premium and that farmers plant cover crops even without benefiting from this premium in order to improve the quality of their soil. Nataïs' strategy is therefore to financially encourage the adoption of plant cover crops and also to demonstrate the agricultural benefits of this technique to farmers.
Key success factors	- **The implementation of a single carbon premium and agronomic support for farmers has made** it possible to overcome the two main obstacles encountered (lack of funding and lack of training). It remains to be scaled up so that all partner farmers can benefit from a carbon premium on all their plots. - Historic encouragement of partner farmers to plant cover crops by demonstrating the benefits of this practice. Nataïs is developing a consistent approach to the adoption of plant cover crops over time. - Sustained support for its farmer network - **Collaboration with various organisations:** Agro d'Oc, INRAE-CESBIO, UMR AGIR and STMS

3. Aggregation of carbon credits by a third party

3.1. Presentation of the model

In the model of carbon credit aggregation by a third party, all the credits generated by multiple projects are grouped together and marketed to buyers who wish to voluntarily offset their emissions (see Figure 9). This may be an association (such as France Carbon Agri Association), cooperatives, companies, etc. One of the advantages of this model is to transfer the administrative and marketing work from the farmers to the aggregator. It can also be a way to reduce the MRV costs for farmers by sampling several farms per project. One of the risks that may exist in this kind of project is the capture of value by these aggregators, as it is necessary to ensure that all the value generated by farmers is not transferred to these organisations.

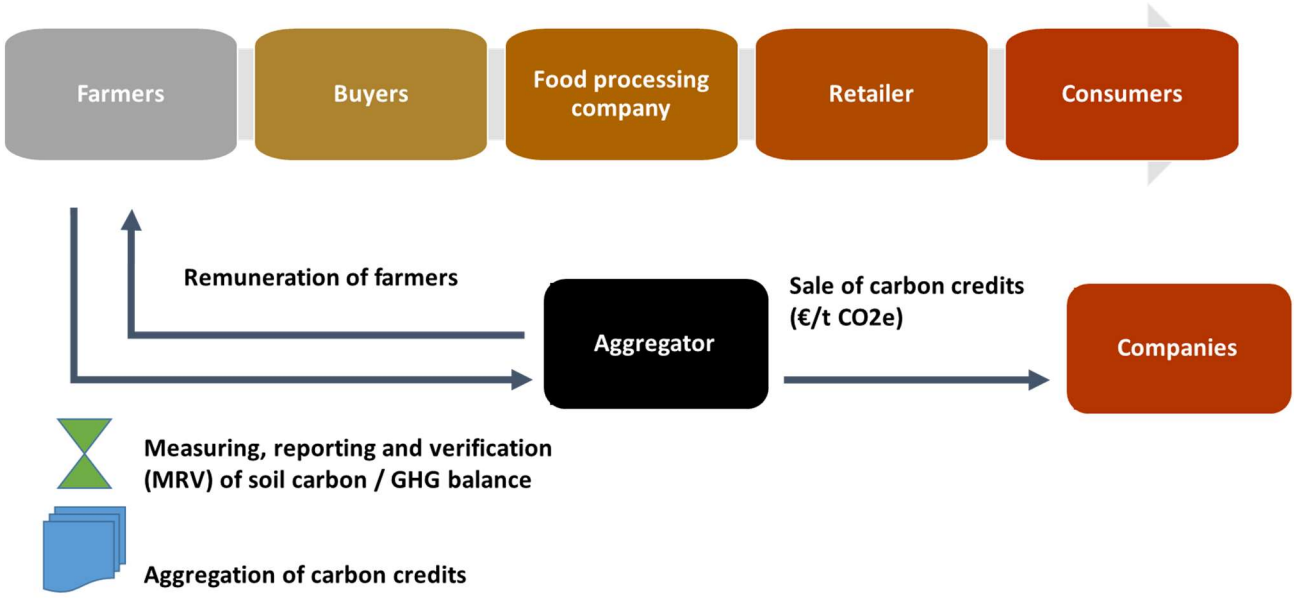


Figure 9: Aggregation of carbon credits by an aggregator outside the sector (association, digital platform)

3.2. France Carbone Agri Association (FCAA)

France Carbone Agri Association (FCAA - https://www.france-carbon-agri.fr/) is an important example to consider as it is the first French agricultural player whose "CARBON AGRI" methodology was certified by the Ministry of Ecological and Solidarity Transition (MTES) on 30 September 2019. This reactivity is the result of upstream work begun several years earlier, enabling the development of the CAP'2ER tool (see Yogo et al. 2021 - Deliverable I of this project), which makes it possible to evaluate GHG emission reductions and carbon storage and to make the link between environmental, technical and economic performance.

3.2.1. Presentation of the project

FCAA was created in 2019 at the initiative of livestock farmers' representatives (Fédération Nationale Bovine (FNB), Fédération Nationale Production Laitière (FNPL), Fédération Nationale de l'élevage caprin (FNEC), Fédération Nationale de l'élevage Ovin (FNO)). It aims to bring together projects using the Carbon Agri method in order to aggregate emission reduction and carbon storage projects. FCAA has several main missions:

- It provides technical expertise to projects and farmers
- It supports the low-carbon certification of projects
- It is looking for funders who want to finance the reduction of emissions
- It carries out the contractualisation between the different actors. This contractualization can be bipartite (between FCAA and the carbon credits buyers) or tripartite (between the breeders, the project holders and FCAA)
- It makes financial payments to farmers

Figure 10: Actions carried out by FCAA in supporting projects

The Carbon Agri method aims to account for and remunerate greenhouse gas (GHG) emission reductions and carbon storage in livestock farming and field crops. Since 2013, the livestock sector has been committed to reducing its carbon footprint, and more than 16,000 farms are now involved in reducing greenhouse gas emissions or increasing carbon storage. The launch of the Low Carbon Label in 2018 represented an opportunity to certify GHG emission reductions for all these farms. Linked to the national on-farm assessment tool CAP'2ER®, the Carbon Agri methodology was registered by a consortium made up of the Institut de l'Élevage, the dairy interprofession (CNIEL), the meat interprofession (Interbev), the National Livestock Commission and I4CE. This methodology was certified by the Ministry of Ecological Transition and Solidarity as compliant with the Low Carbon Label on 30 September 2019.

This method is aimed at individual project holders supported by a trustee or at several projects supported jointly by a single trustee. The grouping of farmers with project leaders facilitates the implementation of these projects in the different regions and avoids the need for each farmer to submit a project, apply for certification, look for buyers or set up a sales contract.

Following the call for projects launched at the end of 2019 by FCAA, 300 French breeders have signed up. Several types of project holders are part of this first call for projects:

- Chambers of Agriculture
- Meat producer organisations
- Dairies

- SCAs (limited partnership with shares) for meat

Many individual requests from farmers have been made, which complicates the overall process because it would then be necessary to carry out individualised technical support. This is why FCAA prefers to work with project leaders because they are the ones who propose the technical support, who carry out the CAP'2ER, and the intermediary steps that must be done within the Carbon Agri methodology. Moreover, the use of collective projects allows an economy of scale and project engineering.

3.2.2. Practices:

The duration of the projects is 5 years, renewable for another 5 years. These farms must have at least: a dairy workshop, and/or a livestock production systems, and/or a livestock production systems. To qualify for the use of this method, three main criteria have been defined:

- For the duration of the project, it is necessary that the farm respects the organic nitrogen ceiling defined by the nitrate regulation of 170 kg Norganic/ha of UAA issued by the nitrate directive (whether the farm is in a vulnerable zone or not). This measure therefore limits access to the Carbon Agri methodology to intensive farms.
- The cessation of activity of production systems makes the activity concerned ineligible for carbon credits
- It is necessary that the carbon stock within the farm is maintained or increased

GHG emission reductions can be achieved through:

- the management of the herd
- the feeding of the herd
- the management of animal manure
- the optimisation of fertiliser consumption
- the optimisation of energy consumption

Increased carbon storage in soils is achieved by:

- Establishment of permanent grassland areas
- Increasing the place of temporary grassland in the rotation
- Limiting tillage with direct seeding,
- The establishment of intermediate crops,
- The establishment of hedges
- Agroforestry.

3.2.3. Methodology for quantification and verification of measurements:

The CarbonAgri methodology is available on the website of the Ministry of Ecology (https://www.ecologie.gouv.fr/label-bas-carbone). The accounting of reductions is based on a life cycle approach. Direct and indirect emission reductions (GHGs emitted by animals and their feed, by manure management and by crop and grassland management) as well as carbon sequestration (crop and grassland management, hedgerows and wooded areas) are taken into account.

Emissions are verified at the end of the project. The sum of the emission reductions/increases of the production systems and of the carbon sequestration at farm level makes it possible to calculate the total carbon gain at farm level. To assess GHG emission reductions and carbon storage, the CAP'2ER® level 2 tool (or any other methodologically equivalent tool certified by a third-party organisation) is used. This assessment allows for a study at farm level in order to estimate the total emissions reduction achieved by the practices and the farmer and to avoid a transfer of emissions from one livestock production systems to another. The CAP'2ER® tool allows a multi-criteria assessment of other environmental aspects (water and air quality, energy consumption and production, biodiversity). This assessment also ensures that there is no negative impact on other environmental aspects and would also allow for a better valuation of carbon credits with their buyers. After the final assessment by Cap'2ER® an audit is carried out by an

independent third party to ensure that the CarbonAgri methodology has been respected. This audit is carried out on a minimum sample of 5 farms (a minimum of ½ √total number of farms) in the case of collective projects.

Project leaders can choose between two specific scenarios. Either the promoters choose the specific scenario and, in this case, the carbon footprints are assessed via CAP'2ER® at the beginning and end of the project (either on a sample of farmers or on all farmers). If the project leaders choose the generic scenario, then the initial CAP'2ER is replaced by generic references defined on the basis of results provided on a sample of average farms in France (values varying according to the farming systems and regions). A 10% discount is applied to the carbon credit results of the generic scenarios (present in the Carbon Agri methodology).

3.2.4. Business model

One year after the notification of the first project to MTES, 13% of the carbon credits available through this first call for projects had already been sold. The main buyers are currently the Caisse des Dépôts et des Consignations and the Kering group.

Table 9: France Carbon Agri Association business model

Type of data	Figure	Comment
Number of farms involved	300 farmers grouped together in 20 project leaders. To date, it is estimated that in 5 years, 137,000 tons of CO_2 will be avoided thanks to these 20 projects.	A second call for projects was launched on 2 November 2020. It includes 56 project leaders and 1300 farmers.
Funding received	The association has received funding to do all the work of getting started. Then the association will operate entirely on the remuneration of carbon credits, by taking a percentage of the carbon credit.	-
The remuneration received	The remuneration received depends on a performance obligation. Currently, each player receives a certain amount per tonne of CO_2 equivalent sold: - 3€/t CO_2e for FCAA - 5€/t CO_2e for the project developer - Between 30 and 35 € /t CO_2e for the farmer. This remuneration depends on the type of project and the actions implemented on the farms. A threshold of 30 euros has been contractually fixed for the remuneration of farmers.	- 40% of the amount is received in the middle of the project following the mid-term audit to ensure the implementation of practices. The balance will be paid at the end of the project based on the CO_2 stored and avoided verified by Cap'2ER® and after the certification audit by external auditors. - A traceability of GHG/carbon reductions is made for each farmer. If during the course of the project, the value of the carbon credit were to change, then the farmer would be remunerated at the new current price.
Cost of verification	- Approximately €1500 at entry (including a CAP'2ER Assessment, the creation of a carbon plan and a technical and economic visit), - 400 € per year per farm for individual assistance. - Approximately 1000 € for the final assessment (CAP'2ER® and report)	The Carbon Agri method allows the verification of projects on a sample basis, which should allow for economies of scale and thus help to reduce these costs.

3.2.5. Review of the FCAA model

Table 10: Review of the FCAA case

Application	- Greenhouse gas (GHG) emission reductions and carbon storage in livestock and arable farming
Points to watch out for	- One year after the notification of the first project to MTES, 13% of the carbon credits available through this first call for projects had been sold. FCAA has yet to sell the rest of the carbon credits and the interest of buyers for these credits is yet to be confirmed. - A threshold of 30 euros/tCO_2e has been set for the remuneration of farmers. This high valuation is favourable to farmers and goes hand in hand with the costs of changing practices, but it can be an obstacle for buyers (the average price on the international markets for a tonne of CO_2 is 6 euros).
Key success factors	- Development of the CAP'2ER® tool which could be directly used in the LBC. - First method validated by the LBC, making it a precursor in the French voluntary carbon market. - The grouping of farmers with project leaders facilitates the implementation of these projects in the different regions and avoids the need for each farmer to submit a project, apply for certification, look for buyers or set up a sales contract. This allows an economy of scale and ensures project engineering - Growing interest from farmers (300 farmers in the first call for projects and 1300 in the second).

3.3. The Australian Emissions Reduction Fund

The Australian Emissions Reduction Fund was studied as a precursor to the development of carbon credits. Established in 2011, it has delivered over 1 million units of agricultural carbon credits[5], issued through over 143 projects.

3.3.1.Presentation of the project

The Emissions Reduction Fund (ERF) is a voluntary mechanism to encourage organisations and individuals to adopt practices and technologies that reduce their emissions. The Australian government agency is responsible for awarding Australian Carbon Credit Units (ACCUs), each equivalent to one tonne of CO_2 equivalent sequestered or avoided. ACCUs can be sold to the government through a carbon offset contract or to other buyers who wish to offset their emissions. In order to receive ACCUs, methodologies defined by the Australian government must be followed. For the agricultural sector, the methodologies are divided into 7 groups and one methodology specifically addresses carbon storage in agricultural soils. It defines the rules for obtaining ACCUs and the types of farming practices that can benefit from them:

- Pastures
- Crops
- Horticulture
- Mixed farming systems

The carbon storage methodology we will study here dates from 2018. Two other methodologies were already available but were not widely adopted because of the high cost of direct verification measures associated with them and the small number of production types available. This third method proposed by the government is designed to be more flexible, to take into account a larger number of production types.

3.3.2. Practices

To be eligible for carbon credits, farmers must:

- Identify eligible land for this process: pasture, crop (which may include horticulture and fruit/vegetable production) or bare fallow within the last ten years
- Establish their legal right to the land to implement the project and obtain carbon credits from it (lease, land title, agreement signed with other landowners)
- Obtain regulatory approvals and consent from all persons with an eligible interest in the land allocated to the project (this may include banks, state governments or indigenous bodies).
- Ensure that the project is new and that it actually corresponds to the application of new agricultural practices

In order for the project to be accepted, the farmer must apply at least one of the following practices:

- Apply nutrients, lime or gypsum
- Installing a new irrigation system
- Re-establishing or rejuvenating a pasture through seeding
- Establish or maintain grazing where none previously existed (cultivated land or bare fallow)
- Change in grazing duration or intensity
- Retain crop residues after harvesting

[5] http://www.cleanenergyregulator.gov.au/maps/Pages/erf-projects/index.html

- Conversion from intensive to no or low tillage
- Changing landscape features to remediate soils
- Use mechanical means to add or redistribute soil across the soil profile

If these conditions are met, then the Clean Energy regulator can validate or not the registration of the farmer's project.

3.3.3. Methodology for quantification and verification of measurements

Farmers must propose a management plan at the beginning of the project, which will be reviewed and validated by auditors. In order to be eligible for Australian carbon credits, the additionality of emission reductions must be demonstrated. The baseline soil carbon level is defined by the soil carbon level in the 10 years prior to the project launch. The number of credits obtained is dependent on the additional amount of carbon stored which is calculated based on a model. Sampling requires 9 samples to be taken to a minimum depth of 30 cm for each area storing carbon.

The period during which a farmer can earn credits from his project is 25 years. Every 5 years or more, the farmer is also required to report on his project. He receives carbon credits whenever he reports an increase in carbon levels.

For these projects, a permanence period of 25 or 100 years (duration chosen by the farmer) must be defined to ensure the permanence of the carbon storage. This permanence period starts as soon as the farmer obtains credits. In order to take into account the permanence of carbon, discounts are applied to the total carbon stored in the soil. A 25% discount is applied to the total number of credits obtained for 25-year projects. Similarly, a 5% discount is applied to 100-year projects. If the carbon storage is not permanent over this period, then the farmer would be obliged to return the credits obtained.

At the end of the project, farmers submit a report which includes:

- The dates and location of the samples taken
- The areas on which the project was carried out and the practices that were adopted
- The amount of credit obtained is equal to this amount of net carbon stored minus the emissions made during the project (fuel, fertilisers, etc.).

3.3.4. Business model

At present, the government buys 95% of the ACCUs sold. In order to sell ACCUs, the actors in possession of these credits must submit invoices to the government or to the buyers. The acceptance of these invoices is based on the consistency between low costs and emission reductions. When these invoices are accepted, the seller receives the amount specified on them. By September 2020, the regulator had signed contracts with a total of 143 projects for a total of 1 million ACCUs. Demand for ACCUs from buyers other than the state appears to be low and ACCUs are competing with other cheaper emission reduction units on a national level. This demand from buyers may change as companies increasingly set climate targets and demand emission reduction products and as international demand for low carbon products develops.

The Clean Energy Regulator holds regular auctions on their website to buy carbon credits. This allows farmers to sell their obtained carbon credits. This can be a way for them to secure their sales by obtaining a forward contract of up to 10 years. For the year 2019/2020, the average price of carbon credits on the voluntary market is $16.35/credit. This price is still considered insufficient to develop reforestation projects and an average price of between A$25 and A$40 per tonne of CO_2e would be needed by 2030 (*Carbon neutral, 2020 review of the ERF consultation paper*).

At this stage, it is still difficult to determine the exact cost of this method for farmers. However, it should be noted that Australian farms are larger than French farms and therefore benefit from an effect of scale in the implementation of carbon storage. The costs to be taken into account for a carbon recovery project are developed in Table 11.

Table 11: Types of costs borne by farmers in Australian carbon projects

Types of costs for the farmer	The breakdown of these costs
Agricultural costs depend on the practices implemented by farmers.	This may include: - Purchase and application of fertiliser

	- The cost of installing and operating irrigation - Fencing to manage grazing - Time spent monitoring and recording measurements
Costs of sample collection and analysis	- Technician for soil sampling: between 1500 and A$ 2000per day plus travel costs. Estimated total cost: A$ 5,000 - Laboratory analysis: between A$ 40 and A$ 100 per sample. Estimated minimum total price: A$ 1,800 As these costs were considered a significant barrier, an advance of A$ 5000 is now available to fund the sampling costs.
The preparation of reports can also be time-consuming and should be charged for or costed if staff are employed (at least one report every 5 years)	-
An auditor must be hired to perform a minimum of 3 audits over the 25 year period	-

3.3.5. Review of the Australian model

Table 12: Review of the Australian model

Application cases	A methodology defined by the Australian government that applies to the following cultural practices: - Pastures - Crops - Horticulture - Mixed farming systems
Points to watch out for	- A significant project cost for farmers (about A$ 6800 per farm). An advance of A$ 5000 is proposed by the state to finance the sampling costs. - Credits purchased mainly by the Australian government - An average price of A$ 16.35 considered insufficient to develop reforestation projects
Key success factors	- A pioneering case of carbon credit development - Recognised mechanism managed by the Australian state - The government buys 95% of the credits sold - 1 million units of carbon credits, issued through 143 projects - The large size of farms in Australia which facilitates economies of scale.

3.4. The carbon market in Alberta

From 2002 to the present, Alberta has been Canada's largest emitter of greenhouse gases. In July 2007, the Canadian province of Alberta became the first jurisdiction in North America to impose a carbon compliance system.

3.4.1.Presentation of the project

Alberta is a province that accounts for almost a third of the country's agricultural land and half of its beef cows. Businesses generating more than 100,000 tonnes of greenhouse gases per year produce more than half of Alberta's total emissions. In July 2007, the Canadian province of Alberta became the first jurisdiction in North America to impose a carbon compliance system. In order to regulate these emissions, these companies are required to do one or more of the following:

- Reduce emissions from their own activities,
- Pay a fixed carbon price to the *Technology Innovation and Emissions Reductions (*TIER) fund. Currently the price is $30/tCO$_2$e, rising to $40/tCO$_2$e in 2021 and $50/tCO$_2$e in 2022. The revenue from this tax is expected to be $485 million in 2022-23,
- Purchase *Emissions Performance Credits* (EPCs*)* from companies that have exceeded their annual emissions reduction obligations and have received an equivalent number of EPCs,
- Paying for offsets from Alberta's carbon market that come from both the agriculture and non-agriculture sectors. The value of these carbon credits in 2020 was approximately $28 (Carbon market business brief, IETA, June 2020).

Offset credits are credits generated by voluntary projects that increase removals or decrease reductions of GHG emissions. Each credit is equivalent to one tonne of CO_2 equivalent reduced or eliminated that would have existed in the absence of the project. These credits are validated using Alberta-approved methodologies and are verified by a third-party organization that performs standard validations, verifications and audits. Emission reduction projects must meet the requirements of the TIER regulation, to standard greenhouse gas reduction contribution project standards and to a protocol approved by Alberta.

3.4.2. Practices

There are 25 credit generation protocols in Alberta. In the agriculture sector, carbon credits are generated by complying with 4 approved protocols:

- Conservation Agriculture, which is by far the most widely used methodology in agriculture
- Biogas (anaerobic decomposition of agricultural materials)
- Cattle (reduction of greenhouse gas emissions from cattle)
- Microgeneration (decentralised renewable energy production). This protocol is still very little used due to the low number of offers, low carbon prices and uncertainties regarding certification requirements.

3.4.3. Business model

In theory, aggregators are not needed to use the offset market. In practice, large companies prefer to buy carbon credits in large quantities and sign a single contract, rather than negotiate multiple contracts for small volumes. Aggregators act as project developers/compilers and manage the many requirements for creating and selling viable offsets. This includes:

- Managing data collection
- Verification of storage by a third party
- Credit marketing (marketing and sales)

Examples include the Radicle and Trimble aggregators that aggregate carbon credits from farms using the conservation agriculture protocol.

The value a farmer receives from the sale of these credits depends on:

- The fixed price of carbon to be paid to the TIER fund, as the sale price of offsets is generally lower than the fixed price of carbon,
- The evolution of the sale price of offsets,
- The division of income between farmer(s) and aggregator. Association with an aggregator is not mandatory for farmers, however, industry generally prefers to buy credits through a single contract rather than negotiate several small volume contracts.
- The amount of carbon stored/avoided, which may be limited by the associated protocol.

Table 13: Methodologies and associated carbon storage in Alberta

Methodology	Storage	Total stored carbon	Expiry of the protocol
Conservation agriculture	Alberta no-till producers store approximately : - 0.11 tonnes/acre per year in the Parkland area (0.27 tonnes/ha/year). - 0.06 tonnes/acre per year (0.15 tonnes/ha/yr). In the Dry Prairies (south eastern Alberta) irrigated areas of the Dry Prairies store 0.11 tonnes/acre per year. Generally the split of offset sales for this methodology is 1/3 to aggregators and 2/3 to farmers. This figure varies for the other protocols.	Between 600,000 and 700,000 tonnes per year	31 December 2021
Cattle (reduction of greenhouse gas emissions from cattle)	Quantity of credit generated = Initial rejected emissions - reduction of emissions	-	-
Microgeneration (decentralised renewable energy production)	The carbon efficiency of microgeneration is set at 0.64 kilograms per kilowatt-hour (kWh) in 2019. An installation producing 10,000 kilowatt hours (kWh) per year would produce 6,400 kg or 6.4 tonnes	-	-

In Alberta, since 2002, approximately 13 million tonnes of CO_2 equivalent have been stored/avoided through practice changes (mostly through reduced tillage projects, biogas generation) generating carbon credits. Aggregators such as Radicle and Trimble aggregate carbon credits from farms and sell them to companies. It is estimated that these emission credits have generated $170 million in revenue for farmers and aggregators.

3.4.4. Alberta's Carbon Market Review

Table 14: Review of Alberta's carbon market

Application cases	There are 25 credit generation protocols in Alberta. In the agriculture sector, carbon credits are generated by complying with 4 approved protocols: - Conservation Agriculture, which is by far the most widely used methodology in agriculture - Biogas - Cattle - Microgeneration
Points to watch out for	- Companies are required to comply with carbon regulations in Alberta, which encourages the purchase of carbon credits, which is not the case in other countries.
Key success factors	- Since 2002, approximately 13 million tonnes of CO_2e have been stored/avoided through changes in practices - These emission credits generated $170 million in sales to farmers and aggregators. - Aggregators such as Radicle and Trimble aggregate carbon credits from farms and sell them to companies. - Typically the split of offset sales for this methodology is 1/3 to aggregators and 2/3 to farmers. It can be noted that the aggregators receive a higher remuneration here (in proportion) than FCAA. - A changing price per tonne of CO_2: this price is $28/tCO2e. As carbon pricing is set to change in 2021 ($40/tCO2e) and 2022 ($50/tCO2e), the price of carbon credits should also increase in the coming years

4. Aggregation of credits by a platform

4.1. Presentation of the model

Platforms are private companies that constitute new marketplaces for the sale of voluntary carbon credits (see Figure 10). They bring together companies, citizens and farmers who store carbon in the soil. In this type of model, farmers start by applying on their website to present their storage project. Once the project is validated and accepted by the platform, and the farmers have stored carbon the carbon removals are verified and quantified by an independent or non-independent third party (depending on the platform). Once the emission reductions and/or carbon storage is verified, carbon credits are issued and traded by the platform. Buyers can pay on this marketplace for the number of tonnes of carbon storage they wish to finance and the carbon absorption certificates are removed from the sale to avoid double counting. There are several examples of such platforms such as Indigo AG, Nori or SoilCapital.

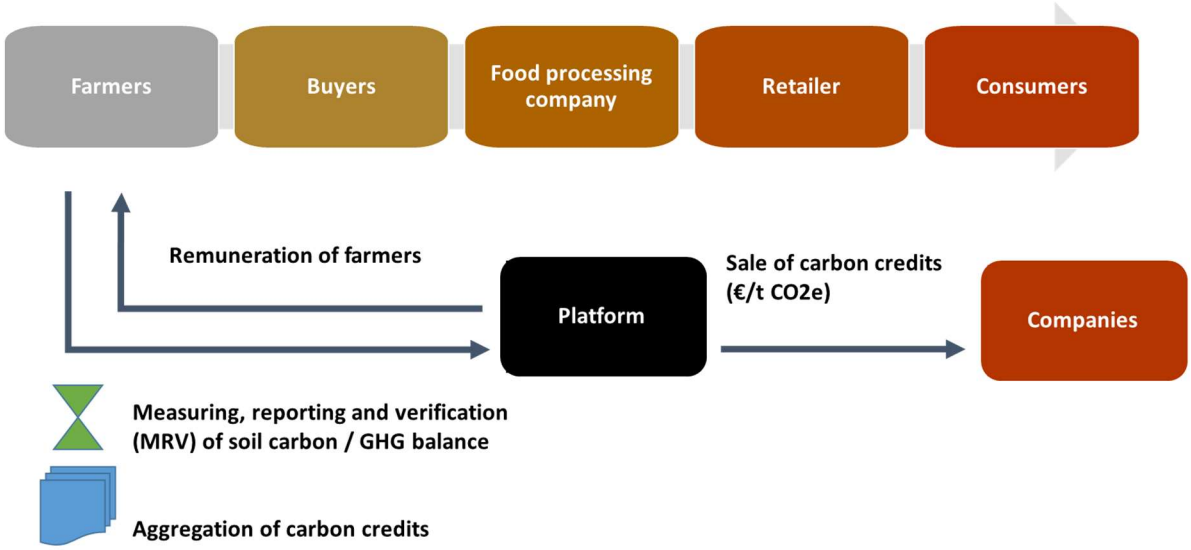


Figure 11: Aggregation of credits by a platform

4.2. Soil Capital

Soil Capital is an independent company that offers support to French and Belgian farmers wishing to exploit the carbon stored in the soil. It is a platform that allows farmers to apply directly on their site. It is a paying service that includes agronomic and commercial support. Following verification of the carbon storage using the *Cool Farm Tool*, the credits are marketed by South Pole, which is a partner of Soil Capital. This company was selected for this study because it is a growing European platform. The fact that it is a platform is also interesting because it makes it easier for farmers to access carbon valuation.

4.2.1. Presentation of the project:

Soil Capital is an independent company of farmers whose primary objective is to support farmers in improving farm profitability and soil health. In 2020 they launched a remuneration programme for farmers in France and Belgium called *Soil Capital Carbon*. This 5-year programme aims to market carbon certificates for stored or avoided emissions. The company supports its farmer members by providing agronomic support for the development of carbon-storing practices, measuring emission reductions and

carbon storage achieved. Each year the net carbon gains will be estimated by Soil Capital and the credits are traded by their partner South Pole.

4.2.2. Practices:

Soil Capital's offer is for arable farms, tree crops are not included in this model. The practices that will be applied will depend on the prognosis made on the farms, this includes

- minimum or no tillage (practices identified as non-storing in the French metropolitan context by Pellerin et al. 2019),
- the establishment of plant cover,
- diversification of rotations, residue management, optimised or organic fertilisation.

4.2.3. Methodology for quantification and verification of measurements

Soil Capital Carbon's methodology complies with the international standard ISO 14064. Once the farmer has registered for the programme, Soil Capital works with him or her to carry out an assessment of the farm using the Cool Farm Tool (see deliverable 1 of this study), which quantifies the GHG footprint of the farm. Actions are then identified to improve the farm's profitability and GHG impact.

Soil Capital takes into account no-till as a carbon storage lever (which is not the case in the LBC and which is not validated by the INRAE 4 per 1000 study). This may lead to a higher estimate of the amount of carbon stored and make Soil Capital more attractive than the Low Carbon Label which is supposed to be the reference validated by the French scientific corpus.

4.2.4. Business model

As of September 2020, 175 farmers representing a total of 35,000 hectares had signed up to the programme and more than €500,000 of carbon certificates (or tonnes of $C0_2e$ not emitted or stored) had already been purchased partly by the company Cargill and the Iba Foundation.

Table 15: Soil Capital business model

Farmers' remuneration:	The selling prices of the carbon certificates are estimated at 27.5 euros/t of $C0_2e$. During the first 5 years of the programme, farmers will receive 80% of the emission reductions achieved. The remaining 20% will be paid after the 11th to 15th year if there are no unexpected $C0_2e$ losses on the farms. If not, this 20% will be used to compensate for the losses observed.
Costs incurred by farmers	- 980 euros per year to join the programme, i.e. 4,900 euros for the whole project. - Costs/gains of changing practice
Value of carbon sold	500,000 euros in carbon certificates

4.2.5. Balance sheet of the Soil Capital model

Table 16: Review of the Soil Capital model

Application cases	French and Belgian field crop farms (arboriculture is not included in this model) implementing practices such as minimum or no tillage, plant cover, rotation diversification, residue management, optimised or organic fertilisation.
Points to watch out for	- A rather high cost to participate in this programme (4900 euros over 5 years) - Soil Capital takes into account no-till as a carbon storage lever, which is not the case in the Low Carbon Label.
Key success factors	- Platform that can collaborate with any French or Belgian farm wishing to valorise the carbon stored in the soil - 175 farmers representing a total of 35,000 hectares have joined the programme - High value of carbon certificates (estimated at €27.5/t CO_2e) - More than €500,000 of carbon certificates have already been traded

4.3. Svensk Kölinlagring

Svensk Kölinlagring is presented here because it is a platform whose model allows for a significant remuneration of the farmer. Three companies: MAX Burgers, Oatly and Grant Thornton directly financed the changes in practice of farmers who receive approximately 100 euros per hectare.

4.3.1.Presentation of the project:

Svensk Kolinlagring is a Swedish platform established in 2019 that brings together scientists, farmers, food companies and other stakeholders to design a system that enables and creates incentives to store carbon dioxide in Swedish agricultural soils. The innovation is led and managed by MiljöMatmetikMalmö AB (MMM), a company whose mission is to "transform the food system and encourage the contribution of food as a solution for prosperous societies within the boundaries of the planet". The long-term ambition is for the platform to become a new, not-for-profit, member-owned cooperative. Food companies (MAX Burgers, Oatly and Grant Thornton) are already funding carbon storage by farmers.

In 2021-2022 the number of hectares, farms and collaborations will continue to increase and Svensk Kölinlagring will continue to build its platform to sequester more carbon in Swedish agricultural soils.

4.3.2. Practices in place

The 2020 pilot farms are mainly located in Skåne and Halland, but also in Uppland and Närke. Fourteen pilot farmers are involved in 2020 and the project is applied on 300 ha for the pilot year (2020). The smallest farm is 3 ha in total and the largest is over 500 ha. The farmers produce milk, beef, eggs and chickens, vegetables and cereals. Some are organic and some are conventional.

Farmers were given an introduction to carbon farming, focusing on the basic principles. Some farms tried new methods, others developed what they were already doing, and still others integrated other methods into their systems. Svensk Kölinlagring let the farmers decide for themselves which methods they wanted to try during the pilot year. Starting with basic principles rather than separate individual methods encouraged innovation on the farms, as Svensk Kölinlagring felt this gave them more and better carbon storage methods in their range of options.

The following practices have been used to store carbon:

- Agroforestry
- Plant cover
- Grazing
- No ploughing (a practice identified as non-stocking in the French metropolitan context by Pellerin et al. 2019),

4.3.3. Methodology for quantification and verification of measurements

In the 2020 pilot project, Svensk Kölinlagring assumed a fixed sequestration value of 0.3 tonnes of carbon, which corresponds to one tonne of carbon dioxide equivalent per hectare per year. This is a fixed value based on a minimum change in management practices, such as the incorporation of cover crops. With this approach, they sequestered at least 300 t of carbon dioxide equivalents in 2020.

4.3.4. Business model:

Currently, farmers' compensation for stored carbon is financed directly by companies that want to contribute to the fight against climate change. These companies finance the application of practices per hectare independently of the carbon stored (see following table).

Table 17: Svensk Kölinlagring's business model

Farmers' remuneration:	Currently, pilots receive 1000 sek/ha (95€/ha) and this is not based on stored CO_2. Later it would be based on CO2 per hectare.
The source of funding for this project:	The Lanshypotek Bank Research Foundation provided 45,000 SEK (~4500 €) for soil sampling (verification). MAX Burgers, Oatly and Grant Thornton financed 100 ha each with 1000 SEK/ha (~100 €) going directly to the farmer.

4.3.5. Review of the Svensk Kölinlagring case

Table 18: Review of the Svensk Kölinlagring case

Application cases	Fourteen Swedish pilot farms apply the following practices to store carbon: - Agroforestry - Plant cover - Grazing - No ploughing
Points to watch out for	- A carbon assessment based on the literature. A value was selected to estimate the amount of carbon stored. The diversity of practices used can make an accurate estimate of carbon stored difficult.
Key success factors	- Companies that directly finance the establishment of carbon storage. The remuneration received by farmers is high: 100 euros per hectare - An emerging model attracting a growing number of farmers and businesses - A platform that brings together scientists, farmers, food companies

5. Citizen financing of carbon storage projects

This type of financing allows project leaders to collect funds directly from the general public. This is the case of Ecotree, which allows citizens or companies to buy trees. The latter will receive a return on their investment when the trees are sold for timber. Although this model is not based on the direct valuation of carbon credits, the promotion of stored carbon represents a selling point for buyers.

5.1. Presentation of the project

Ecotree is a French startup. It is an investment fund for individuals and companies (e.g. SNCF). The company's clients buy trees individually or through a monthly subscription and become their owners. Ecotree is responsible for the acquisition of the land and for all sustainable forestry management, maintaining a density of between 1,000 and 10,000 trees per hectare.

The remuneration of its clients is made when the trees reach maturity (several decades after the purchase of the trees) and the wood is sold in tenders, the latter being intended to become timber. At that time, each client receives a share of the proceeds from the felling of the mature trees on the forest where the investment was made (and therefore does not only receive the proceeds from its own trees). This practice limits the risks for buyers, as the trees acquired may disappear before the cutting date. Today, more than 30,000 individuals and 500 companies are already clients of this startup, which manages around 600,000 plants or trees in France. The company also operates in the UK, Ireland and Sweden.

5.2. Practices in place :

This is the silvicultural management method used by Ecotree:

- The tree species planted are diversified
- Removal is practised (unlike the clear-cutting)
- Chemicals, pesticides and fertilizers are not used
- Establishment of sustainable forestry itineraries favouring biodiversity

The forests managed by Ecotree are also certified as sustainable by PEFC (Programme for the Endorsement of Forest Certification).

5.3. Methodology for quantification and verification of measurements

In this model, there are no carbon credits issued, only an estimate of the carbon stored in the wood. However, carbon storage is an element that is strongly emphasised in the sales arguments. The carbon storage capacity is not the same for all tree species, which do not all have the same density (a poplar weighs 400 kg/m3 while ebony wood weighs 1,400 kg/m3).

The following model is used to estimate the amount of CO_2 stored per tree: A 1,000 kg tree with a moisture content of 100% would be composed of 500 kg of water and 500 kg of dry wood. Of the 500 kg of dry wood, 47.5% is carbon, which represents 237.5 kg of carbon. To make this carbon, the tree would have absorbed 237.5 x 3.67 = 871.625 kg of CO_2 (it takes 1 kg of carbon to make 3.67 kg of CO_2). These carbon calculations have been verified by Bureau Veritas.

5.4. Review of the Ecotree case

Table 19: Review of the Ecotree case

Application cases	Investment fund for individuals and companies whose clients buy trees individually or through a monthly subscription
Points to watch out for	- The quantity of carbon stored depends greatly on the species planted. However, Ecotree is transparent on this subject, and the quantities of carbon stored are provided as an indication
Key success factors	- The forests managed by Ecotree are PEFC certified - The emphasis on stored carbon seems to be a relevant selling point to customers. In addition, the carbon calculations used are verified by Bureau Veritas.

6. Conclusion

The voluntary carbon market is still evolving and many business models are emerging. Some projects are financing the adoption of carbon-storing practices themselves in order to contribute to the fight against climate change and to improve the quality of agricultural soils. They see this as an investment in the future preservation of their value chain, but may also aim for future valuation.

Others join forces with aggregators (associations, companies, cooperatives) which not only allow them to benefit from economies of scale (administrative costs, monitoring, verification) but also to facilitate access to the carbon credit system for farmers.

The platforms serve as a marketplace for carbon credits. They provide an easy link between farmers and buyers, who can then decide on the exact amount of carbon they wish to acquire. This model seems to be developing rapidly, as seen with the Soil Capital case, but we could also mention the INDIGO AG platform valued at more than 1.4 billion dollars, partly for marketing other services and products.

In this study, business models based on low-carbon food labels were not investigated. It would be interesting to develop this aspect at a later stage, as the company Farm Frites explained to us that, according to a study carried out by this company, consumers would be prepared to pay 10% more for products with this type of label.

While the number of business models and projects is proliferating, it seems that project owners are finding it difficult to find buyers. The question therefore arises as to the advantage of acquiring this type of credit. Indeed, if the purchase of these products depends on the will of the financiers and these emission reductions are neither tradable nor refundable, then the main interests lie in the communication that can be made by the purchasing companies and in the preservation of their value chain in the face of climate change.

Table 20: Summary table of case studies

Business model	Case study	Points to watch out for	Key success factors
Financing carbon storage by an agri-food company in its value chain	**The example of Nataïs**	- Financing of carbon storage from the company's own funds - The cost of planting vegetation cover is much higher than the carbon premium	- The introduction of a single carbon premium and agronomic support for farmers - Historic encouragement of partner farmers to plant cover crops - Sustained support for its farmer network
Aggregation of carbon credits by a third party	**France Carbone Agri Association (FCAA)**	- One year after the first project was notified to MTES, 13% of the carbon credits had been sold - A threshold of 30 euros/tCO2e has been set for the remuneration of farmers.	- Development of the CAP'2ER® tool which could be directly used in the LBC - First method validated by the LBC - Grouping of farmers with project leaders - Growing interest from farmers
	The Australian Emissions Reduction Fund	- A significant project cost for farmers - Credits purchased mainly by the Australian government - An average price of $16.35/tCO2e	- A pioneering case of carbon credit development - Recognised mechanism managed by the Australian state - 1 million units of carbon credits, issued through 143 projects - The large size of farms in Australia facilitates economies of scale
	The carbon market in Alberta	- Companies are required to comply with carbon regulations in Alberta, which encourages the purchase of carbon credits	- Aggregators aggregate carbon credits from farms and sell them to companies - A rising price per tonne of CO_2
Aggregation of credits by a platform	**Soil Capital**	- A rather high cost to participate in this programme (4900 euros over 5 years) - Soil Capital takes into account no-till as a lever for carbon storage, which is not the case in the LBC	- Platform that can collaborate with any French or Belgian farm wishing to valorise the carbon stored in the soil - 175 farmers representing a total of 35,000 hectares have joined the programme - 27.5 euros/t of CO_2 stored / avoided - 500,000 euros worth of carbon certificates have already been traded
	Svensk Kölinlagring	- A carbon assessment using the literature - The diversity of practices used can make it difficult to estimate the carbon stored accurately.	- Companies that directly finance the establishment of carbon storage (100 euros per hectare) - An emerging model attracting a growing number of farmers and businesses - A platform that brings together scientists, farmers, food companies
Citizen financing of carbon storage projects	**Citizen financing of carbon storage projects**	- The quantity of carbon stored depends greatly on the species planted. However, Ecotree is transparent on this subject, and the quantities of carbon stored are provided as an indication	- The forests managed by Ecotree are PEFC certified - The emphasis on stored carbon seems to be a relevant selling point to customers. In addition, the carbon calculations used are verified by Bureau Veritas.

7. Soil carbon project sheets with existing economic valuation

France Carbon Agri Association	
Presentation of the project	France Carbon Agri Association aims to coordinate emission reduction and carbon storage projects on livestock farms (low-carbon labelling, contractualisation, search for funders). Following the first call for projects launched in November 2019, 300 farmers grouped in 20 projects are still engaged with FCAA. The emission reduction potential of this project is estimated at 137,000 tCO_2e. Today, 13% of the credits have already been sold and should bring farmers a minimum remuneration of 30 euros/tCO_2e
Website :	https://france-carbon-agri.fr/
Country	France
Key partners :	IDELE / Chambers of Agriculture / Caisse des dépôts
The farms involved:	300 farmers grouped in 20 project leaders. A second call for projects was launched on 2 November 2020 to increase the number of farms involved. It brings together 56 project leaders and 1300 farmers.
The type of agricultural production system :	Farms must have at least: a dairy and/or a beef farm and/or a livestock production system.
Types of practices implemented for carbon sequestration/protection :	GHG emission reductions can be achieved through : - Herd management, herd feeding, manure management, optimisation of fertiliser consumption, optimisation of energy consumption Increased carbon storage in soils can be achieved through : - The establishment of permanent grasslands, the increase of temporary grasslands in the field rotations, the limitation of soil work with direct seeding, the establishment of intermediate crops, the establishment of hedges, agroforestry.
The objectives of the project :	Reducing GHG emissions and increasing carbon storage on livestock farms
The remuneration received :	The remuneration received depends on an obligation of results. Currently, each player receives a certain amount per tonne of CO_2e sold: - 3€/t CO_2e for ACTS - 5€/t CO_2e for the project developer - Between 30 and 35 € /t CO_2e for the farmer. This remuneration depends on the type of project and the actions implemented on the farms. A threshold of 30 euros has been contractually fixed for the remuneration of farmers.
The number of tonnes of CO_2 that this project aims to store/avoid :	To date, it is estimated that in 5 years, 71,000 tonnes of CO_2e will be avoided thanks to the 22 projects of the first call for projects.
Costs incurred by farmers	- 1,500 € at the beginning of the project (including a CAP'2ER evaluation, the creation of a carbon plan and a technical-economic visit), and 400 € per year per farm for individual assistance. - Approximately 1000 € for the final assessment (CAP'2ER® and report)
The source of funding for this project :	The association has start-up funding to do all the work of getting started. Then the association will operate entirely on the remuneration of carbon credits, by taking a percentage of the carbon credit.

The Australian Emission Reduction Fund (ERF)

Presentation of the project	The Emission Reduction Fund (ERF) awards Australian farmers carbon credits where net carbon storage has been demonstrated. The duration of the projects is 25 years and the average credit valuation for the 2019/2020 year is $16.35. The cost of the project to farmers appears to be significant.
Website :	https://www.industry.gov.au/funding-and-incentives/emissions-reduction-fund
Country	Australia
Type of agricultural production system	Farms that can demonstrate the application of the following cultural practices: - Pastures - Crops - Horticulture - Mixed farming systems
Types of practices implemented for carbon sequestration/protection	- Application of nutrients, lime or gypsum - Installation of new irrigation system - Re-establishment or rejuvenation of a pasture through seeding - Establishment or maintenance of pasture where none previously existed (cropland or bare fallow) - Change in grazing duration or intensity - Conservation of crop residues after harvesting - Conversion from intensive to no or low tillage - Changing landscape features to remediate soils - Use of mechanical means to add or redistribute soil across the soil profile
Costs incurred by farmers	At this stage, it is still difficult to determine the exact cost of this method for farmers. However, it should be noted that Australian farms are larger than French farms and therefore benefit from an effect of scale in the implementation of this carbon storage. The costs to be taken into account for a carbon recovery project are **Agricultural costs depend on the practices implemented by farmers:** - Purchase and application of fertiliser - The cost of installing and operating irrigation - Fencing to manage grazing - Time spent monitoring and recording measurements **Costs of sample collection and analysis :** - Technician for soil sampling: between 1500 and 2000$ per day plus travel costs. Estimated total cost: $5,000 - Laboratory analysis: between $40 and $100 per sample. Estimated minimum total price: $1,800 **Administrative costs :** - The preparation of reports can also be time-consuming and should be charged for or costed if staff are employed (at least one report every 5 years) **Audit costs :** - An auditor must be hired to perform a minimum of 3 audits over the 25 year period As these costs were considered a significant barrier, an advance of $5,000 is now available to fund the sampling costs.

The carbon market in Alberta	
Presentation of the project	Offset credits are credits generated by voluntary projects that increase removals or decrease reductions of GHG emissions. Each credit is equivalent to one tonne of CO_2 equivalent reduced or eliminated that would have existed in the absence of the project. These credits are validated using Alberta-approved methodologies and are verified by a third-party organization that performs standard validations, verifications and audits.
Website :	https://www.alberta.ca/alberta-emission-offset-system.aspx
Country	Canada
The farms involved:	Farms implementing practices such as: - Conservation agriculture - Biogas generation (anaerobic decomposition of agricultural materials) - Reducing greenhouse gas emissions from cattle - Microgeneration (decentralised production of renewable energy).
The remuneration received :	It is estimated that these emission credits generated a turnover of $170 million to farmers and aggregators. This remuneration depends on: - The fixed price of carbon to be paid to the TIER fund, as the sale price of offsets is generally lower than the fixed price of carbon, - The evolution of the sale price of offsets, - The division of income between farmer(s) and aggregator. Association with an aggregator is not mandatory for farmers, however, industry generally prefers to buy credits through a single contract rather than negotiate several small volume contracts. - The amount of carbon stored/avoided, which may be limited by the associated protocol. Generally the split of offset sales for this methodology is 1/3 to aggregators and 2/3 to farmers. This figure varies for the other protocols.
The number of tonnes of CO_2 that this project aims to store/avoid :	In Alberta, since 2002, approximately 13 million tonnes of CO_2e have been stored/avoided through practice changes (mostly through reduced tillage projects, biogas generation) generating carbon credits.

Soil Capital	
Presentation of the project:	The project was led by Soil Capital, an independent agronomy company made up of farmers whose primary objective is to support farmers in improving farm profitability and soil health. They launched a remuneration programme for farmers in France and Belgium in 2020: *Soil Capital Carbon*. This 5-year programme aims to market carbon certificates for stored or avoided emissions. Each year the net carbon gains will be estimated by Soil Capital and the credits are marketed by South Pole.
Website:	www.soilcapital.com
Country	France, Belgium
Key partners:	A network of external agronomists, who support the farmers' portfolios in the transition of their practices. South Pole provides technical and commercial expertise.
The farms involved:	The programme focuses on arable and mixed farms where livestock production does not account for more than 20% of GHG emissions.
The type of agricultural production system:	Mainly arable land
Types of practices implemented for carbon sequestration/protection:	Once the farmer has signed up to the programme, Soil Capital works with him or her to carry out a farm assessment using the Cool Farm Tool, which quantifies the GHG footprint of farms. Actions are then identified to improve the farm's profitability and GHG impact. The practices that will be applied will depend on the prognosis made on the farms, including minimum or no tillage, plant cover, rotation diversification, residue management, optimised or organic fertilisation.
The objectives of the project:	Carbon storage in agricultural soils and emission reduction
Maturity of the project:	Launched in 2020
Farmers' remuneration:	The selling prices of the carbon certificates are estimated at 27.5 euros/t of CO_2e and the quantity of credit generated could reach 2 t/ha/year. During the first 5 years of the programme, farmers will receive 80% of the emission reductions achieved. The remaining 20% will be paid after the 11th to 15th year if there are no unexpected CO_2e losses on the farms. If there are no unforeseen losses, the 20% will be used to compensate for the losses.
The number of tonnes of CO_2 that this project aims to store/avoid:	10,000 tonnes of CO2 in 2020/21. Soil Capital plans to store 750,000 tonnes of CO2 in 2024/25.
Costs incurred by farmers	- 980 euros (excl. VAT) per year to join the programme, i.e. 4,900 euros (excl. VAT) for the whole project. - Costs/gains of changing practice
Value of carbon sold	500,000 euros of carbon certificates

Svensk Kolinlagring	
Presentation of the project:	Svensk Kolinlagring is a platform that brings together scientists, farmers, food companies and other stakeholders with the objective of designing a system that enables and creates incentives to store carbon dioxide in Swedish agricultural soils. The innovation is led and managed by MiljöMatmetik Malmö AB (MMM), a company whose mission is to transform the food system and encourage the contribution of food as a solution for prosperous societies. This project has been underway since 2019 and the solutions developed are intended to be extended to new pilot farms in 2021. The long-term ambition is for the platform to become a new non-profit cooperative, owned by its members. Food companies (MAX Burgers, Oatly) are already financing carbon storage by farmers.
Website:	www.kolinlagring.se / www.miljomatematik.se
Country	Sweden
Key partners:	Lund University, Uppsala University, Stockholm University, Swedish University of Agricultural Sciences, Albaeco and the pilot farms.
The farms involved:	The 2020 pilot farms are mainly located in Skåne and Halland, but also in Uppland and Närke. 14 pilot farmers are involved in 2020 and the project is applied on 300 ha for the pilot year (2020). The number of hectares on which the project would be applied is expected to increase in the coming years.
The type of agricultural production system:	Mainly arable land, livestock systems, mixed systems and agroforestry.
Types of practices implemented for carbon sequestration/protection:	Grazing management, cover crops, agroforestry, no/less tillage. Later, other methods will also be applied.
The objectives of the project:	Soil carbon storage, soil carbon protection, and certification preparation.
Maturity of the project:	Farmers are paid for carbon conservation/storage in the soil.
Farmers' remuneration:	Currently, pilots receive 1000 sek/ha (95€/ha) and it is not based on stored CO_2/ha. Later it will be based on CO_2 per hectare.
The number of tonnes of CO2 that this project aims to store/avoid:	There is no set target for carbon storage.
Costs incurred by farmers	-
The source of funding for this project:	- The Lanshypotek Bank Research Foundation provided SEK 45,000 (~€4,500) for soil sampling. - MAX Burgers, Oatley and Grant Thornton financed 100 ha each with 1000 SEK/ha (~100 €) going directly to the farmer.

MoorFutures	
Presentation of the project:	Moorfutures was born in 2011 with the desire to have an instrument to finance rewetting measures for peatlands that capture GHGs and prevent CO_2e emissions. These 50-year projects are coordinated independently by 3 different Länder (Landgesellschaft Mecklenburg-Vorpommern, Landesforst Mecklenburg-Vorpommern). MoorFutures projects are implemented independently in different Länder. Each MoorFuture is registered at regional level by regional coordination institutions. Each MoorFuture generated is unique and corresponds to an emission reduction of one tonne of CO_2 equivalent. These carbon certificates are based on the Verified Carbon Standard (VCS) and the Kyoto Protocol and meet the requirements of the internationally recognised environmental standards ISO 14064 and 14065. They can therefore be purchased on the voluntary carbon market by companies and individuals wishing to voluntarily offset part of their greenhouse gas emissions. These credits are therefore neither transferable nor valid in mandatory markets.
Website:	https://www.moorfutures.de/
Country	Germany
Key partners:	The three German regions: Mecklenburg-Vorpommern, Brandenburg and Schleswig-Holstein
Types of practices implemented for carbon sequestration/protection:	Peatlands are among the most efficient carbon reservoirs in the world. For example, they store twice as much carbon as forests for the same area. If the peat is drained, this carbon reservoir becomes a source of greenhouse gases and produces GHGs as a result of oxidative reactions. MoorFutures are therefore generated by rewetting peatlands and are attached to specific projects. The quantification of the carbon credits generated is carried out by taking into account several carbon compartments such as the soil (in particular the fossil carbon accumulated in the peat), the above-ground and below-ground biomass, and possibly the dead wood and litter. The greenhouse gases taken into account are CO_2, CH_4 and N_2O. Discounts on the total sequestered emissions can be made to avoid overestimation.
The number of tonnes of CO2 that this project aims to store/avoid:	A total of 71,089 tonnes of CO_2e since the creation of Moorfutures.

MoorFutures: Current projects by region	
Mecklenburg-Vorpommern / Gelliner Bruch	The objective of this project was the rewetting and protection of 6.7 hectares of peatland. This project represents a reduction of 7,500 tonnes of CO_2e which, with the discounts established by the MoorFutures methodology, allowed for the production of 5,300 certificates at a price of 40 euros each. On 14 January 2020, all the MoorFutures of the Gelliner quarry were sold.
Brandenburg / Rehwiese	The aim of this project is to eliminate excessive soil drainage created by a ditch. The rewetting of the peat bogs is achieved by overflowing this watercourse in the 9.7 hectare Rehwiese area. According to the MoorFutures methodology, this would produce a total of 6744 tonnes of MoorFutures generated over 50 years. These carbon credits are sold at a price of 80 euros (including 12.77 euros VAT).
Schleswig-Holstein / Königsmoor	The project covers an area of 68 hectares on the Königsmoor. It is part of a peat bog with a total area of about 1,200 ha. The aim of the project was to close all the ditches and drains in the area and to build flat peat walls to retain and store winter rainfall. It is estimated that the project will generate 39,520 tonnes of CO_2e over 50 years, which will be sold at a price of €70 per tonne (including €10.22 VAT).

8. Bibliography:

Gabriella CEVALLOS, Valentin BELLASSEN, Julia GRIMAULT, Domestic carbon standards in Europe, 2019: https://www.i4ce.org/download/domestic-carbon-standards-in-europe/.

Wreford, A., A.Ignaciuk and G. Gruère (2017-04-27) overcoming barriers to the adoption of climate friendly practices in agriculture, OECD Food, Agriculture and Fisheries Papers, No. 101, OECD Publishing, Paris. http://dx.doi.org/10.1787/97767de8-en.

Dessart et al, Behavioural factors affecting the adoption of sustainable farming practices: a policy-oriented review, 2019: https://academic.oup.com/erae/article/46/3/417/5499186.

Godefroy Grosjean, Sabine Fuss, Nicolas Koch, Benjamin L. Bodirsky, Stéphane De Cara & William Acworth (2018) Options to overcome the barriers to pricing European agricultural emissions, Climate Policy, 18:2, 151-169, DOI: 10.1080/14693062.2016.1258630.

Bamière, Laure (a); Camuel, Alexandre (b); De Cara, Stéphane (a); Delame, Nathalie (a); Dequiedt, Benjamin (a); Lapierre, Aline (c); Lévêque, Benjamin (b). 2017. Analysis of barriers and measures for the deployment of negative cost mitigation actions in the agricultural sector: coupling economic modelling and field surveys.

Bamière, Laure; Pellerin, Sylvain et al,. What contribution can French agriculture make to reducing greenhouse gas emissions? Mitigation potential and cost of ten technical actions. Summary of the report of the study conducted by INRA on behalf of ADEME, MAAF and MEDDE - July 2013.

ADEME (2016). Changing behaviours, shifting social practices towards more sustainability - The contribution of human and social sciences to understanding and acting.

Jaffe A. (2016) Barriers to Adoption of No-cost Options for Mitigation of Agricultural Emissions: A Typology, Motu Note #24.

Lucas A. (2004) The Psychology of Changing Farmer's Behaviours, Scotland's Rural College.

Presley L. (2014) Understanding barriers to agricultural conservation practice adoption Master's Candidate Agriculture and Integrated Resource Management, Colorado State University.

Rodriguez, J. M., Molnar, J. J., Fazio, R. A., Sydnor, E., & Lowe, M. J. (2009). Barriers to adoption of sustainable agriculture practices: Change agent perspectives. Renewable Agriculture and Food Systems, 24(1), 60-71.

Vanclay, F. (1992). Barriers to adoption: a general overview of the issues. Rural Society, 2(2), 10-12.

Wreford, A., A. Ignaciuk and G. Gruère (2017), "Overcoming barriers to the adoption of climate-friendly practices in agriculture", OECD Food, Agriculture and Fisheries Papers, No. 101, OECD Publishing, Paris: https://www.oecd-ilibrary.org/agriculture-and-food/overcoming-barriers-to-the-adoption-of-climate-friendly-practices-in-agriculture_97767de8-en.

François J Dessart, Jesús Barreiro-Hurlé, René van Bavel , Behavioural factors affecting the adoption of sustainable farming practices: a policy-oriented review , European Review of Agricultural Economics, Volume 46, Issue 3, July 2019, Pages 417-471,: https://doi.org/10.1093/erae/jbz019.

Yogo et al, Analysis of soil carbon assessment and monitoring methodologies and recommendations for the writing of a large-scale farming method in the framework of the Low-Carbon label, 2021.

Natais:

Paul Grousset, Améliorer le stockage de carbone dans les sols agicoles en itinéraire maïs popcorn, September 2020

Australia ERF:

Department of Industry, Energy Science and Resources:

- Presentation of ERFs
- Methods that can be used to obtain ERFs
- Measuring carbon sequestration in agricultural soils

Climate change Authority:

- Climate Change Authority, Review of the Emissions reduction fund, October 2020,

Clean energy regulator, Soil carbon projects:

- Presentation of the elements required to apply to soil carbon storage projects
- Climate Solutions Fund, Understanding your soil carbon project, July 2020
- Advance of $5,000 to finance sampling costs

Federal register of legislation:

- CarbonCredits(CarbonFarmingInitiative-MeasurementofSoilCarbonSequestrationin AgriculturalSystems)MethodologyDetermination2018
- Supplement to the Carbon Credits (Carbon Farming Initiative-Measurement of Soil Carbon Sequestration in Agricultural Systems) Methodology Determination 2018

Carbon neutral:

- Carbon neutral, 2020 review of the ERF consultation paper

Alberta:

- Tier conventional Oil and Gas: Technology innovation and Emission Reduction Regulation,Alberta Environment and Parks, November 2019
- 2019 Compliance Workshop Session 2: Alberta Emission Offsets, Alberta Environment and Parks, February 19, 2020
- Carbon offset emission factors handbook. Version 2.0, November 1, 2019
- Carbon market business brief, IETA, June 2020

- Protocols:
  - Quantification protocol for conservation cropping. Version 1.0
  - Quantification protocol for reducing greenhouse gas emissions from fed cattle : version 3.0
  - Energy generation from the combustion of biomass waste. Version 2.2
  - Agricultural carbon offsets - Micro-Generation Protocol

FCAA:

- CARBON AGRI: Methodology for assessing greenhouse gas emission reductions from livestock production : CARBON AGRI: Methodology for assessing greenhouse gas emission reductions from livestock production

- Bonvillain, foucherot & Bellasen, Will *the obligation of environmental results green the CAP?* I4CE, 2020 : Bonvillain,foucherot& Bellasen, Will*the obligation of environmental results green the CAP?*I4CE, 2020.
- Webinar Low Carbon Label I Presentation of the CARBON AGRI method : Webinar Low Carbon Label I Presentation of the CARBON AGRI method

MoorFutures:

- Federal Agency for Nature Conservation, Integration of additional ecosystem services (including biodiversity) into carbon credits - standard, methodology and transferability to other regions, 2015: https://www.bfn.de/fileadmin/BfN/service/Dokumente/skripten/Skript407.pdf
- Moorfutures flyer: https://www.moorfutures.de/app/download/32603826/MoorFutures_Flyer.pdf
- Moorfutures website: https://www.moorfutures.de/
- Gelliner project profile: https://www.moorfutures.de/app/download/32603660/MoorFutures-Projekt_Gelliner-Bruch_Kurzinfo-ANE_web.pdf
- Gelliner project: https://www.moorfutures.de/app/download/11848432/Moorfutures_Gelliner-Bruch_Projektdokument.pdf
- Rehwiese project profile: https://www.moorfutures.de/app/download/31771614/MoorFutures_Rehwiese_Steckbrief.pdf
- Validation of the Rehwiese project: https://www.moorfutures.de/app/download/31771617/MoorFutures_Rehwiese_Validierung_HNEE.pdf
- Profile of the MoorFutures project "Königsmoor" (Schleswig-Holstein): https://www.moorfutures.de/app/download/31771647/Steckbrief-Koenigsmoor_+2017.pdf
- Project Document (PDD) "Königsmoor" (Schleswig-Holstein):
- https://www.moorfutures.de/app/download/31771646/Moorfutures_Koenigsmoor_Projektdokument.pdf

Webography:

- https://cichprofile.ca/module/8/section/6/page/greenhouse-gas-emissions-by-province-and-territory-canada-1990-2005-and-2015/
- https://www.alberta.ca/agricultural-carbon-offsets-overview.aspx
- https://www.alberta.ca/alberta-emission-offset-system.aspx
- https://www.csaregistries.ca/albertacarbonregistries/eor_about.cfm
- https://www.alberta.ca/alberta-emission-offset-system.aspx#toc-2
- https://www.alberta.ca/agricultural-carbon-offsets-conservation-cropping-protocol.aspx
- https://www.youtube.com/watch?v=xduT0rbxVEQ
- https://www.lemonde.fr/festival/article/2017/08/14/l-incroyable-histoire-de-l-arnaque-au-carbone-le-resume-des-cinq-episodes_5172257_4415198.html

TERRITORIAL DEMONSTRATORS OF CARBON STORAGE IN SOIL - DELIVERABLE 2

Many business models are emerging or are already well established. Some projects finance the adoption of stocking practices themselves in order to contribute to the fight against climate change and improve the quality of agricultural soils. Others join forces with aggregators (associations, companies, cooperatives) which not only allow them to benefit from economies of scale (administrative costs, monitoring, verification) but also to facilitate access to the carbon credit system for farmers. Some platforms serve as carbon credit marketplaces to facilitate the sale and purchase of credits.

Whatever business model is adopted, it is essential that farmers are rewarded for the risks and investments they make (both tangible and intangible). Today, it is difficult to obtain information on the costs and benefits for the farmer. One challenge is to increase the transparency of the arrangements for the distribution of value.

Assessing the amount of carbon stored is an important part of the cost of these projects. A balance must be struck between cost and accuracy.

Centre Headquarters
147 rue de l'université
75007 Paris

Tel: +33 (0)1 42 75 90 00

Join us on :

https://www.inrae.fr/centres/centre-siege

RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

INRAE