



Case Study – France

Sustainable Agriculture and Soil Conservation (SoCo Project)

Philippe Pointereau, Sylvain Doublet, Frédéric Coulo, Marion Houtin, Maxime Moncamp,
Paolo Prosperi, Jean Michel Terres



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Preface

Agriculture occupies a substantial proportion of European land, and consequently plays an important role in maintaining natural resources and cultural landscapes, a precondition for other human activities in rural areas. Unsustainable farming practices and land use, including mismanaged intensification and land abandonment, have an adverse impact on natural resources. Having recognised the environmental challenges of agricultural land use, in 2007 the European Parliament requested the European Commission to carry out a pilot project on 'Sustainable Agriculture and Soil Conservation through simplified cultivation techniques' (SoCo). The project originated from close cooperation between the Directorate-General for Agriculture and Rural Development (DG AGRI) and the Joint Research Centre (JRC). The JRC's Institute for Prospective Technological Studies (IPTS) coordinated the study and implemented it in collaboration with the Institute for Environment and Sustainability (IES). The overall **objectives of the SoCo project** are:

- (i) to improve the understanding of soil conservation practices in agriculture and their links with other environmental objectives;
- (ii) to analyse how farmers can be encouraged, through appropriate policy measures, to adopt soil conservation practices; and
- (iii) to make this information available to relevant stakeholders and policy makers EU-wide.

In order to reach a sufficiently detailed level of analysis and to respond to the diversity of European regions, a case study approach was applied. Ten case studies were carried out in Belgium, Bulgaria, the Czech Republic, Denmark, France, Germany, Greece, Italy, Spain and the United Kingdom between spring and summer 2008. The case studies cover:

- a screening of farming practices that address soil conservation processes (soil erosion, soil compaction, loss of soil organic matter, contamination, etc.); the extent of their application under the local agricultural and environmental conditions; their potential effect on soil conservation; and their economic aspects (in the context of overall farm management);
- an in-depth analysis of the design and implementation of agri-environmental measures under the rural development policy and other relevant policy measures or instruments for soil conservation;
- examination of the link with other related environmental objectives (quality of water, biodiversity and air, climate change adaptation and mitigation, etc.).



The results of the case studies were elaborated and fine-tuned through discussions at five stakeholder workshops (June to September 2008), which aimed to interrogate the case study findings in a broader geographical context. While the results of case studies are rooted in the specificities of a given locality, the combined approach allowed a series of broader conclusions to be drawn. The selection of case study areas was designed to capture differences in soil degradation processes, soil types, climatic conditions, farm structures and farming practices, institutional settings and policy priorities. A harmonised methodological approach was pursued in order to gather insights from a range of contrasting conditions over a geographically diverse area. The case studies were carried out by local experts to reflect the specificities of the selected case studies.

This Technical Note is part of a series of ten Technical Notes referring to the single case studies of the SoCo project. A summary of the findings of all ten case studies and the final conclusions of the SoCo project can be found in the **Final report on the project 'Sustainable Agriculture and Soil Conservation (SoCo)'**, a JRC Scientific and Technical Report (EUR 23820 EN – 2009). More information on the overall SoCo project can be found under <http://soco.jrc.ec.europa.eu>.

BE - Belgium	West-Vlaanderen (Flanders)
BG - Bulgaria	Belozem (Rakovski)
CZ - Czech Republic	Svratka river basin (South Moravia and Vysočina Highlands)
DE - Germany	Uckermark (Brandenburg)
DK - Denmark	Bjerringbro and Hvorslev (Viborg and Favrskov)
ES - Spain	Guadalentín basin (Murcia)
FR - France	Midi-Pyrénées
GR - Greece	Rodópi (Anatoliki Makedonia, Thraki)
IT - Italy	Marche
UK - United Kingdom	Axe and Parrett catchments (Somerset, Devon)



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Acronyms

AEM	Agro-Environmental measure
AUP	Agence Unique de Paiement
CAP	Common Agricultural Policy
CIPAN	Cultures Pièges à Nitrate
CLC	Corine Land Cover
CT	Conventional Tillage
DS	Direct Sowing (or No-Tillage)
FSS	Farm Structure Survey
GAEC	Good Agricultural and Environmental Conditions
IACS	Integrated Administration and Control System
ICCS	Indemnité Compensatoire de Couverture des Sol
IGN	National Geographic Institute
IOBC	International Organisation of Biological Control
LFA	Less Favoured Areas
MAET	Mesures agro-environnementales territorialisées
MS	Member State
NT	No-Tillage
PDRH	Plan de Développement Rural Hexagonal
PDRN	Plan de Développement Rural National
PHAE	Prime Herbagère Agro-Environnementale



RDP	Rural Development Plan
RT	Reduced Tillage
SCEES	Service Central des Etudes Economiques et Statistiques
SD	Surfaces de biodiversité
SMR	Statutory Management Requirements
SPS	Single Payment Scheme
UAA	Utilised Agricultural Area
UF	Unfarmed Feature
WF	Water Framework Directive
ZAC	Zone d'Action Concertée
ZES	Zone d'Excédent Structurel



Executive Summary

The French case study is an integral part of the Project on Sustainable Agriculture and Soil Conservation (SoCo), which aims at understanding how farmers can be encouraged to adopt soil conservation practices through European and national agricultural and environmental policies.

This case study analysed the application of soil conservation issues and practices in France, their effect on the natural environment and their economics. The role policies, regulations and other driving forces play in this context were also investigated by looking at a variety of physical, institutional, socio-economic and historical factors.

Policy recommendations of relevance to the European level were elaborated.

This study is based on: 1) inquiries of the main stakeholders and experts involved in soil conservation, including farmers implementing soil friendly techniques; and 2) literature review and the use of relevant data bases (GIS-SOL from INRA, Agricultural Practices Survey 2001 and 2006, FSS).

Inquiries have been carried out in selected, 'hot spots' regions, mostly in the region Midi-Pyrénées, but also in the departments of Seine Maritime and Pas-de-Calais.

The main soil degradation in France is erosion: 12 % of the UAA (5.6 million hectare) is under high or very high risk of erosion (MESALES model, GIS SOL) and 17,000 muddy flows events were registered during the period 1985-2001.

The main land use with high erosion risk relates to spring crops (potatoes, sugar beet, maize, sunflower) and to vineyards. The areas at risk are either located in the northwest France (Nord Pas de Calais, Picardie, Seine Maritime with loamy soils) or in the southwest of France and Mediterranean areas (steep slopes with intense spring rainfall).

A decrease of the carbon stock in agricultural soils was also observed between 1990-1995 and 1999-2004 with a loss of about 6 million tons of carbon per year. Over the same period, the increase in storage in forest soils, caused by the increase of woodlands, was about 0.7 million tons of carbon per year. Soils in France have therefore lost 53 million tons of carbon in ten years, or 1.7 % of their estimated stock.

Land use change follows an historical trend with a negative impact on soil erosion and decline of soil organic matter. The period 1970 to 1990 had seen an important decrease of grassland surfaces (-5 million hectare) balanced by an increase of field crops (maize in particular, thanks to the development of silage techniques and irrigation; sunflower), leading to an increased erosion risk. However, this tendency started to revert since 1990 due the low price for protein crops and the 2003 drought.

An increase in specialisation of farming systems, along with a decrease of mixed farms, as well as grazing farms, was also observed. Mixed farm systems with temporary grasslands or annual forage were very efficient to ensure soil cover by implementing grassland just after harvesting cereal. Indeed the trend towards more specialisation, translates geographically with the dominance of arable crops system in the north-western France, in the Bassin-Parisien, in Poitou-Charentes, in the Garonne valley and Alsace. Consequently, crop diversity and crop rotation are low, both at farm but also at local scale.

The changes in agricultural practices with deeper tillage and liming show also negative effects on soil erosion and decline of soil organic matter.

Some techniques implemented recently have shown a positive impact on soil erosion. Grass strips along watercourses are potentially useful to prevent erosion. The measure started as an agri-environment scheme. In 2005 it became part of the GAECs, while it was already a measure of Actions Programmes implementing the Nitrate Directive (will become mandatory



in the 4th Action Programme). Grass strips were linked to the set-aside obligation as put in place in 2003. Its efficiency is higher when implanted in talwegs so that infiltration is increased and run-off is reduced, therefore the results in term of erosion reduction depend largely on where strips are implanted within the catchment. Landscape features management such as hedgerow plantation or limiting the plot size, are also efficient towards erosion reduction, although not really used.

All stakeholders encountered agreed that solutions to erosion must be applied at source to be effective, by increasing the infiltration capacity of soils. Moreover, some technical solutions to reduce erosion problems are already known, and they are even simple to implement (decrease of parcel size, inclusion of grass strips, etc.). Other measures can simply rely on a better communication/coordination between farmers within the same watershed (e.g. rotation: farmers can agree among themselves that the same culture is not replanted the same year in order to reduce runoff). Whatever the solutions, their establishment requires a good knowledge of the local soil and climate conditions (solutions for clay-rich soil and steep slopes, which in Midi-Pyrénées are subject to spring storms, are not necessarily transferable to the loamy soils and gentle slopes of northern France).

Conservation Agriculture (CA) techniques (cover crops, reduced tillage, no-tillage, crop rotations) are a way of reducing land degradation (erosion, organic matter decline) through the improvement of the stability of soil surface structure, restoration of a vertical and connected soil porosity and improvement of soil biodiversity. The soil can then keep its rainfall infiltration capacity and therefore erosion problems are reduced at the origin. In 2006, these techniques represented 34 % of the main arable crops in France altogether (particularly winter crops). However, only 24 % of these surfaces have not been ploughed since 2001 and 1 % only is managed under no-tillage (direct sowing). The main driver for adopting such a set of techniques is mainly economic (reduction of input costs like oil and machinery, saving labour time for soil preparation).

Farmer's survey in Midi-Pyrénées shows that there are many possible forms of CA techniques (and of farming practices), depending on the type of soil tillage used (from reduced tillage to no-tillage), crop rotation implemented and the percentage of soil coverage (30 % to 100 %). All these forms have a positive effect on soil protection. The main disadvantage is the increase in the use of herbicides (+10 %) to control weeds.

Mastering Conservation Agriculture techniques requires several years of field trials and experiments for the farmer. The larger diffusion of these techniques requires their adaptation to local conditions (type of soil, climate, and social conditions). The lack of local references is, at the present time, the main weak point: Without training, implementation of conservation agriculture can severely disrupt farms economy balance. Therefore, there is a need to establish networks of demonstrational farms at the district level (NUTS 4-5) and acquire and build knowledge and expertise (with the participation of agricultural research and technical institutes).

The most advanced forms of CA techniques (no-tillage + long and diversified rotations + soil coverage) allow for a rapid restoration and preservation of soil fertility. In addition, these techniques can also address other agro-ecological issues (water quality, GHG emission, biodiversity) and develop solutions for weed control, without a systematic use of herbicides (crop rotation, mechanical control). Theoretically, these techniques can be adapted to all soil and climate conditions.

There is no specific national policy on soil erosion and conservation agriculture. These themes are addressed indirectly by measures (mainly soil cover and buffer zones) within agricultural and environmental policies, or developed spontaneously by farmers as reduced tillage practices mainly for economical reasons but without relevant support from a specific policy. Reduced or no-tillage were supported in the last French rural development programme on 155,000 ha, representing only 4 % of the total surface under reduced tillage



practices. Those techniques are not supported anymore in the current rural development programme.

The French agri-environment policy focuses mainly (i) on water quality (Nitrate and Water Framework Directives), and (ii) on biodiversity (Habitat and Bird Directives). There is no specific regulation on soil conservation. The current French rural development plan targets these 2 objectives. This is also consistent with requirements linked to cross compliance (Statutory Management Requirements and French Good Agricultural and Environmental Conditions mostly target water quality).

Considering that 65 % of the high and very high erosion risk areas are located in vulnerable zones, the Nitrate Directive can also partially address erosion issues through the implementation of cover crops, a better protection of permanent grasslands and unfarmed landscape features. These objectives have been reinforced during the successive Action Programmes and it is proposed that they become compulsory in the Fourth Programme 2009-2012. These measures were also put forth under the agro-environmental measures inside vulnerable zones (at a time when they were not compulsory).

Water quality and the protection of the drinking water catchments are currently priorities in France (Decree n°2007-882 of 14 May 2007, Water regulation). This decree identifies 'zones under environmental constraints' where specific compulsory measures must be implemented. The decree also targets zones at risk of erosion and wetlands, but only the priority 500 drinking water catchments defined in the 'Grenelle de l'environnement' are concerned at the present time.

The decreasing of public budget and of administration staff will not favour the protection of soil as a 'new' environmental objective if not provided for by a specific Directive.

A first step in designing a soil protection policy should include raising awareness at the national level on the importance of soil degradation phenomena. A comprehensive study of the costs incurred in by erosion events (related to agriculture) would show the importance of addressing the problem upstream and then calculate the gains for society. The agreement on a Soil Framework Directive would raise awareness as well.

In a second step, such a policy, promoted at the departmental level, should be translated into concrete action at the farmers' level (information and training). This would require both the global vision of an agricultural district (at NUTS 4) and a parcel approach (the advisors/technicians must work hand in hand with the farmers). At this step, it would be crucial to have a programme at a coherent scale (e.g. the catchment management structures in Seine-Maritime department), a system of monitoring at local data (e.g. working groups and networks of demonstrational farms implemented in Midi-Pyrénées to show the application of simplified cultivation techniques and conservation agriculture) and a definition of sensitive areas at plot scale (mapping tools adapted).



1 Methodology

In the framework of the SoCo project, the present report is the result of a thorough study of soil conservation issues in agriculture based on two central concepts: the **agri-environment** and the **policy** frameworks.

The agri-environment framework requires that the following themes are considered:

- **Soil** conditions, degradation types and ecological context;
- Related **farming practices** (and trends) that cause or prevent soil erosion;
- **Actors** involved in farming practices and conservation measures implementation (farmers, advisers, administration);
- **Potential farming practices** to reduce degradation;
- **Evaluation** of costs, benefits, effectiveness of farming practices and conservation measures.

The policy framework provides that the following components are studied:

- the **main stakeholders** involved directly or indirectly in soil conservation issues;
- the identification of the **existing policies, institutions and governance structures**;
- the **efficiency** of the current institutions and governance structures;
- the **alternative policies, institutions and governance** (innovation in policies, institutions and governance structures);
- the **recommendations** for the implementation of potentially beneficial alternatives.

Four tasks have been defined to analyse these two main concepts:

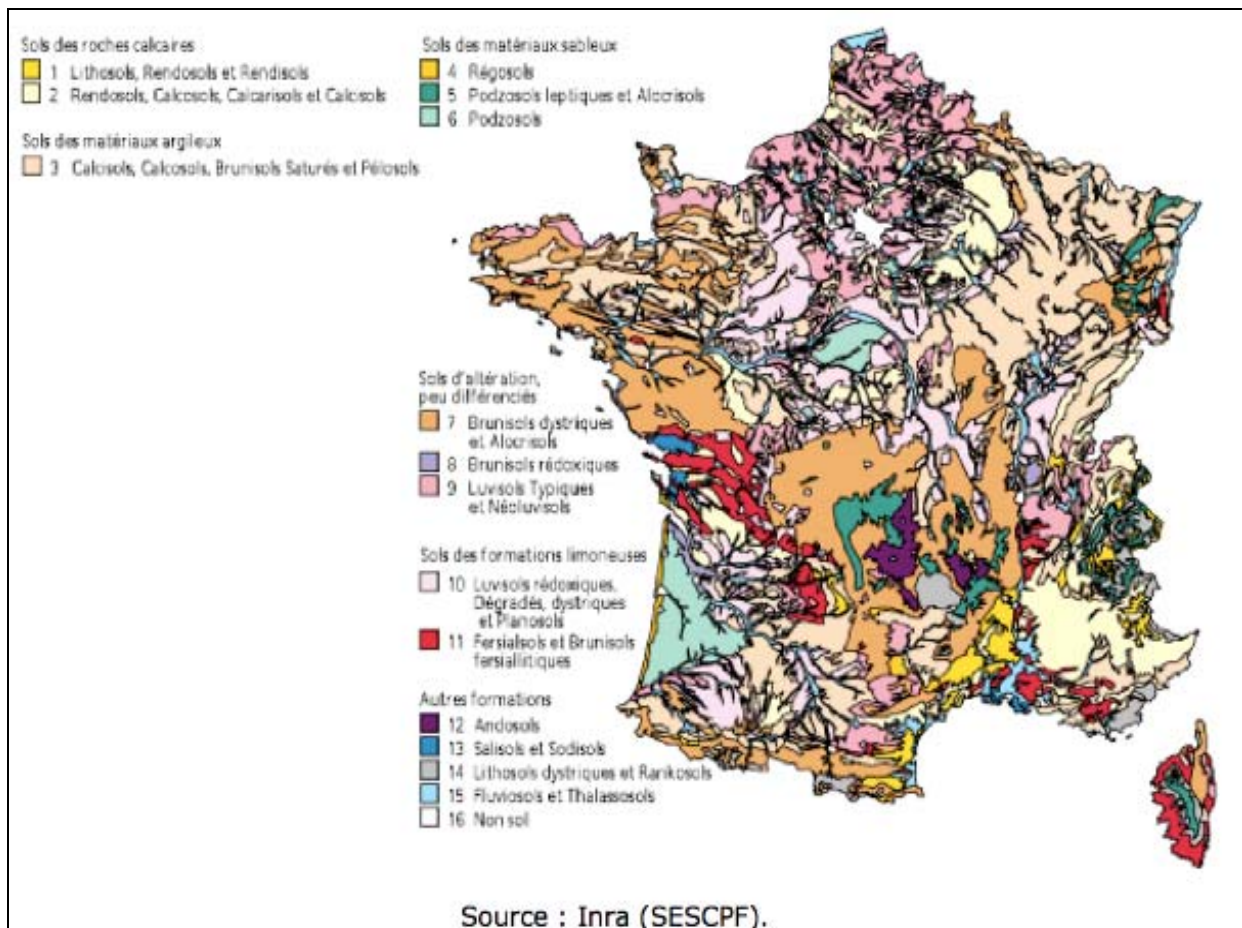
- Task 1: Identification of soil erosion problems related to agriculture,
- Task 2: Inventorying of farming practices related to soil erosion currently applied,
- Task 3: Inventorying of measures to prevent soil erosion and related practices within the policy context and analysis of stakeholders' perspective,
- Task 4: Assessment of implementing soil conservation practices and identification of drivers to implement them.

2 The status of soils in France

2.1 Soil types

Located in Western Europe, with a surface of 550,000 km², France has a wide range of landscapes, climatic conditions, **soils** and land uses (see map below).

Map 2.1: Simplified map of soils in France



Source: Thorette, 1998

Soils in France can be classified into **five major types**, corresponding to the geological structure of the territory. These 5 types are described in the table below.



Table 2.1: Description of the five types of soils in France: distribution, acidification and physical degradation sensibility

Soil type	Localisation	Region concerned	Area (% of national area)	Acidification sensibility	Physical degradation sensibility
Loamy soils	Parisian basin; Aquitaine; Rhodanian basin-	Ile-de-France; Aquitaine; Haute Normandie; Basse-Normandie; Midi-Pyrénées	15 %	Medium	High
calcareous soils	Champagne-Ardenne; Jura; Poitou-Charentes; Provence	Champagne-Ardenne; Poitou-Charentes; Provence-Alpes-Côte d'Azur	14 %	Low	Low
Sandy soil	Sologne, Landes; Vosges; Massif Centrale; Alpes	Centre; Aquitaine; Lorraine; Auvergne; Provence-Alpes-Côte d'Azur	6 %	High	Medium
Clay soil	Sedimentary areas	Midi-Pyrénées; Champagne-Ardenne; Franche-Comté; Bretagne; Basse-Normandie; Lorraine	24 %	Low	Low-Medium
Low altered soils	Old mountains: Vosges; Bretagne; Massif Central	Lorraine; Alsace; Bretagne; Auvergne; Midi-Pyrénées	29 %	Medium	Medium
Others	Volcanic soils; salted soil	Auvergne; Languedoc-Roussillon	12 %	-	-

Source: Thorette, 1998

2.2 Identification of the extent of soil degradation

The draft European Soil Framework Directive lists eight major soil degradation problems. According to Arrouays, one of the experts consulted for the survey, these have the following degree of relevance in France:

- **Salinisation** is not a significant issue in France.
- **Acidification** does not relate to agriculture as it occurs primarily on forest soils and in the Overseas Territories.
- **Desertification is closely** linked to erosion in Mediterranean areas.
- **Soil biodiversity** (the data are being acquired: micro-organisms in soil, functional genes and their determinants).
- **Soil contamination:** the available data only concern metallic trace elements (MTE). The diffuse contamination by MTE focuses on major urban centres and industrial areas. Agriculture is concerned at the margin of these areas with the exception of contamination by copper and zinc in the wine territories and in Brittany (concentration of pig farms).
- **Soil compaction** (research program underway: N₂O emissions, leaching, erosion, groundwater recharge, crop yields).



- **Decline of soil organic matter is a relevant issues directly linked with farming practices or changes in land use.**
- **Erosion and muddy flows remain the main problems related to agricultural activities and their analysis is the most advanced in terms of assessment and cartography.**

2.3 Soil organic carbon

Soil organic carbon is mainly contained in the organic matter that presents a number of environmental functions. In particular, it provides a temporary carbon 'pool' acting either as a source or a sink for organic carbon from the atmosphere in the form of CO₂. Changes in land use or in agricultural practices affect the stocks of both organic matter and organic carbon in soils. As the CO₂ is one of the most powerful climate change gasses, the loss of organic carbon to the atmosphere is therefore of extreme interest nowadays and should be avoided.

The stock of soil organic carbon depends on soil types and their type of use. In temperate zones, values range on average between **40 t/ha** in **cultivated land**, **65 t/ha** in **grassland** and **70 t/ha** under forest in the **first 30 cm of the soil**. Values measured in the soil between 0 and 30 cm from 1970 to 2000 in France were combined with land use data and homogeneous areas were defined. Stocks of soil organic carbon are **very low**, in the range of 15 to 40 t/ha in the soils of the major **vineyard** areas: valleys of the Saone and the Rhone, Bordeaux, Languedoc-Roussillon. They are **small**, 40 to 50 t/ha in **intensive cultivation areas**: North, its Paris-Basin, **and South-West**. Stocks of soil organic carbon are **high**, with more than 70 t/ha in **mountain** areas: Ardennes, Jura, Pyrenees, Alps and Massif Central. The same is true in forested areas or wooded (hedgerows) areas: Lorraine, Brittany. Extreme values reach 350 t/ha of peat soils.

The stock of soil organic carbon measured in forests, pastures and grasslands are still higher than in crops cultivated on the same type of soil. Weaker stocks mainly observed shallow soil or sandy soils. Stocks are higher in soils derived from volcanic materials or humus soil in mountain areas. The **low temperatures and humidity** are important factors against the degradation of organic matter and therefore against the release of organic carbon. Similarly, the rate of decomposition decreases when the **soil is poorly drained and suffers from anaerobic conditions**.

The soil crusting and diffuse erosion are caused by soil unstable structure on which heavy rain (over 30 or 40 mm/hour, Robert, 1996) causes the breakdown of soil aggregates (see figure below). The particles and aggregates come loose fill the interstices of the structure and form a surface crust, known as capping (or crusting). The water cannot pass through this crust. Runoff leads to diffuse erosion that can turn into localised concentrated erosion paths: lines of maximum gradient, ploughing rows, seeding or wheel paths of machinery, and lead to the formation of gullies and ravines.

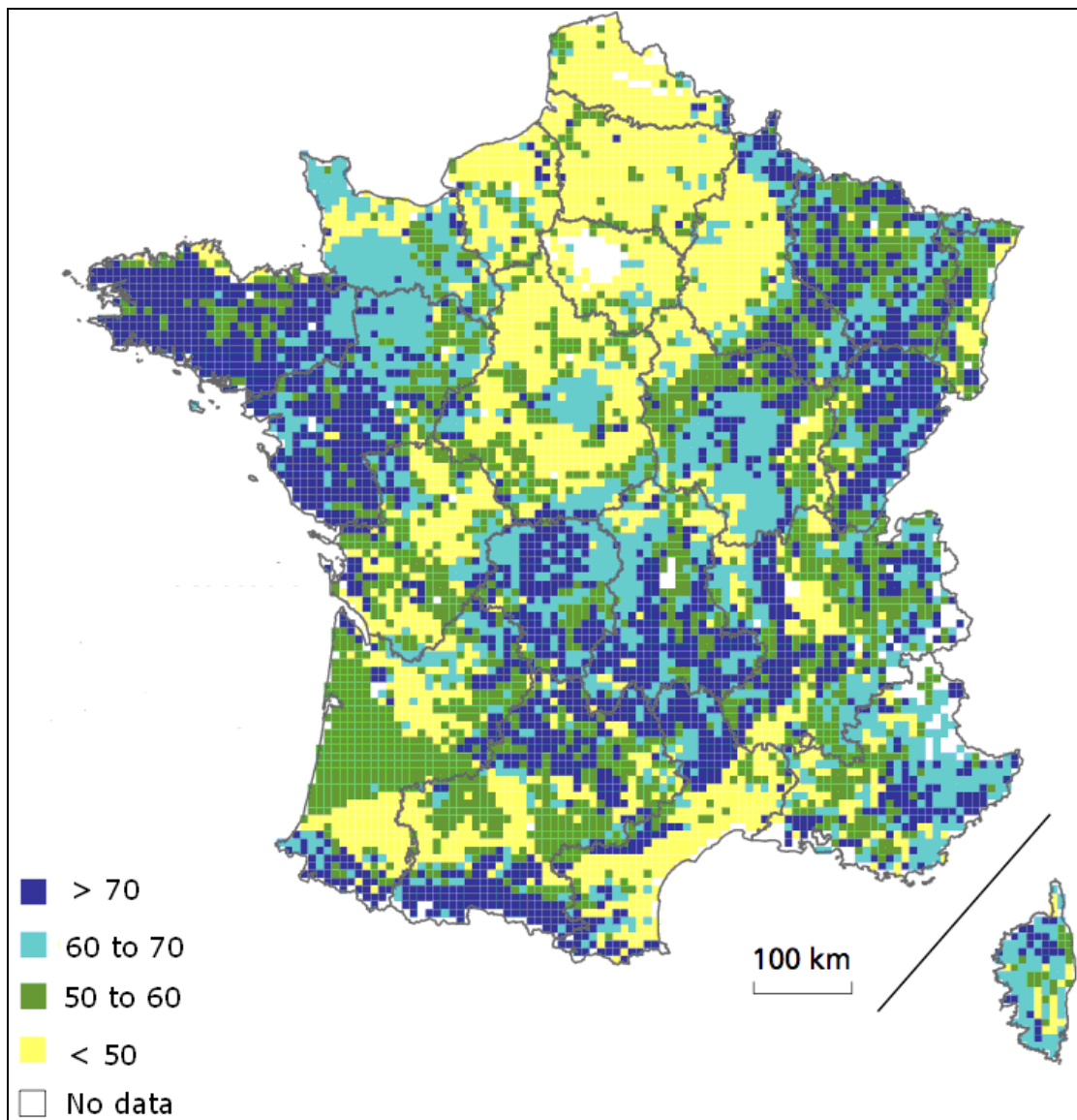
The main characteristics that influence soil structural stability are:

- first, the texture of the soil (**loamy texture** are at risk of erosion broadcasts if it contains less than 15 % clay, Robert, 1996), and
- second, the decrease of organic matter at levels below 2 or 3 % (Le Bissonais and Arrouays, 1997), which causes a decrease in aggregate stability to water.

Soil physical degradation by crusting and erosion is an increasing problem in France.



Map 2.2: Estimation of the stock in organic carbon in the top soil (0-30 cm) (in t/ha)

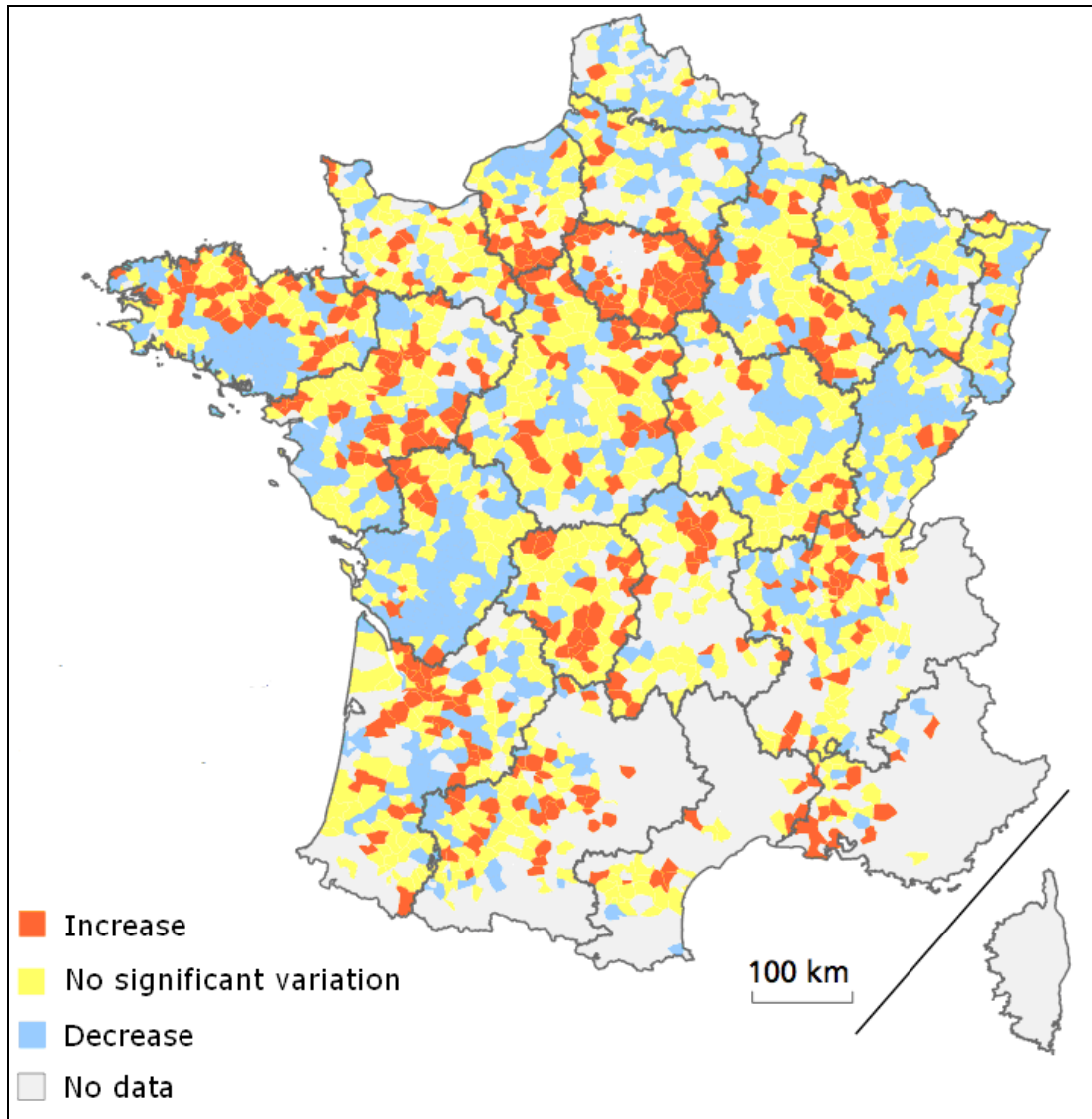


Source: INRA, 2001 (Antoni and Arrouays, 2007)

A decrease of stock of organic carbon in agricultural soils between 1990-1995 and 1999-2004 has been observed. The loss of about **6 million tons of carbon (around 0.2 per cent) per year** mainly affects the superficial layers. Meanwhile, over the same period, storage in forest soils caused by the increase in wooded areas is about **0.7 million tons of carbon per year**. **Soils of France have therefore lost 53 million tons of carbon in ten years equivalent to 1.7 % of their estimated stock.**



Map 2.3: Variation of the stock in organic carbon in the top soil (0-30 cm) 1990-1995 and 1999-2004 at NUTS 4 level

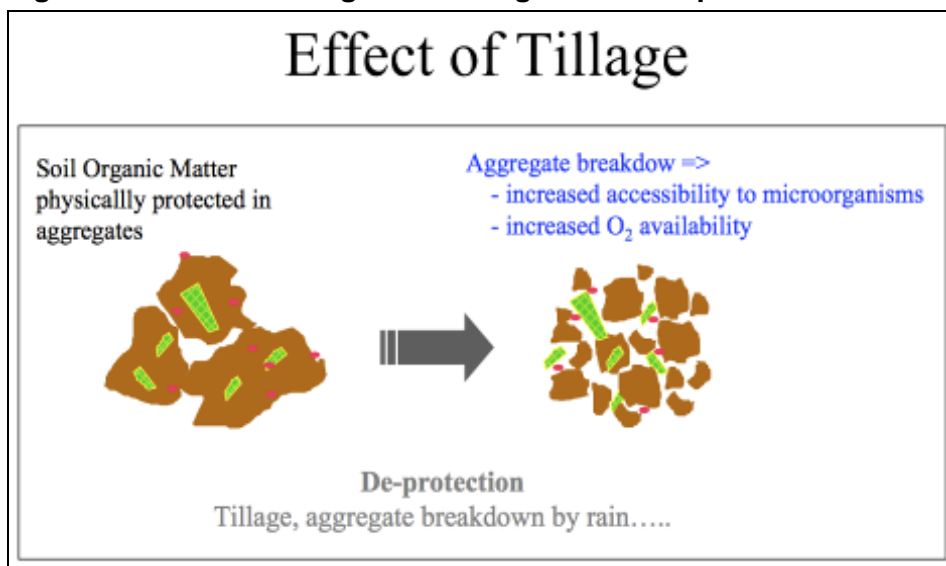


Source: Gis Sol, DBAT, 2007 (Antoni and Arrouays, 2007)

More in detail, the organic carbon content decreased along the Atlantic coast (Brittany, Poitou-Charentes), between the two periods (1990-1995 and 1999-2004). In Britain, the organic carbon content decreased mainly in the southern districts, where the initial levels were high. Several explanations can be advanced for that: an overall ecosystem transformation of **grasslands to crops** and changes in agricultural practices with **deeper tillage (see figure below) and liming**. The levels also decreased in North and East. The decrease observed in Lorraine may be associated again with the **conversion of natural grassland into arable land**. The levels have instead increased in some cantons and mainly in the periphery of the Ile-de-France.



Figure 2.1: Effect of tillage on soil organic matter protection



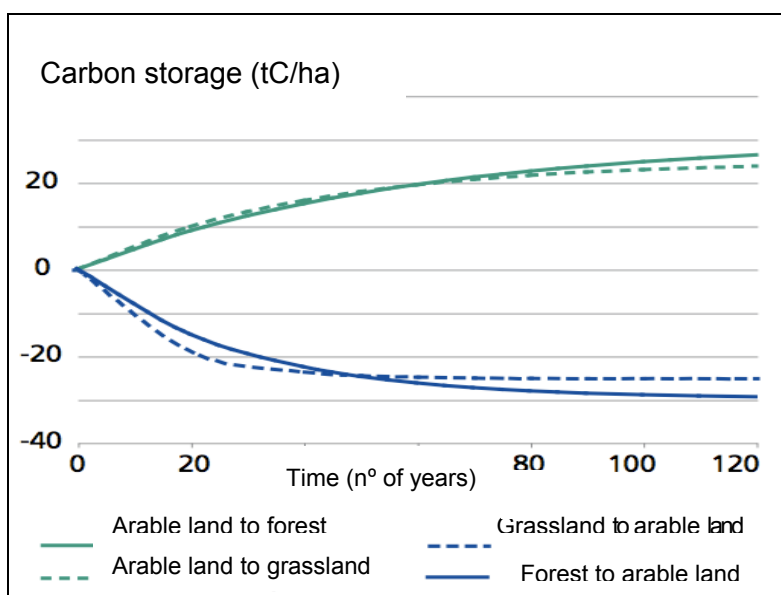
Source: Robert, 2001

Changes in **land use** or **farming practices** alter the stock of carbon in the soil. Some changes promote **storage**, as the conversion of **crops into forests** or **grasslands**. On the contrary, the **cultivation** of grasslands, forests leads to a **reduction** in stocks of carbon. The speed of development of organic carbon in the soil is not symmetrical (see figure below).

Thus, in 20 years, the stock decreased due the conservation of grassland (or forest) to annual crops (1 t C/ha/year) is twice as fast as the storage resulting from the abandonment of culture to grassland or forest (0.5 t C/ha/year).

Between 1995 and 2005, woodlands have increased their surface at the expense of agricultural zones (65,000 ha) and grassland (453,000 ha), representing 0.1 % and 0.8 % of the country area. 81,000 ha of crops have gone into grasslands. Despite these favourable conversions, the flows associated with observed changes in land use between 1995 and 2005 have lead to a reduction of the organic carbon stock.

Figure 2.2: Carbon flow related to land use changes



Source: Arrouays, 2002



Methods to increase carbon storage in soils

Some agricultural practices promote carbon storage in soils as such, but their overall environmental impact should be carefully assessed. For example, **the intensification of cropping** generates only little additional carbon storage but increases the risk of nitrate pollution and **emissions of nitrous oxide (N₂O)** in the stock of greenhouse gases.

Intercrops (green manure, cover crop, etc.), **inter-rows vegetative covers in the vineyards** and orchards and the implementation of **hedges** could all contribute to the storage of carbon in the order of 0.15, 0.40 and 0.10 t C/ha/year respectively. The establishment of **perennial herbaceous vegetation** on the fallow would allow storage of carbon equivalent to that of permanent grassland, while the removal of a bare fallow is estimated to be equivalent to 0.6 t C/ha/year.

Finally, simplified tillage techniques (surface tillage, direct seeding, etc.) generate a gain of up to 0.20 t C/ha/year. They may however have negative effects, such as soil compaction or proliferation of weeds or pests that can induce an increased use of pesticides.

2.4 Soil erosion

Erosion is a problem that produces an important impact on the landscape, especially in agricultural areas. Yet, soil erosion has long been considered in France as a problem exclusive of steep slopes and/or high intensity rainfall, restricted to the **Alps**, the **Pyrenees** and to the **Mediterranean** area. No real attention was paid to soil erosion on agricultural soils on plateaux and hilly areas before the early 80's (Vogt, 1979 in Auzet *et al.*, 2006).

However, there is now an increasing awareness of on-site and off-site impacts of runoff and soil erosion in regions occupied by **intensive agriculture**, even where slope gradients and rainfall intensities are relatively low (Papy and Douyer, 1991 in Auzet 2006) and in particular in regions which are subject to urban sprawling.

Data show evidence of a negative trend of soil erosion related problems in France (Auzet, 2006), especially in correspondence to areas where **concentration of annual crops or specialised crops** like vineyards and vegetables has taken place. Also areas of recent **expansion of urbanisation** seem to be particularly affected.

Among the most important soil degradation problems at national scale, water erosion is particularly relevant.

As for mechanical erosion, tillage has been identified as a major factor of soil redistribution on sloping arable land in the southwest of France (Romero, 2001).

2.4.1 Water erosion: muddy flows

In terms of water erosion, off-site effects such as muddy flows are often the most visible effects of damages caused by soil degradation. Muddy flows originating from agricultural fields frequently enter into urbanised areas located in adjacent valley bottoms or at the outlet of small catchments. Water authorities, Regional and Departmental Boards are also well aware of less visible damages such as sediments deposits in river courses and related degradation of water and ecosystems quality (Maret, 2004 in Auzet, 2006).

More than **17,000 muddy flows events were registered during the period 1985-2001 in France (Le Bissonais *et al.*, 2002)** according to the distribution of Map 2.4, Figure 2.3 and Figure 2.4.

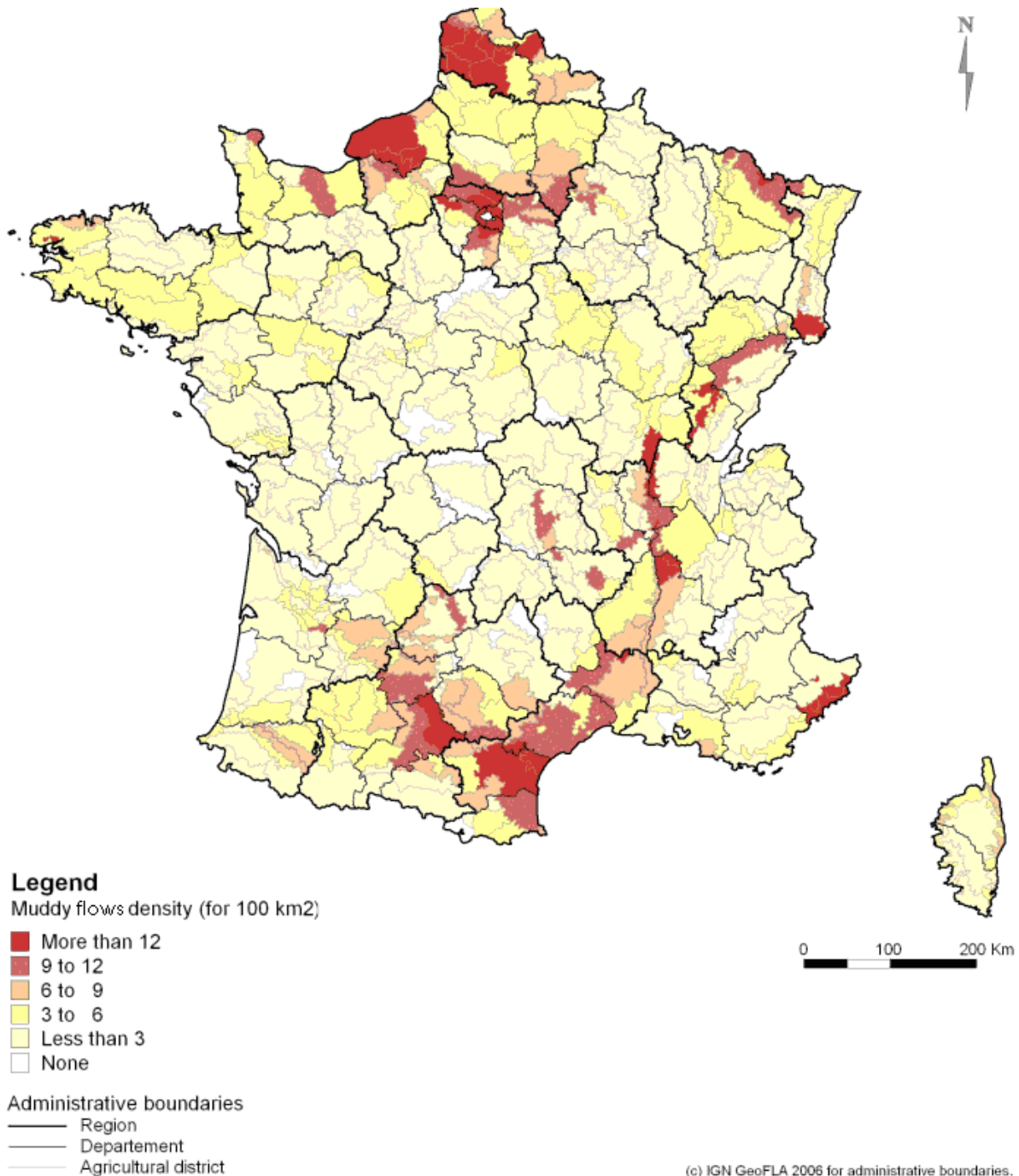
Data on muddy flows originate from an inventory of natural disasters managed by the Ministry of Ecology. In 1995 this inventory fed into the Corinte database (Local to natural and technological hazards), which records all the types of occurring natural disasters including muddy flows.



In 2001 this inventory ceased to be updated. However, a **significant increase in claims for muddy flow damages from 1991 was recorded.**

The number of events seems to be **linked to annual rainfall averages beyond certain thresholds**, but the extension of urbanisation, and therefore vulnerability, are other factors that could explain this negative trend (Thorette *et al.*, 2005).

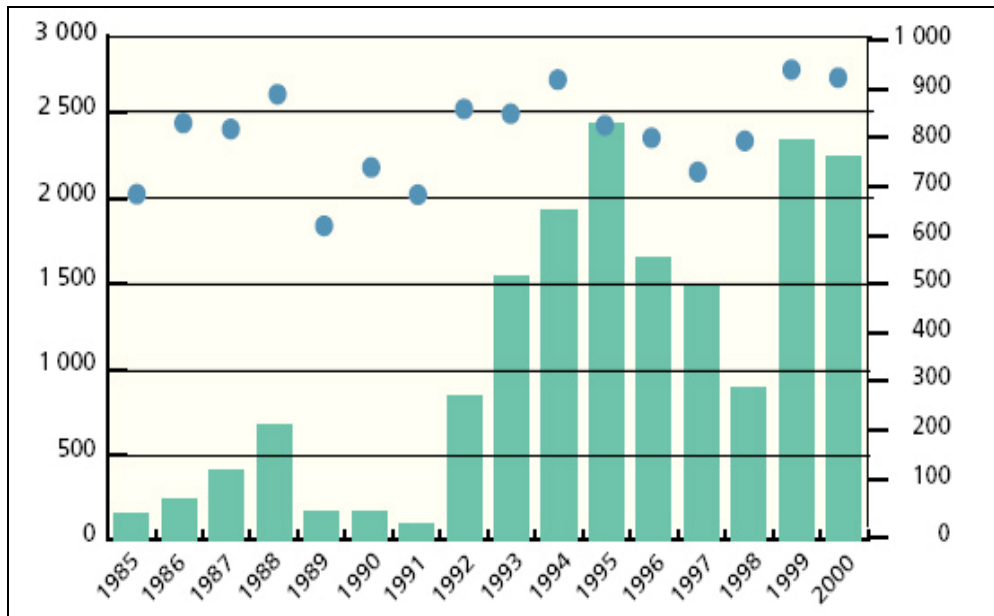
Map 2.4: Muddy flows density at regional scale 1985-2000



Source: Ministry of Environment, Corinte data base, IFEN



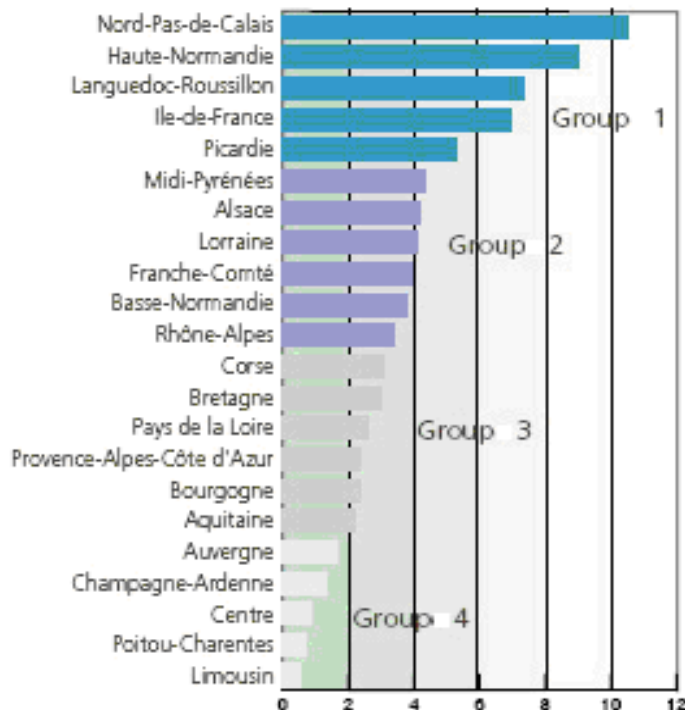
Figure 2.3: Development of the annual number of muddy flows and rainfall events from 1985 to 2000



Legend: Number of muddy flows ■ , Cumulative rainfall (mm) ●

Source: Thorette *et al.*, 2005

Figure 2.4: Muddy flow density (nb/100 km²), results at regional scale



Source: Thorette *et al.*, 2005



Table 2.2: Description of the four groups of regions affected by muddy flows as shown in Figure 2.4

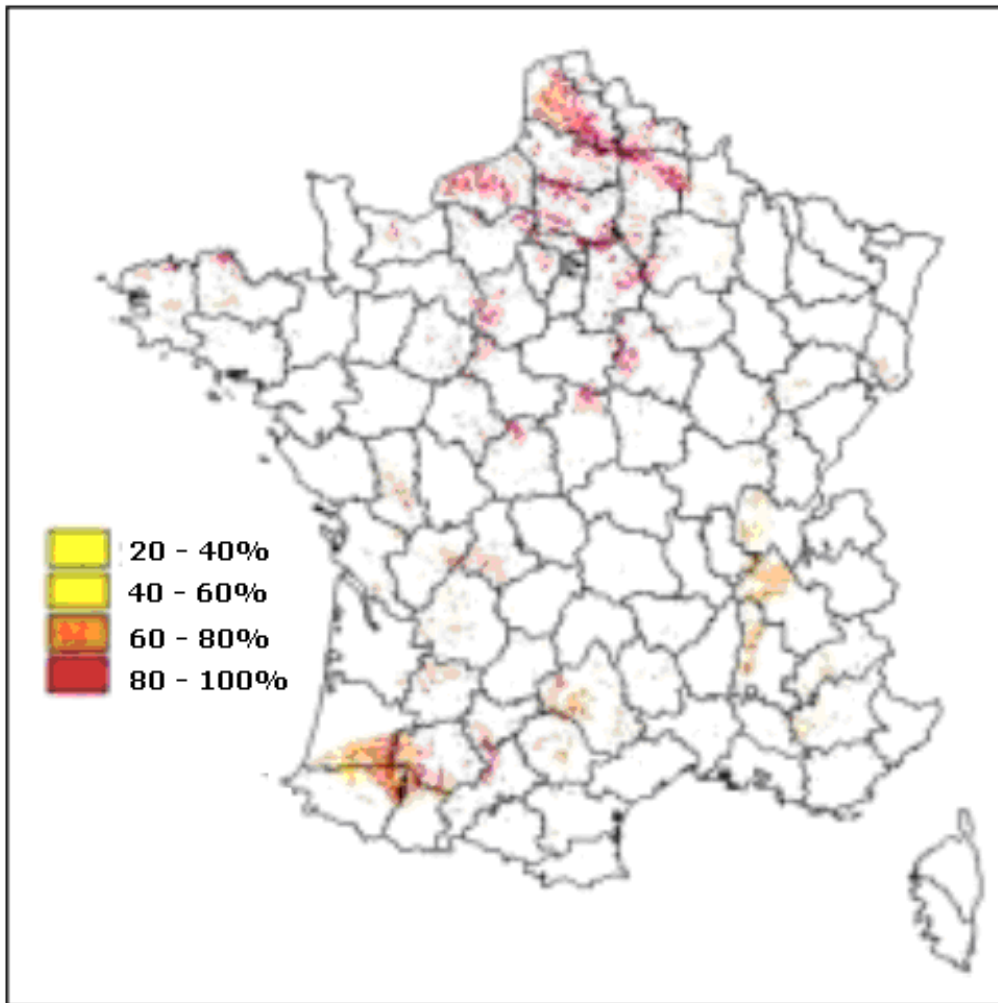
Groups	% of total muddy flow	Muddy flow density (nb/100 km ²)	Affected region
1	35 %	From 3.5 to 10.6	Nord-Pas-De Calais; Haute-Normandie; Languedoc-Roussillon; Ile-de-France; Picardie
2	34 %	From 3.4 to 4.4	Midi-Pyrénées; Alsace; Lorraine; Franche-Comté; Basse-Normandie; Rhône-Alpes
3	24 %	From 2.2 to 3	Corse; Bretagne; Pays de la Loire; Provence-Alpes-Côte d'Azur; Bourgogne; Aquitaine
4	8 %	Less than 1.7	Auvergne; Champagne-Ardenne; Centre; Poitou-Charentes; Limousin

2.4.2 Localised erosion phenomena

The North-western Paris basin (**Nord-Pas-De Calais, Haute-Normandie, Picardie**) appears as one of the areas most affected by soil erosion, despite low erosivity of rainfall and moderate slope gradient. Indeed, here, the low structural stability of the **loamy soils**, the **extension of the annual crops**, the large amount of **rain during autumn and winter**, and the **extension of urbanisation**, are the main factors which account for the most of the damage (Auzet, 2006). In loamy soils, aggregate stability depends on the content and dynamics of soil organic matter. In France a large proportion of these soils have weak organic matters contents leading to an increased risk of soil erosion (Annabi, 2005). For these soils (Map 2.5), a decrease of soil organic matter contents under a threshold value of about 2-3 % is one of the main controlling factors of this type of degradation (Le Villio *et al.*, 2001).



Map 2.5: Location of loamy soils under arable lands exhibiting a significant erosion risk



Note: Percentages in legend indicate the proportion of surface of soils having an organic carbon content value under the threshold of 1.5 %

Source: Le Villio *et al.*, 2001

In the Southwest (**Midi-Pyrénées**), the highest rate of soil erosion damage occurs in spring and at the beginning of summer, in relation to **low soil cover**, **high slope gradient** and **tillage operations** (Brunet, 1957; Revel and Rouaud, 1985; Revel *et al.*, 1990 in Auzet, 2006).

The Rhone valley, the Mediterranean area, the Southwest part of France and the Northwest of the Paris Basin suffer from significant off-site erosion damages throughout the year. These regions support a high **increase of urbanisation** (SCEES, 2000).

The Mediterranean (**Languedoc-Roussillon**) zone is particularly affected when high **intensity rainfall** occurs during the autumn. In this area, **rainfall erosivity** is the highest. Soil erosion problems are particularly severe after forest fires and in **vineyards**. **Steep slopes** and **non-cohesive materials** such as marls, molasses and sandy soils are particularly subject to erosion. In non cultivated areas, vegetation cover, even sparse, is essential to prevent erosion (Auzet, 2006).

Records show that only few regions are devoid of by muddy flows, mainly in the central regions (Centre, Auvergne, Limousin) and the central part of the West (Poitou-Charentes). **Grasslands still remains an important landscape feature** in these regions of extensive cattle breeding. Erosion may occur, however, on very sensitive volcanic soils, without leading to off-site damage (Auzet, 2006).



In **mountains**, erosion has decreased since the end of the 19th century due to landscape restoration schemes and the reduction of agricultural activities. Due to natural and artificial **reforestation** and **mountain river control**, **soil erosion has decreased** in the 20th century. Mountain urbanisation can sometime cause localised phenomena.

- Vineyards

Vineyards are cultivated in a variety of **climatic** conditions, **slope** gradients, **soils**, **length of the parcels** and by use of several **farming practices** (tillage, no-tillage, grassed interrows or bare soil). Part of the **Rhone valley** and **Mediterranean** vineyards seem the most affected. A clear link has been found with farming practices. In the **Alsace**, the increased use of a **grass cover in the interrows** has led to a decrease in soil erosion. Thunderstorms can occasionally lead to strong erosion if tillage was carried out few days before.

- Arable crops

In arable crops, soil erosion appears to be related to the combination of different factors such as **heavy precipitations and bare soils**. Of course, this occurs somewhat irregularly, due to thunderstorm distribution. Erosion might be particularly high after **tillage** in recently **sown spring crops** (maize, sugar beet, vegetables) in Alsace, in Northern France, in Brittany or in the Southwest. These phenomena occur every year in several regions, but do not affect the same catchments each year (Auzet, 2006).

In the Paris basin in **winter**, catastrophic erosion events may occur even **with moderate rainfall intensities**. The combination of the amount of rain over the whole region during autumn and winter seasons, the predominance of **loamy soils** with low structural stability and the **extension of annual crops** that leads to **limited cover** in this period, all result in a strong **decrease of water infiltration** and filling in of artificial basins with sediments transported by runoff (Auzet, 2006).

The high proportion of areas that may produce overland flow, even for low intensity rainfall in agricultural catchments, leads to a **high connectivity** and **rapid runoff** before reaching the permanent network (ditches or rivers), resulting in rill and ephemeral gully erosion. In these cases, the impact of **agricultural practices is very important**: soil surface characteristics can lead to very different runoff and erosion responses (Auzet, 2006).

2.4.3 Erosion risk assessment

Objectives

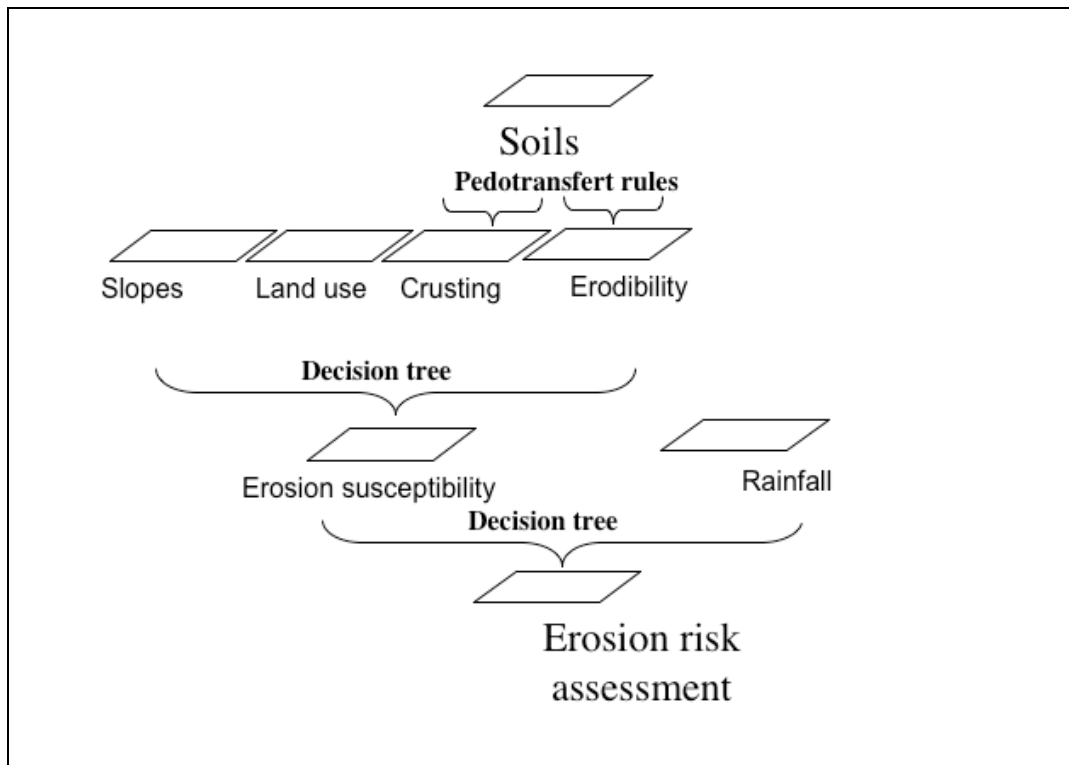
To assess the potential risk of (water) erosion at national level, the French National Institute for Agricultural Research (INRA) and the French Institute for the Environment (IFEN) developed a specific model named MESALES (Méthode d'Evaluation Spatiale de l'ALéa Erosion des Sols). The model takes into account the **modifications of the UAA at agricultural district level** and the high variability of **soil types** in France.

MESALES is based on 5 thematic input datasets (see Figure 2.5 below):

- Soil quality,
- Land cover,
- Agricultural data,
- Slopes,
- Climate.



Figure 2.5: Description of the water erosion risk assessment in the MESALES model



Source: Le Bissonnais, 2008

The source of the above datasets for the present study is hereafter detailed.

Thematic datasets

a) Soil quality (related to erosion)

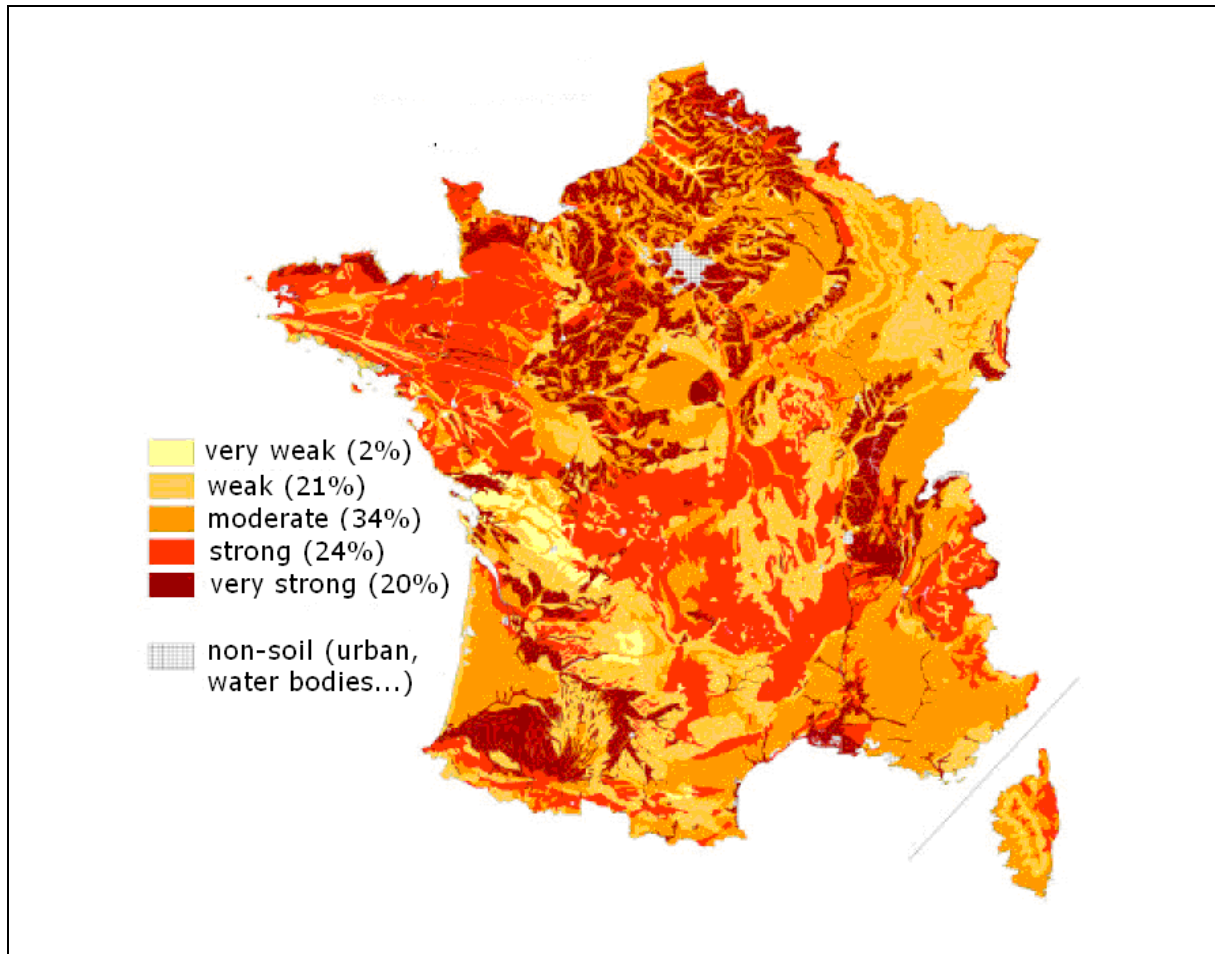
Two parameters were extracted from the French soils database:

- the soil sensibility to **deterioration of the superficial structure** under rainfall (the crusting);
- the **erodibility** of row materials (stability and coherence).

Note: Organic matter effect on structural stability was not taken into account (this information is not available in the database)

The crusting sensibility assessment (Map 2.6) is based on the textural parameter (dominant texture and secondary texture):

- Coarse, very coarse textures and fine texture are classified as low crusting
- Fine and medium textures are classified as moderately to highly sensitive to crusting depending on the secondary texture and materials.

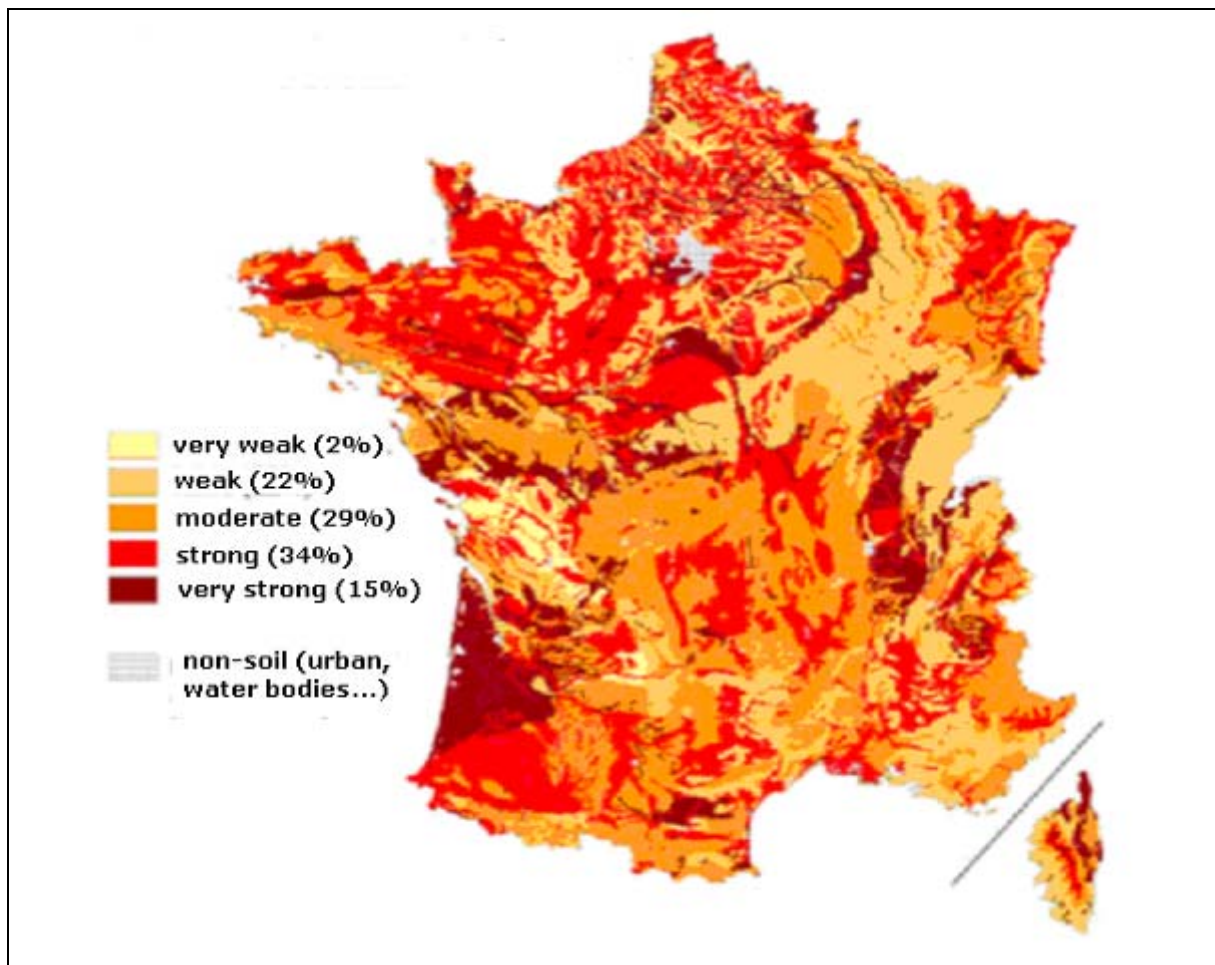
**Map 2.6: Soil crusting sensibility**

Source: Le Bissonais *et al.*, 2002

Estimation of erodibility (Map 2.7) is based on textural parameter (dominant and secondary textures and parental materials). Heavy rocks as granite or calcareous are classified as weakly erodible level, while friable rocks as sand or molasses are classified as highly erodible.



Map 2.7: Erodibility classes (assessment) based on dominant and secondary textures and parental materials



Source: Le Bissonais *et al.*, 2002

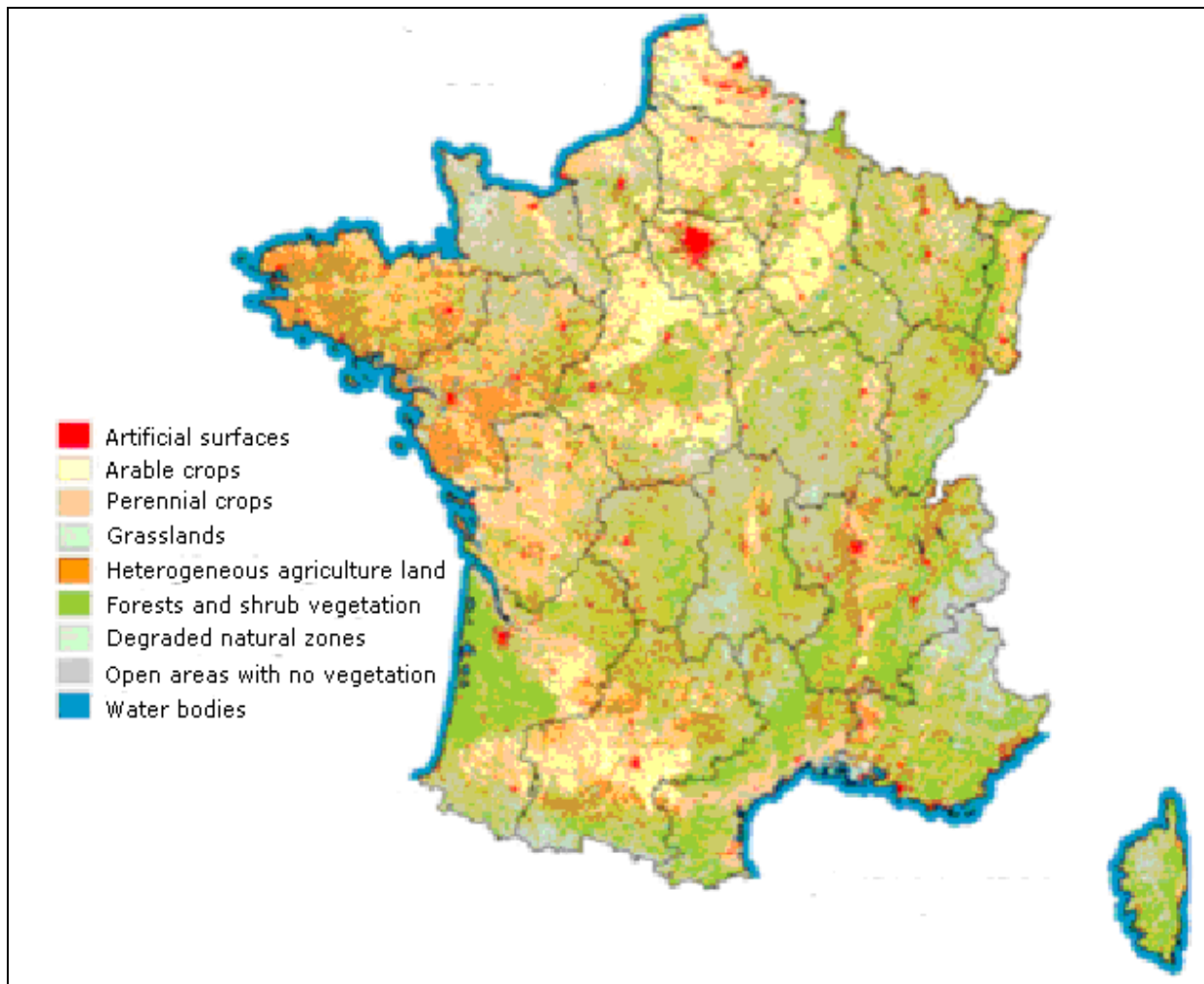


b) Land cover

Data on soil cover come from the Corine Land Cover (CLC) system. Nine classes were extracted. Their CLC definitions are given here:

- Arable land, which can be naked during a long period in the year
- Grasslands, which protect the soil surface and promote the infiltration
- Heterogeneous agricultural areas, contrasted land. This diversity is a limiting factor to run off in comparison with arable land
- Perennials crops like vineyards
- Forests
- Degraded natural areas. Areas which can be very sensitive to erosion, because soils could be naked on very high slopes (badlands, etc.)
- Open areas without vegetation, such as naked rocks or beaches
- Free water areas: lakes, rivers, etc.
- Artificial territories

Map 2.8: French soil cover used in the MESALES model



Source: Le Bissonais *et al.*, 2002



c) Agricultural data

The MESALES model use indicators to describe agricultural activities at agricultural district level. These indicators are:

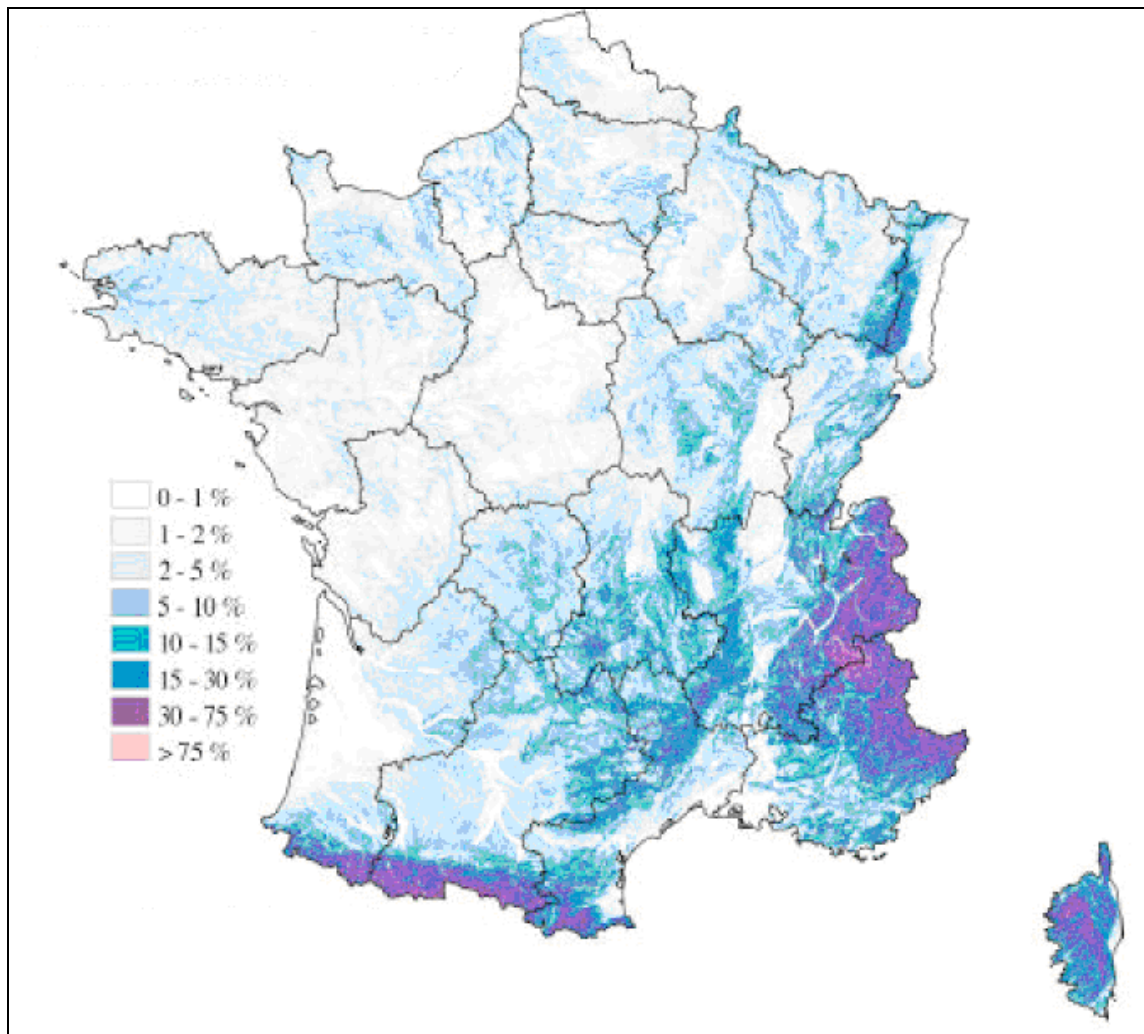
- percentage of winter crops in the UAA
- percentage spring crops in the UAA
- percentage of grasslands in the UAA

This information was retrieved directly from the national farm structure surveys (FSS).

d) Slopes

The indicator of topography is based on gradient of slopes (Map 2.9). The digital model of soil (DMS) has a resolution of 250 m for the whole France.

Map 2.9: Slope classes in France



Source: Le Bissonais *et al.*, 2002



e) Climate

Rainfall is the main factor of water erosion. Météo France developed a method to collect data on erosive rainfall (Aurelhy data base) and make this information available for the MESALES model. Then, the MESALES model takes into account:

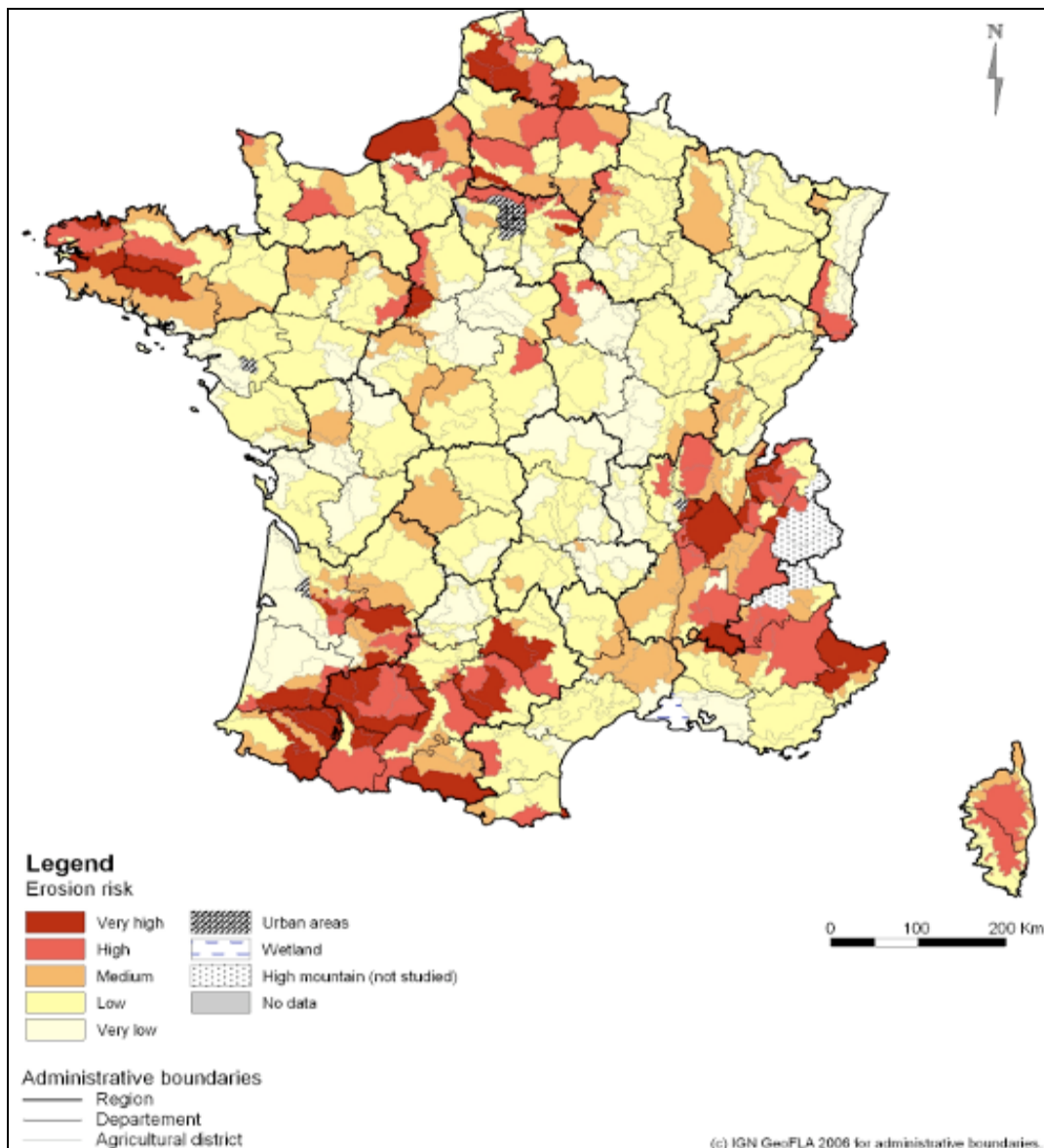
- rainfalls intensity upper or equal to 15 mm per hour;
- medium frequency by season.

Model results: water erosion risk assessment at national level

Results of the model are presented by different maps presenting the erosion risk at annual and seasonal level (Map 2.10 and Map 2.11).

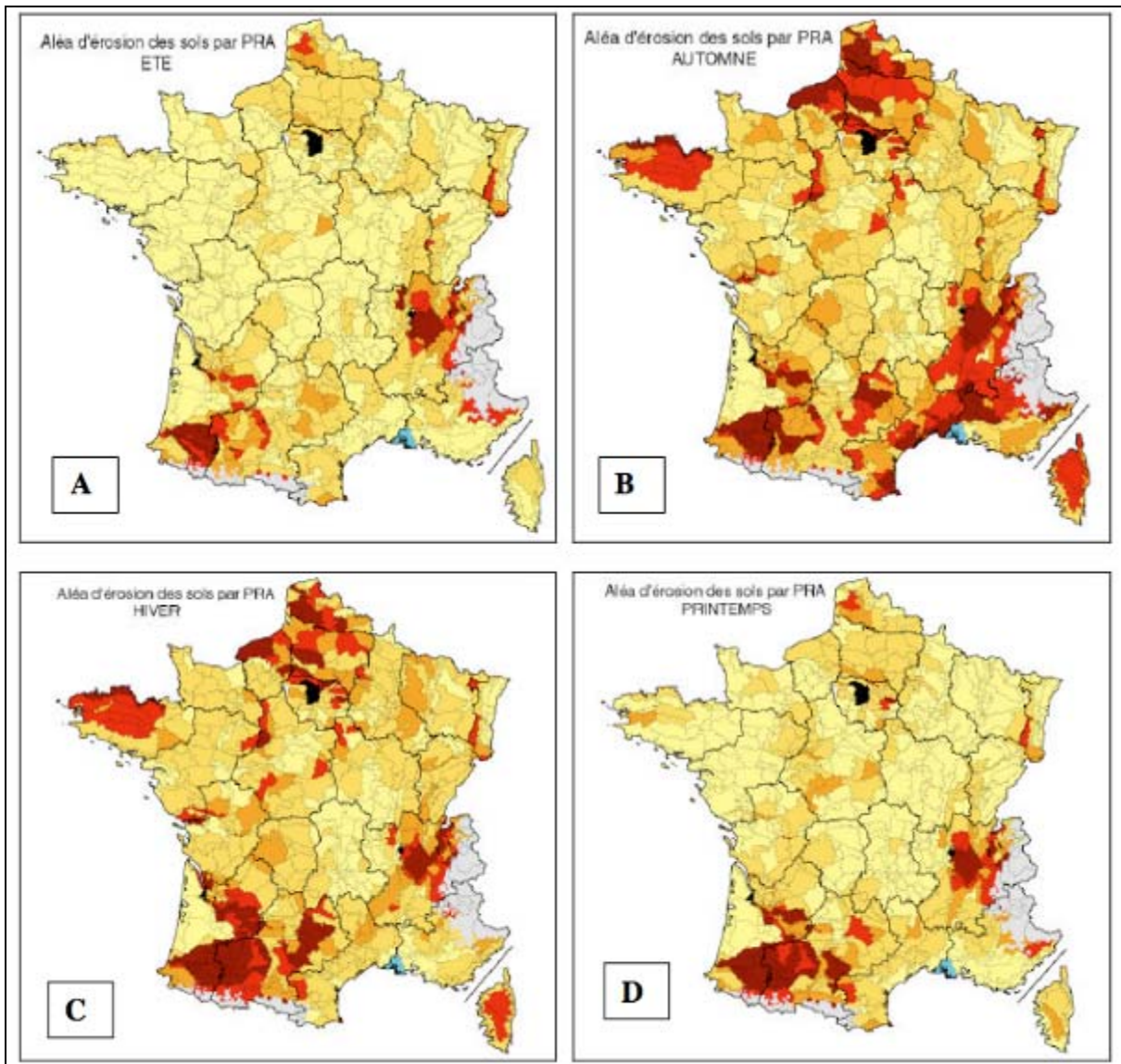
a) Annual erosion risk

Map 2.10: Annual erosion risk in France, result of the MESALES model, data aggregation per agricultural district



Source: GIS SOL, 2002

b) Seasonal erosion risk

Map 2.11: Seasonal erosion risk

Note: Result of the MESALES model, data aggregation per agricultural district

A = Summer; B = Autumn; C = Winter; D = Spring

Source: GIS SOL, 2004

c) Analysis

At national level, percentages of the total national area concerned by erosion risk are:

- Very low level of erosion risk: 63 %
- Low level of erosion risk: 14 %
- **Medium level of erosion risk: 10 %**
- **High level of erosion risk: 5 %**
- **Very high level of erosion risk: 3 %**
- Area not affected: 5 %



A breakdown of these percentages per type of agricultural surface, may contribute to better understand the scale of the problem.

Table 2.3: Aggregation of agricultural surfaces per erosion risk class areas in France 2000

	UAA 2000	Arable Land	Spring crops
High or very high risk areas	5,624,687 ha	3,176,285 ha	1,555,847 ha
Medium risk areas	4,143,354 ha	2,065,297 ha	823,564 ha
No, very low or low risk areas	18,088,272 ha	8,384,806 ha	3,013,842 ha
TOTAL	27,856,313 ha	13,626,389 ha	5,393,253 ha

The national overview and the seasonal assessment of the erosion risk both show a great variability within a year and the existence of regions systematically affected by soil erosion, such as: Nord-Pas-De-Calais, Haute-Normandie, Picardie, Midi-Pyrénées and Rhône-Alpes. These data are coherent with the muddy flow distribution analysis.

For these regions, risk of soil erosion is high and permanent as a result of the negative combination of numerous factors as indicated in Table 2.4 below.

Table 2.4: Regions and sub-regions (department or agricultural district) affected by soil erosion and driving forces concerned

Regions and sub-regions	Agricultural context	Slope gradient	Soil	Climate	Main season of erosion risk
Haute-Normandie (department of Seine-Maritime)	Extension of annual crops, bare soils	Low slope gradient	Loamy soil – very low structural stability	Low rainfall erosivity	Autumn, winter
Nord-Pas-De-Calais, Picardie	Annual/spring crops (sugar beet, potatoes), bare soils	Low slope gradient	Loamy soil – very low structural stability	Low rainfall erosivity	Autumn, winter
Midi-Pyrénées (Agricultural district: Lauragais; Toulouse area)	Annual and spring crops, bare soils, tillage	High slope gradient	Clay soils	High rainfall erosivity	Winter, spring
Midi-Pyrénées (Agricultural district: Rougiers de Camares)	Grassland and fodder area, extension of annual crops	High slope gradient	Very low structural stability (specific local soil type)		Autumn, winter, spring
Rhône-Alpes (Agricultural district: Côtière des Dombes; North of Drôme)	Annual and spring crops, bare soils	High slope gradient	Loamy soil – very low structural stability		Autumn, winter, spring
Rhône-Alpes (vineyard area)	Vineyard area, bare soils	High/medium slope gradient			Autumn

Source: Le Bissonnais *et al.*, 2002



2.5 Conclusions

Soil erosion is the main soil degradation issue in France and the main problem related to agricultural activities. This phenomenon is clearly linked to the degradation of top soil structural stability and the reduction of soil organic matter (especially for loamy soils).

Three among regions and sub-regions (department or agricultural district) affected by a high or very high level of erosion risk have been selected for more detailed analysis:

- **Midi-Pyrénées region** (agricultural district: **Lauragais**): Arable crops-spring crop + tillage operation + clay soils + high rainfall erosivity + high slope gradient.
- Haute-Normandie region (Department of Seine-Maritime): Extension of annual crops + loamy soils + low rainfall erosivity + moderate slope gradient.
- Nord-Pas-De-Calais region: Annual crops-spring crops + loamy soils + low rainfall erosivity + moderate slope gradient.

For dimension and importance, the largest part of this study focuses on Midi-Pyrénées. The specific agricultural district of Lauragais is also studied as representative of an area under arable crop subject to water erosion.

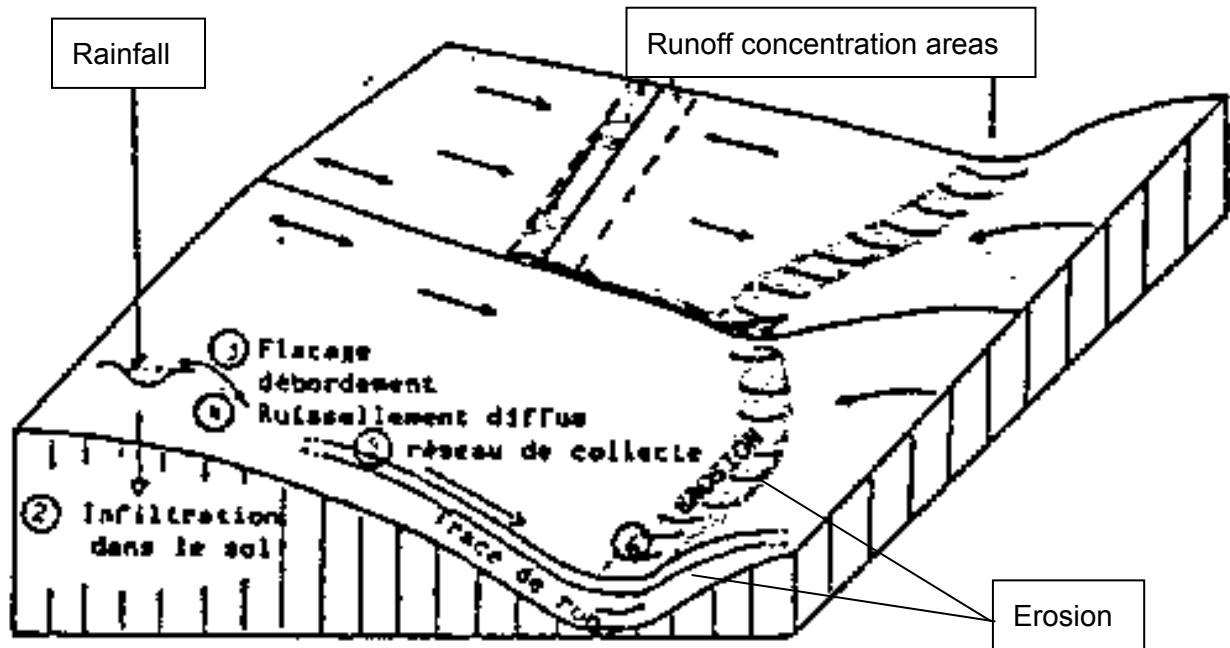
However, the level of analysis was adapted from national to farm level according to the importance of phenomena. Table 2.5 below describes the different scales.

Table 2.5: Level of analysis within the France case study

Thematic	National level	Regional level (hot spots)	Farm level
Soil state			
Soil erosion (water erosion)	Yes	Midi-Pyrénées region and 2 specific NUTS 3 area in France (Seine-Maritime, Pas-De-Calais)	15 farms (Midi-Pyrénées) + 5 farms (2 specific NUTS 3 area)
Farming Practices			
Currents practices for soil conservation (erosion)	Yes	Midi-Pyrénées region (and 2 specific NUTS 3 area in France) Expert consultations	15 farms (Midi-Pyrénées) + 5 farms (2 specific NUTS 3 area)
Conservation agriculture practices	Yes	Midi-Pyrénées region Expert consultations	15 farms
Economic and environmental benefits of conservation agriculture	Yes	Midi-Pyrénées region Expert consultations	15 farms
Policy on soil conservation	Yes	Midi-Pyrénées region (and 2 specific NUTS 3 area in France) Expert consultations	15 farms (Midi-Pyrénées) + 5 farms (2 specific NUTS 3 area)



Figure 2.6: Erosion process schema in Pays-de-Caux – Seine-Maritime



Source: Boffin *et al.*, 1986



3 Farming systems and practices in France

Several different factors, both natural and human induced, have contributed to the current status of agricultural soils in France. Excluding the natural factors such as soil, climate, etc., that have already been presented above, the following chapter focuses on the analysis of farming systems and practices, along with their trends, that most influence soil conservation/degradation.

In addition, it has to be noted that the agricultural orientation Law of 1968, strongly promoted **the enlargement of parcels size with the scope** to develop a more intensive agriculture.

3.1 Mixed farm systems

The surface occupied by mixed farms which traditionally use temporary grasslands, allowing a long rotation with cereal crops, has highly decreases from 11.1 million hectare in 1970 to 5.6 millions in 2000. At the same time, the surface of specialised field crops increased from 5.6 to 9.6 million hectare (Table 3.1).

The farm surface dedicated to grazing also decreased, corresponding to a decrease of the national herd volume.

Table 3.1: Development of the number of farms per farm types between 1970 and 2000

	N° of farms (in 1,000)		Development (%)	UAA (in 1,000 ha)		Development (%)
Years	1970	2000	-	1970	2000	-
Field crops	161	134	-15	5,6	9,6	+70
Horticulture	41	16	-60	0,1	0,1	-10
Vineyard	200	92	-50	1,1	1,1	
Fruits	56	25	-60	0,4	0,3	-20
Bovines	481	165	-70	9	8,6	-5
Other herbivorous	118	82	-30	2,6	2,1	-20
Granivores	14	23	+60	e	0,5	
Mixed	518	126	-80	11,1	5,6	-50
Total	1,588	664	-58	29,9	27,9	-7

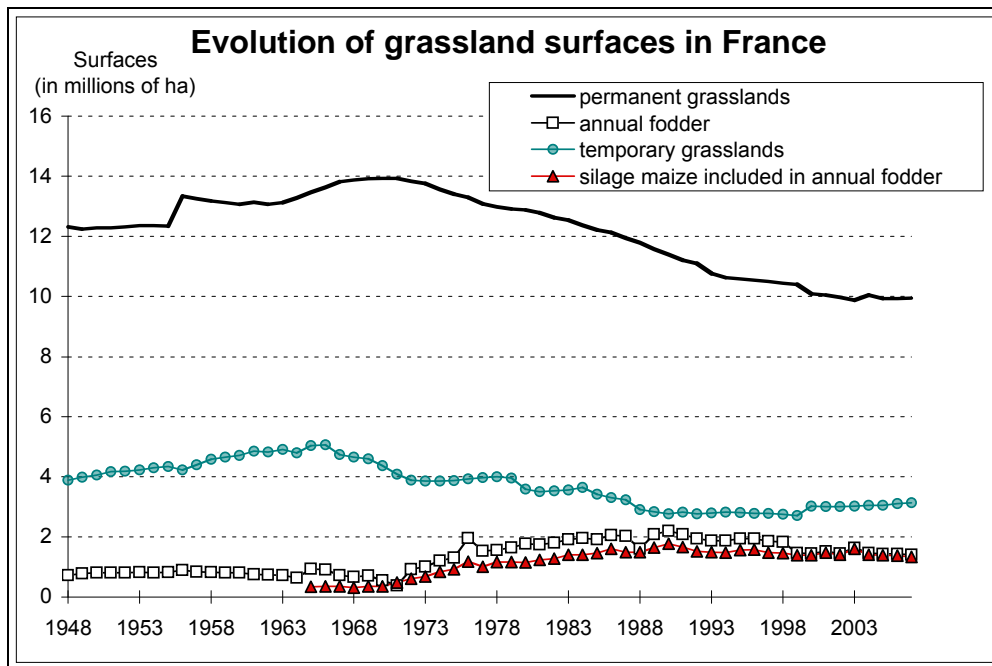
Source: FSS, 1970 and 2000

As a consequence of these trends, a decrease of the grassland surfaces can be observed, especially in low lands where they are usually ploughed (Figure 3.1 and Map 2.9 below).

It is calculated that 5.6 million hectare of permanent and temporary grasslands have been lost between 1966 (year of the maximum extension) and 2007 (corresponding to -30 %). Part of these surfaces has been abandoned, part afforested, mainly in mountainous areas. But in the plains and the plateaux, the majority of these surfaces has been ploughed and used to cultivate arable crops, increasing significantly the erosion risk.



Figure 3.1: Development of grassland surfaces in France



Source: SCEES, 2004

More in detail, the surfaces of field crops (cereals, oil seeds, protein crops and industrial crops) increased from 1960 to 1990, and remained then stable from 1990 to 2006, covering around 12 million hectare.

Table 3.2: Development of the surfaces of field crops

	1960	1980	1990	2000	2006
Surface of field crops in 1,000 ha	9,985	11,099	12,212	12,036	11,970

Source: SCEES, 2004

Irrigated crops surfaces increased continuously from 400,000 ha in 1955 to 1.9 million ha in 1997. This irrigation development is linked mainly to the development of grain maize which covers 47 % of the irrigated surfaces.

3.2 Crop rotation

Crop rotation (crop diversity) is a very important contributor to soil conservation, but it is difficult to study, because of the number of possible crop combinations and the lack of field information.

A methodology was therefore established to develop two indicators for the analysis of the available data:

- A 'crop diversity' indicator (Pointereau and Bisault, 2006), in the range of 1 (monoculture) to 10 (large rotation and/or large surface of grasslands) refers to each farm type and each municipality. This indicator has been used also to manage the data of the agricultural practices survey.
- A 'crop rotation' indicator to measure the percentage of the crop surfaces with more than 4 different crops during the last 6 years (2001-2006). Maize silage and grain maize are considered as the same crop, as well as common wheat and durum wheat.

Data sources were identified in the **FSS census** (1970, 1980, 1988, 2000), which provides the surfaces of each crop for all farms, and in the **Agricultural Practices Survey (2006)**,

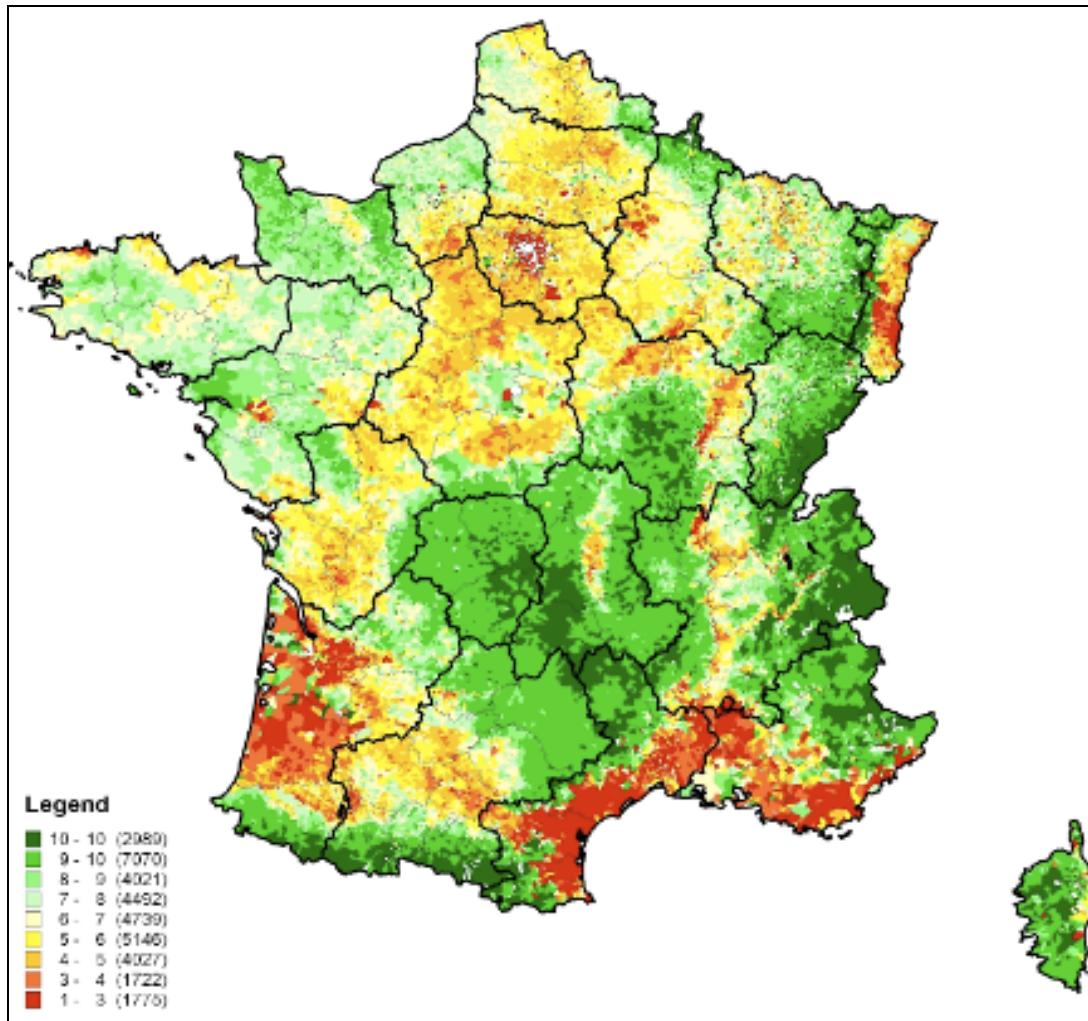


which provides information on the type of crops cultivated in the five previous years (i.e. the rotation during the last six years) for any given area.

The trend observed in France as of 1970 indicates a **simplification of the crop diversity particularly in the specialised cereal crop areas** (Map 3.1, Map 3.2 and Map 3.3).

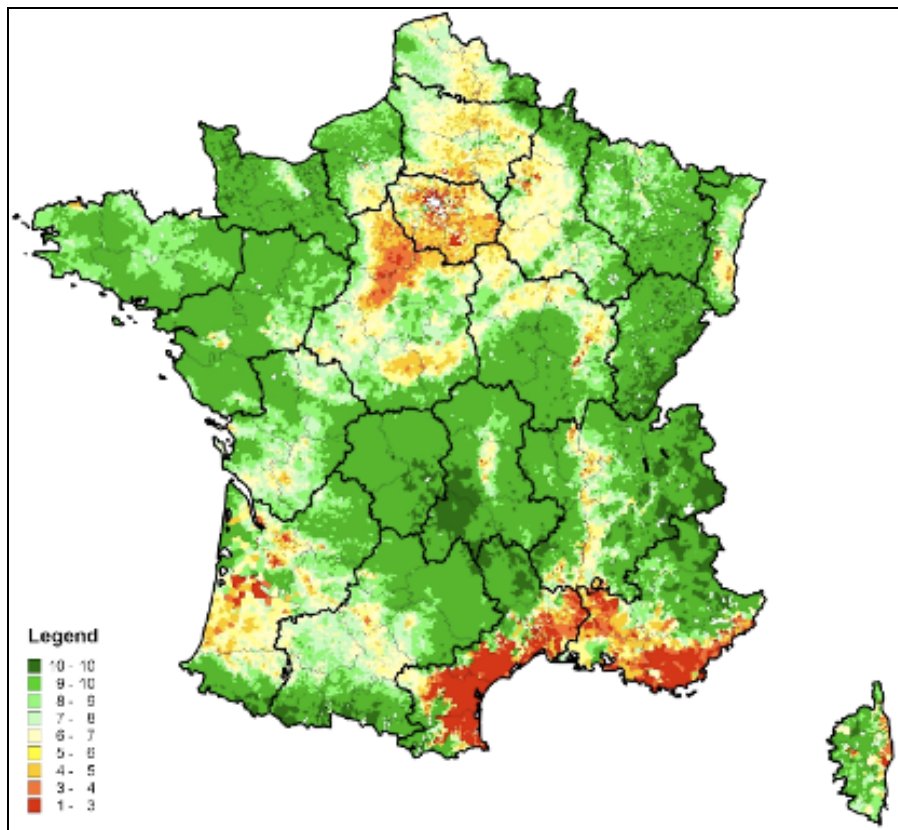
In 2000, large areas with a score less than 4 points, can be observed in the South West and Alsace (monoculture of grain maize) and in the Mediterranean area (specialised vineyards and orchards systems), but also in the *Bassin Parisien*, *Poitou-Charentes* and *Garonne* valley, where a short rotation is developed based on wheat, maize, rapeseed and fallow mainly.

Map 3.1: Diversity of crops and share of permanent grassland by commune 2000

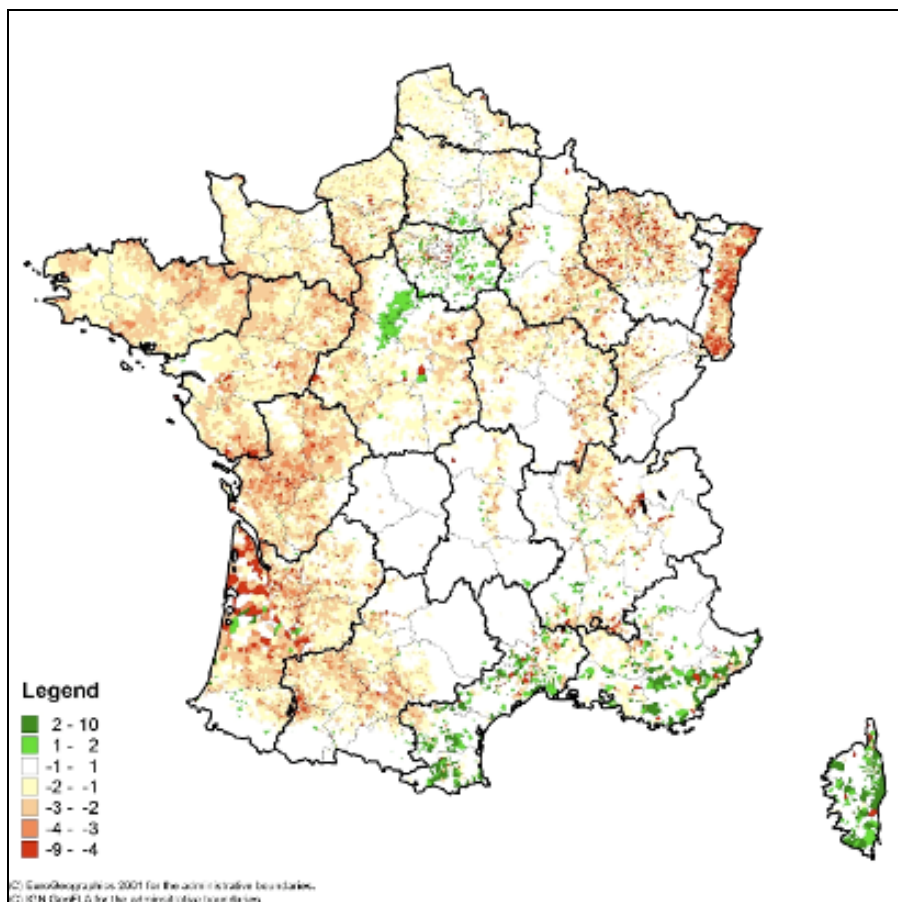




Map 3.2: Diversity of crops and share of permanent grassland by commune 1970



Map 3.3: Diversity of crops and share of permanent grassland by commune 1970-2000





Despite the above maps, rotation is still diversified for most of the crops, especially when the rotation includes peas, potatoes, sugar beet, rapeseeds, barley or common wheat (Table 3.3). Between 80 to 100 % of the surface of these crops in 2006, was included in a rotation with more than four different crops or fodder surfaces during the 6 years period 2001-2006. The rotation is more simplified for grain maize (score of 3.2) and durum wheat (score of 3.7).

Table 3.3: Score of the indicator of diversity of crop rotation for the main crops

Field crops	Ploughed crop in 2006	Crops under no-tillage since 2001
Peas	5,7	nc
Potatoes	5,4	nc
Sugar beet	5,2	5,3
Rapeseeds	5,3	5
Barley	5,1	4,9
Sun flower	4,9	4,6
Common wheat	4,3	4,1
Durum wheat	3,4	3,7
Grain maize	3,4	3,2
Silage maize	3,4	3,2

Note: The calculated score is the average score of the parcels observed representative of the crop at the regional and national levels. The maximum score is 6 when 6 different crops are observed during the 6 years period. The minimum score is 1 corresponding to a monoculture (same crop during 6 years)

Source: Agricultural Practices Survey 2006

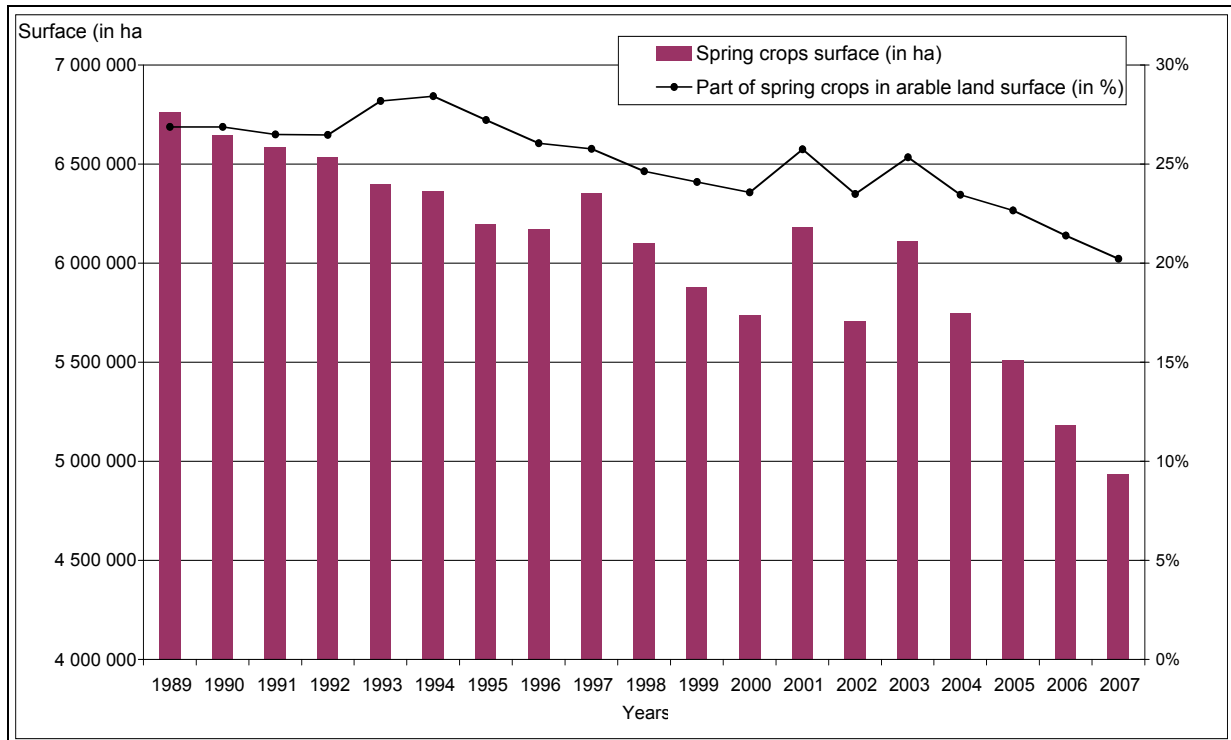
3.3 Spring crops

As it was anticipated in paragraph 2.4.2 and as it will be discussed in the next paragraph, spring crops are particularly prone to erosion. Their extension and trends, therefore, are of specific interest in the discussion of agriculture practices related to soil conservation.

In 2007, spring crop represented more than 20 % of arable land corresponding to 4.9 million hectares, but in 1989 they accounted for 27 % of arable land (and 6.7 million hectares). This decrease of **1.8 million hectares** (-27 %, Figure 3.2), has worsened as of 2003 when a severe drought occurred, but it was partly offset by an increase in winter crops (+9 % corresponding to 0.7 million hectares).



Figure 3.2: Development of spring crops surfaces in France 1989-2007

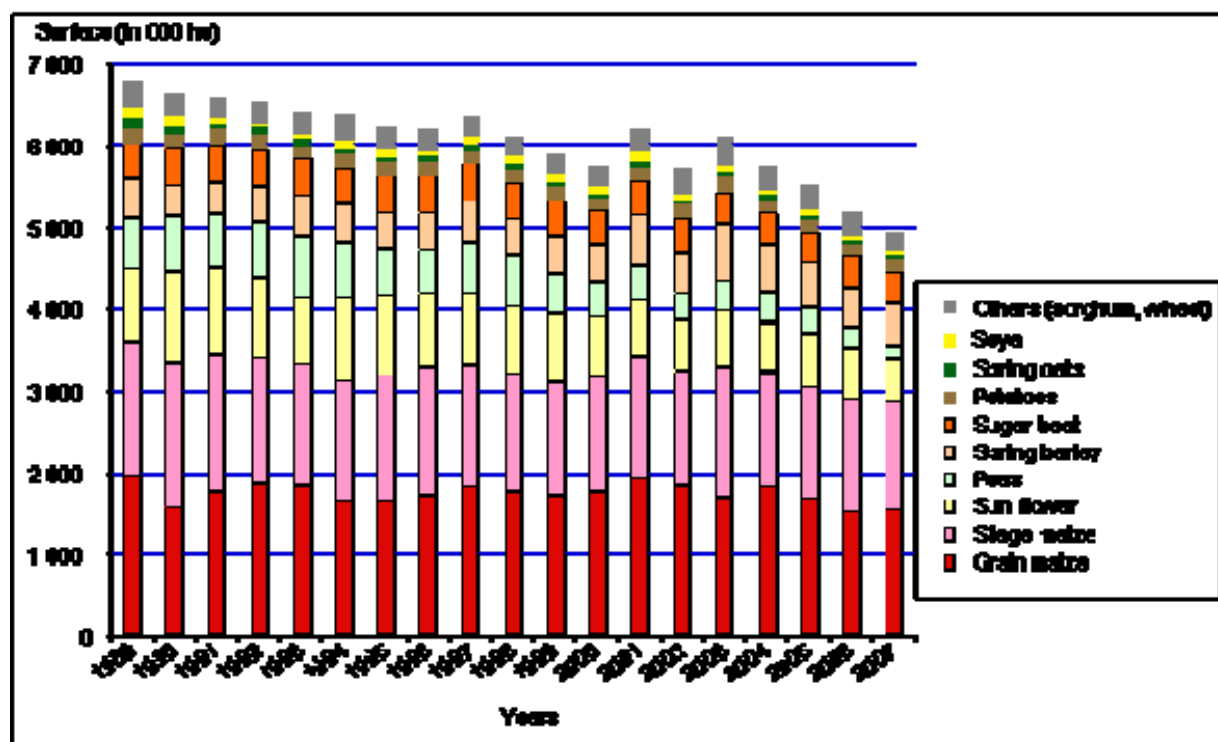


Source: Annual Agriculture Statistic, MAP, 1989-2007

The main crops concerned are (see Figure 3.3 and Table 3.4):

- Peas (-460,000 ha and a surface reduction of 74 %)
- Grain maize (-420,000 ha and a surface reduction of 22 %)
- Sunflower (-370,000 ha and a surface reduction of 42 %)
- Silage maize (-315,000 ha and a surface reduction of 19 %)

Figure 3.3: Development of spring crops surfaces in France 1989-2007



Source: Annual Agriculture Statistic, MAP, 1989-2000

Table 3.4: Development of spring crops surfaces in France 1989-2007

Spring crops	1989		2002		2007		Evolution 1989-2007	
	Surface (in ha)	%	Surface (in ha)	%	Surface (in ha)	%	in ha	in %
Grain maize	1 941 071	30%	1 829 133	34%	1 522 270	33%	-418 801	-22%
Silage maize	1 647 015	26%	1 406 617	26%	1 332 011	28%	-315 004	-19%
Sun flower	891 113	14%	614 732	11%	518 606	11%	-372 507	-42%
Peas	621 936	10%	335 919	6%	162 424	3%	-459 512	-74%
Spring barley	479 172	7%	473 989	9%	514 569	11%	35 397	7%
Sugar beet	433 270	7%	437 919	8%	393 494	8%	-39 776	-9%
Potatoes	158 731	2%	162 207	3%	159 776	3%	45	0%
Spring oats	137 893	2%	59 995	1%	40 644	1%	-97 249	-71%
Soya	131 884	2%	74 747	1%	32 384	1%	-99 500	-75%
Others (sorghum, wheat)	321 089	5%	312 304	6%	260 261	6%	-60 828	-19%
TOTAL France	6 444 074	100%	5 397 260	100%	4 677 185	100%	-1 766 889	-27%

	1989		2002		2007		Evolution 1989-2007	
	Surface (in ha)	% of the arable land	Surface (in ha)	%	Surface (in ha)	%	in ha	in %
All winter crops	7 998 886	32%	8 107 658	33%	8 720 216	36%	731 328	9%

Source: Annual Agriculture Statistic, MAP, 1989-2007



3.4 Cover crops

In 2000-2001, cover crops were poorly developed and represented only 200,000 ha, or 5 % of spring crop area (Table 3.5 and Map 3.4). They were mainly located in some specific regions (Bretagne, Champagne-Ardenne, Nord-Pas-De-Calais and Picardie). In these region implementation of the Nitrates Directive is certainly the main driver for cover crop implementation (see chapter on Nitrates Directive).

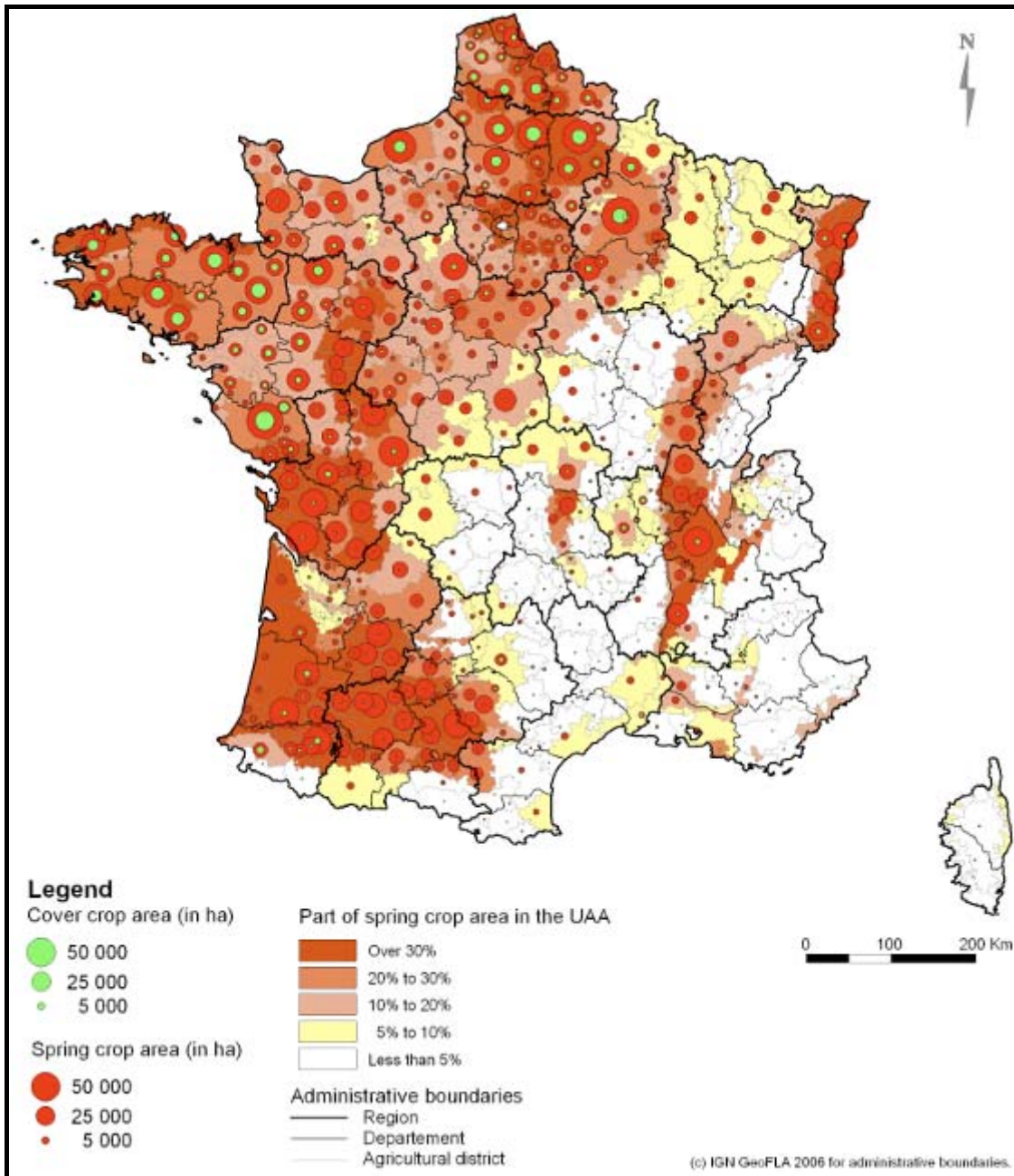
Table 3.5: Cover crop surfaces of main spring crops in France 2001

REGIONS	Ploughed crops surfaces			Simplified tillage crops surfaces		
	Spring crops surfaces (in ha)	Cover crop surfaces (in ha)	Part of cover crop	Spring crops surfaces (in ha)	Cover crop surfaces (in ha)	Part of cover crop
ALSACE	114 696	4 143	3,6%	36 482	0	0,0%
AQUITAINE	353 121	6 720	1,9%	83 808	0	0,0%
AUVERGNE	41 829	0	0,0%	5 578	0	0,0%
BASSE-NORMANDIE	188 989	0	0,0%	8 240	0	0,0%
BOURGOGNE	34 044	458	1,3%	1 759	0	0,0%
BRETAGNE	415 661	52 778	12,7%	44 219	0	0,0%
CENTRE	269 923	6 054	2,2%	34 635	1 346	3,9%
CHAMPAGNE-ARDENNE	118 189	10 936	9,3%	11 491	0	0,0%
FRANCHE-COMTE	40 622	506	1,2%	3 452	0	0,0%
HAUTE-NORMANDIE	94 492	3 522	3,7%	11 895	0	0,0%
ILE-DE-FRANCE	105 279	8 958	8,5%	18 735	971	5,2%
LANGUEDOC-ROUSSILLON	0	0		0	0	
LORRAINE	80 981	0	0,0%	5 463	0	0,0%
MIDI-PYRENEES	333 982	4 584	1,4%	62 255	0	0,0%
NORD-PAS-DE-CALAIS	195 328	25 957	13,3%	14 804	0	0,0%
PAYS DE LA LOIRE	422 802	13 869	3,3%	65 632	0	0,0%
PICARDIE	327 431	55 880	17,1%	29 548	0	0,0%
POITOU-CHARENTES	423 017	3 041	0,7%	68 758	0	0,0%
PROVENCE-ALPES-COTE D'AZUR	0	0		0	0	
RHONE-ALPES	154 987	4 737	3,1%	5 623	0	0,0%
Total France	3 715 375	202 143	5,4%	512 377	2 314	0,5%

Source: SCEES, 2001



Map 3.4: Spring crop and cover crops surface in France 2000



Source: FSS, 2000

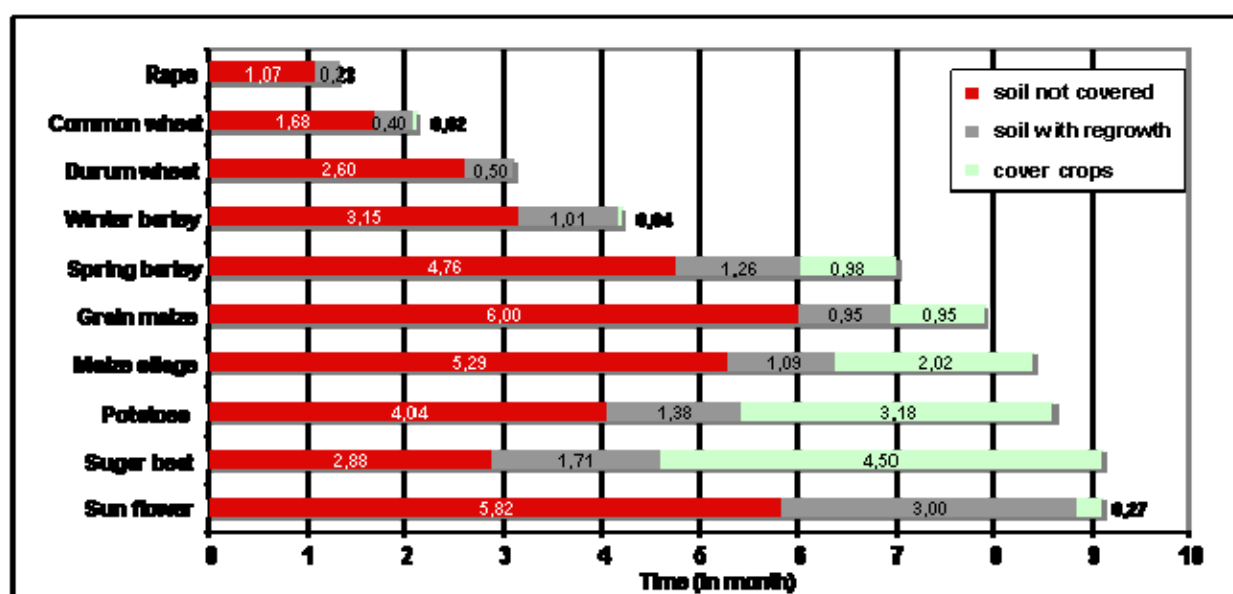
Despite between 2001 and 2006 cover crop surfaces tripled their extent up to 600,000 hectares; these were equivalent to 17 % of the spring crop only (Table 3.6). Therefore, more than 80 % of the area occupied by spring crops remained bare in autumn and winter. A part of potential bare soils is occupied by re-growth (Figure 3.4).

Table 3.6: Cover crop surfaces of main spring crops in France 2006

REGIONS	Crops surfaces ploughed			Simplified tillage crops surfaces		
	Spring crops surfaces (in ha)	Cover crop surfaces (in ha)	Part of cover crop	Spring crops surfaces (in ha)	Cover crop surfaces (in ha)	Part of cover crop
ALSACE	136 134	4 940	3,6%	11 304	0	0,0%
AQUITAINE	283 910	24 228	8,5%	86 349	6 274	7,3%
AUVERGNE	39 028	251	0,6%	4 722	0	0,0%
BASSE-NORMANDIE	182 888	23 032	14,2%	18 870	0	0,0%
BOURGOGNE	46 254	1 941	4,2%	3 246	0	0,0%
BRETAGNE	323 928	152 791	47,2%	96 071	0	0,0%
CENTRE	208 438	19 519	9,5%	41 185	4 898	11,9%
CHAMPAGNE-ARDENNE	137 737	46 797	34,0%	27 930	11 438	41,0%
FRANCHE-COMTE	28 974	1 984	6,8%	6 524	0	0,0%
HAUTE-NORMANDIE	80 795	14 814	21,0%	10 725	0	0,0%
ILE-DE-FRANCE	78 958	21 063	26,7%	11 394	0	0,0%
LANGUEDOC-ROUSSILLON	15 925	0	0,0%	1 275	0	0,0%
LORRAINE	70 283	2 628	3,7%	4 455	0	0,0%
MIDI-PYRENEES	243 700	4 407	1,8%	79 289	929	1,2%
NORD-PAS-DE-CALAIS	189 928	47 193	27,8%	14 434	0	0,0%
PAYS DE LA LOIRE	327 585	83 194	29,3%	84 585	18 792	22,2%
PICARDIE	281 947	97 981	37,4%	32 841	0	0,0%
POITOU-CHARENTES	305 178	5 572	1,8%	62 444	3 280	5,2%
PROVENCE-ALPES-COTE D'AZUR	0	0		0	0	
RHONE-ALPES	118 178	3 189	2,7%	13 987	0	0,0%
Total France	3 817 633	637 728	17,0%	841 388	46 381	7,4%

Source: SCEES, 2006

Figure 3.4: Average time of intercropping per type of management in France 2006



Source: SCEES, 2006



3.5 Simplified tillage techniques

3.5.1 Area concerned

Simplified tillage techniques are growing in popularity in France (see tables maps and figures below). They represented **34 %** of main crop areas in 2006 compared to 20.5 % in 2001. The South-West (**Midi-Pyrénées**, Languedoc-Roussillon, Aquitaine) and North (Picardie, Champagne-Ardenne) are the main areas where these techniques have developed. In these regions simplified techniques represent over 40 % of surfaces (and up to **50 % in Midi-Pyrénées**).

Comparatively, no-tillage represented only **1.5 %** of surfaces in 2006 at national level. Therefore, at present, it can be considered a technique of marginal use. **Midi-Pyrénées** is the region where no-tillage is the most developed. It represents **4.1 %** of surfaces.

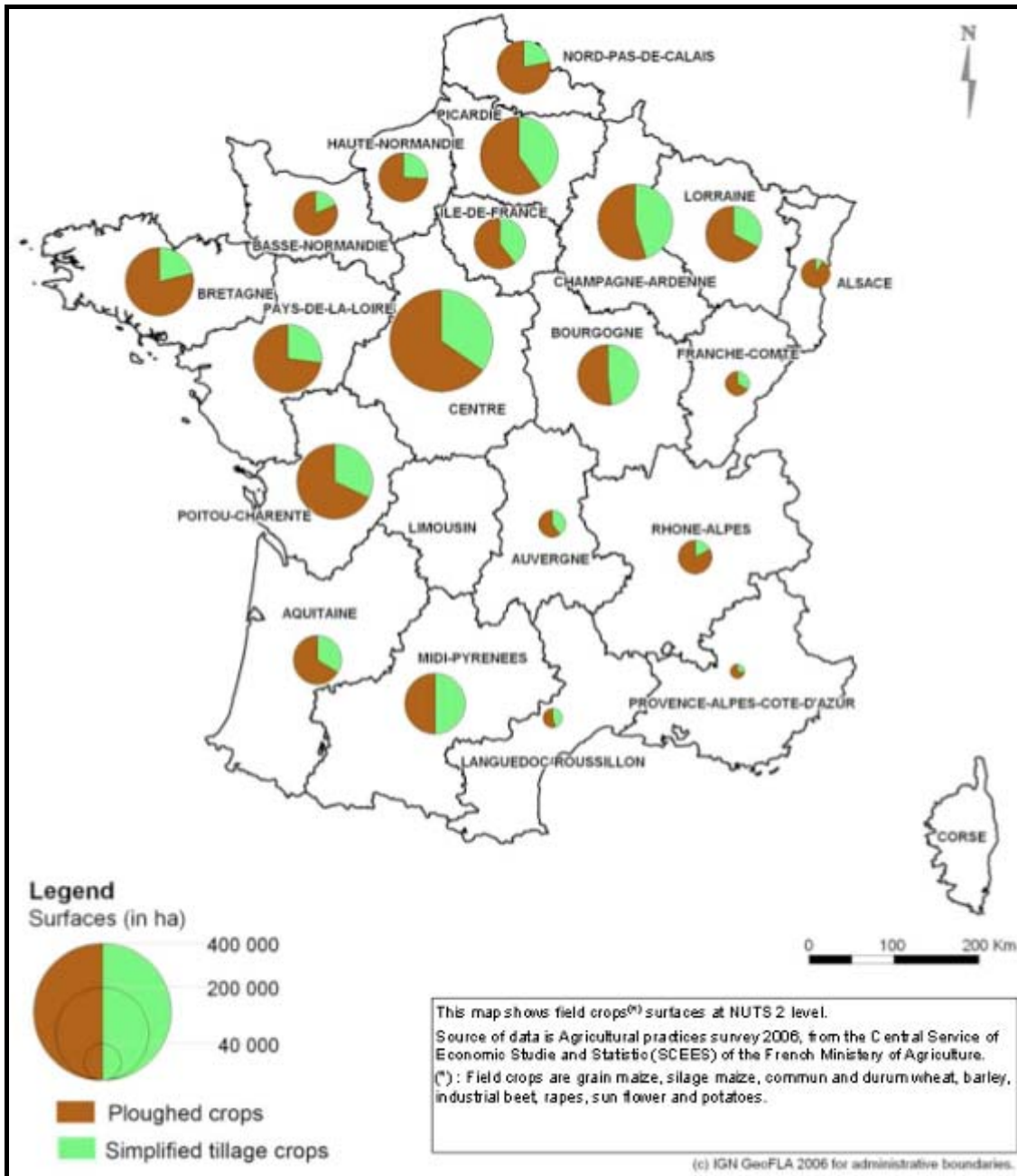
These techniques are far more developed on **winter crops** (cereals and rapeseed) than on spring crops. In 2006, they accounted for **42.3 % of winter crops** and only 17 % of spring crops (up to 24.6 % for Midi-Pyrénées). This represents an **increase of 19.3 %** for the spring crop and **78.9 % for winter crops between 2001 and 2006**.

In 2006, for winter crops, the proportion of surfaces using these techniques exceeded **70 % (79.4 % to 73.9 % Aquitaine and Midi-Pyrénées)**. In Midi-Pyrénées, 85 % of durum wheat and 76 % of the common wheat surfaces are managed with these techniques (Chapelle-Barry, 2008).

Simplified tillage techniques attracted **large farms**. On average, **58 %** of surfaces are no more ploughed in farms of more than **400 hectares** in 2006. This proportion rises to 74 % for common wheat for the same type of farms (Chapelle-Barry, 2008).



Map 3.5: Distribution of simplified tillage techniques within field crops 2006



Source: SCEES, 2006

**Table 3.7: Simplified tillage crops surfaces in France 2006**

REGIONS	Total of crops surfaces in 2006 (in ha)	Simplified tillage crops surfaces in 2006 (in ha)		Simplified tillage crops surfaces in 2001 (in ha)	
		Surfaces (in ha)	% on total surfaces	Surfaces (in ha)	% on total surfaces
AQUITAINE	454 134	152 916	33,7%	58 398	38,2%
ALSACE	186 550	16 566	8,9%	3 195	19,3%
AUVERGNE	144 149	56 849	39,4%	11 956	21,0%
BASSE-NORMANDIE	376 759	70 003	18,6%	17 344	24,8%
BOURGOGNE	653 098	313 084	47,9%	120 292	38,4%
BRETAGNE	784 000	166 835	21,3%	45 205	27,1%
CENTRE	1 580 915	551 009	34,9%	158 414	28,7%
CHAMPAGNE-ARDENNE	960 815	432 841	45,0%	156 988	36,3%
FRANCHE-COMTE	132 280	44 517	33,7%	11 990	26,9%
HAUTE-NORMANDIE	446 700	116 354	26,0%	23 275	20,0%
ILE-DE-FRANCE	463 204	183 876	39,7%	39 060	21,2%
LANGUEDOC-ROUSSILLON	82 500	36 450	44,2%	7 336	20,1%
LORRAINE	574 957	188 390	32,8%	70 738	37,5%
MIDI-PYRENEES	666 349	332 909	50,0%	111 354	33,4%
NORD-PAS-DE-CALAIS	519 265	113 298	21,8%	17 240	15,2%
PAYS DE LA LOIRE	772 851	208 203	26,9%	53 717	25,8%
PICARDIE	1 011 867	406 663	40,2%	78 966	19,4%
POITOU-CHARENTES	958 972	307 455	32,1%	99 673	32,4%
PROVENCE-ALPES-COTE D'AZUR	50 840	13 888	27,3%	5 338	38,4%
RHONE-ALPES	224 214	39 190	17,5%	11 930	30,4%
Total France	11 044 415	3 751 298	34,0%	1 102 409	29,4%

Source: SCEES, 2006



Table 3.8: Simplified tillage field crops surfaces in France 2001

REGIONS	Total of crops surfaces in 2001 (in ha)	Simplified tillage crops in 2001	
		Surfaces (in ha)	Part of simplified tillage surfaces
AQUITAINE	498 921	122 737	24,8%
ALSACE	188 388	44 517	23,8%
AUVERGNE	150 813	47 515	31,5%
BASSE-NORMANDIE	373 533	24 778	6,6%
BOURGOGNE	647 504	193 505	29,9%
BRETAGNE	770 844	70 185	9,1%
CENTRE	1 547 168	320 724	20,7%
CHAMPAGNE-ARDENNE	885 163	262 644	29,3%
FRANCHE-COMTE	138 870	23 735	17,0%
HAUTE-NORMANDIE	441 292	59 898	13,6%
ILE-DE-FRANCE	481 870	134 837	28,2%
LANGUEDOC-ROUSSILLON	77 709	42 328	54,5%
LORRAINE	557 098	124 231	22,3%
MIDI-PYRENEES	708 599	267 618	38,4%
NORD-PAS-DE-CALAIS	529 421	38 098	6,8%
PAYS DE LA LOIRE	748 408	98 652	13,2%
PICARDIE	1 018 124	184 799	18,2%
POITOU-CHARENTES	999 719	185 792	18,6%
PROVENCE-ALPES-COTE D'AZUR	48 534	19 230	39,8%
RHONE-ALPES	244 742	13 295	5,4%
Total France	11 047 339	2 287 116	20,6%

Source: SCEES, 2001



Table 3.9: Simplified tillage surfaces of main spring crops in France 2001 and 2006

REGIONS	Year 2001			Year 2006			Evolution 2001-2006		
	Spring crops surfaces (In ha)	Simplified tillage surfaces (In ha)	Part of simplified tillage	Spring crops surfaces (In ha)	Simplified tillage surfaces (In ha)	Part of simplified tillage	Spring crops surfaces (In ha)	Simplified tillage surfaces (In ha)	Part of simplified tillage
ALSACE	151 179	36 482	24.1%	147 500	11 364	23.3%	-3 679	-25 118	-68.9%
AQUITAINE	436 929	83 808	19.2%	370 258	86 349	7.7%	-66 671	2 541	3.0%
Auvergne	47 407	5 578	11.8%	43 750	4 722	10.8%	-3 657	-858	-15.3%
BASSE-NORMANDIE	197 229	8 240	4.2%	181 559	18 870	10.4%	-15 670	10 630	129.0%
BOURGOGNE	35 802	1 759	4.9%	49 500	3 248	6.6%	13 698	1 487	84.5%
BRETAGNE	459 880	44 219	9.6%	420 000	96 071	22.9%	-39 880	51 852	117.3%
CENTRE	304 557	34 635	11.4%	247 620	41 185	16.6%	-56 937	6 550	18.9%
CHAMPAGNE-ARDENNE	129 680	11 491	8.9%	185 688	27 930	18.9%	35 988	16 439	143.1%
FRANCHE-COMTE	44 074	3 452	7.8%	35 500	6 524	18.4%	-8 574	3 072	89.0%
HAUTE-NORMANDIE	106 387	11 895	11.2%	71 510	10 725	15.0%	-34 877	-1 170	-9.8%
ILE-DE-FRANCE	124 015	18 735	15.1%	90 352	11 394	12.6%	-33 663	-7 341	-39.2%
LANGUEDOC-ROUSSILLON	0	0	-	17 200	1 275	7.4%	17 200	1 275	-
LORRAINE	86 443	5 463	6.3%	74 737	4 455	6.0%	-11 706	-1 008	-18.5%
MIDI-PYRENEES	396 236	62 255	15.7%	323 000	79 299	24.6%	-73 236	17 044	27.4%
NORD-PAS-DE-CALAIS	210 130	14 804	7.0%	184 383	14 434	7.5%	-25 747	-370	-2.5%
PAYS DE LA LOIRE	488 434	65 632	13.4%	412 150	84 585	20.5%	-76 284	18 953	28.9%
PICARDIE	356 979	29 548	8.3%	294 786	32 841	11.5%	-62 193	3 293	11.1%
POITOU-CHARENTES	491 773	68 758	14.0%	387 620	62 444	17.0%	-124 153	-8 314	-9.2%
PROVENCE-ALPES-COTE D'AZUR	0	0	-	0	0	-	0	0	-
RHONE-ALPES	160 611	5 623	3.5%	131 764	13 587	10.3%	-28 847	7 964	141.6%
Total France	4 227 745	612 377	12,1%	3 628 837	611 300	17,0%	-598 908	96 923	19,3%

Source: SCEES, 2001-2006



Table 3.10: Simplified tillage surfaces of main winter crops in France 2001 and 2006

REGIONS	Year 2001			Year 2006			Evolution on 2001-2006		
	Winter crops surfaces (In ha)	Simplified tillage surfaces (In ha)	Part of simplified tillage	Winter crops surfaces (In ha)	Simplified tillage surfaces (In ha)	Part of simplified tillage	Winter crops surfaces (In ha)	Simplified tillage surfaces (In ha)	Part of simplified tillage
ALSACE	37 187	8 035	21,6%	39 050	5 202	13,3%	1 863	-2 833	-35,3%
AQUITAINE	61 982	38 929	62,9%	63 676	66 667	79,4%	21 694	27 639	71,0%
Auvergne	103 208	41 937	40,6%	100 399	52 127	51,9%	-2 807	10 190	24,3%
BASSE-NORMANDIE	176 304	16 538	9,4%	195 200	51 133	26,2%	18 896	34 595	209,2%
BOURGOGNE	611 702	191 746	31,3%	603 598	309 838	51,3%	-8 104	118 092	61,6%
BRETAGNE	310 964	25 966	8,4%	364 000	70 764	19,4%	53 036	44 798	172,5%
CENTRE	1 242 631	286 089	23,0%	1 333 295	509 824	38,2%	90 664	223 735	78,2%
CHAMPAGNE-ARDENNE	765 503	251 153	32,8%	795 147	404 911	50,9%	29 644	153 758	61,2%
FRANCHE-COMTE	95 796	20 283	21,2%	96 780	37 993	39,3%	984	17 710	87,3%
HAUTE-NORMANDIE	334 905	48 001	14,3%	375 190	105 629	28,2%	40 285	57 628	120,1%
ILE-DE-FRANCE	337 655	116 102	34,4%	372 852	172 482	46,3%	35 197	56 380	48,6%
LANGUEDOC-ROUSSILLON	77 709	42 328	54,5%	85 300	35 175	53,9%	-12 409	-7 153	-16,9%
LORRAINE	470 655	118 768	25,2%	500 220	183 935	36,8%	29 565	65 167	54,9%
MIDI-PYRENEES	312 363	195 363	62,5%	343 349	253 610	73,9%	30 986	58 247	29,9%
NORD-PAS-DE-CALAIS	319 291	21 294	6,7%	334 902	98 864	29,5%	15 611	77 570	364,3%
PAYS DE LA LOIRE	259 975	33 020	12,7%	360 701	123 618	34,3%	100 726	90 598	274,4%
PICARDIE	661 145	155 251	23,5%	717 081	373 822	52,1%	55 936	218 571	140,8%
POITOU-CHARENTES	507 946	117 034	23,0%	591 352	245 011	41,4%	83 406	127 977	109,4%
PROVENCE-ALPES-COTE D'AZUR	48 534	19 230	39,6%	50 840	13 888	27,3%	2 306	-5 342	-27,8%
RHONE-ALPES	84 131	7 672	9,1%	92 450	25 603	27,7%	8 319	17 931	233,7%
Total France	6 919 694	1 764 739	25,7%	7 415 692	3 139 996	42,3%	596 999	1 365 257	76,9%

Source: SCEES, 2001-2006



Table 3.11: No-tillage field crops surfaces in France 2001

REGIONS	No-tillage crops surfaces In 2008 (in ha)	Part of no-tillage crops surfaces in simplified tillage crops surfaces
AQUITAINE	4 130	2,7%
ALSACE	0	0,0%
Auvergne	0	0,0%
BASSE-NORMANDIE	0	0,0%
BOURGOGNE	0	0,0%
ORCTAGNE	1 400	0,0%
CENTRE	9 111	1,7%
CHAMPAGNE-ARDENNE	5 881	1,3%
FRANCI-COMTE	543	1,2%
HAUTE-NORMANDIE	1 063	0,8%
ILE-DE-FRANCE	1 889	0,9%
LANGUEDOC-ROUSSILLON	0	0,0%
LORRAINE	8 745	3,8%
MIDI-PYRENEES	13 634	4,1%
NORD-PAS-DE-CALAIS	2 008	1,8%
PAYS DE LA LOIRE	5 147	2,5%
PICARDIE	0	0,0%
POITOU-CHARENTES	4 618	1,6%
PROVENCE-ALPES-COTE D'AZUR	0	0,0%
RHONE-ALPES	1 108	2,8%
Total France	68 745	1,6%

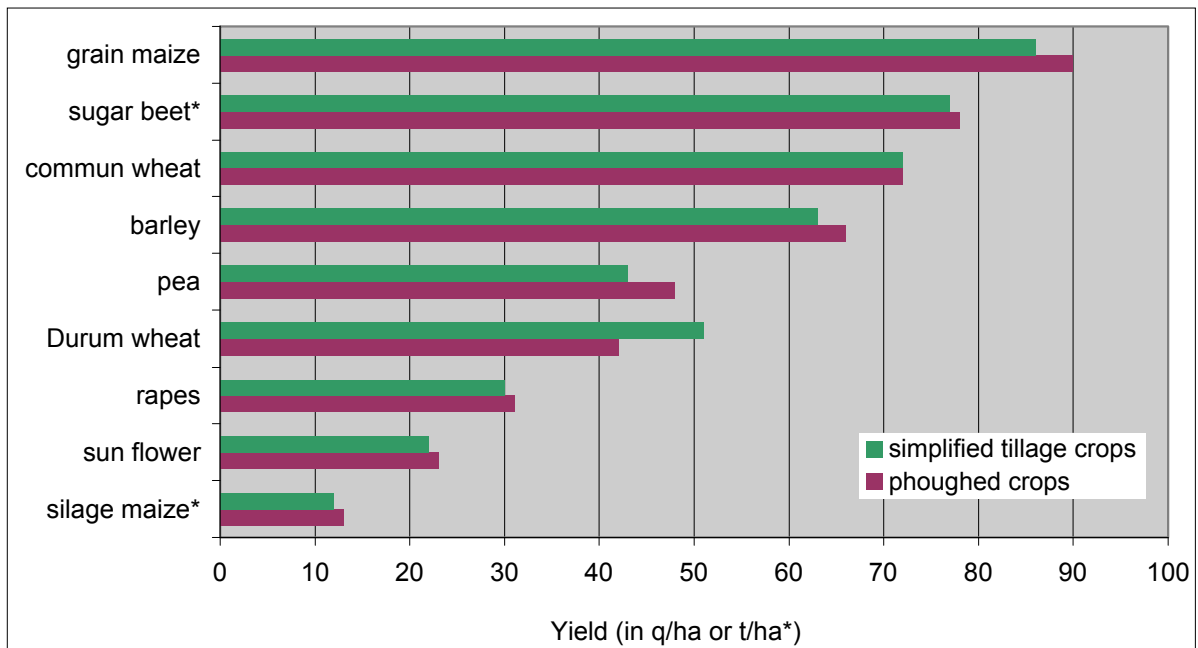
Source: SCEES, 2001

3.5.2 Impact on yields

Nationally, yields of ploughed crops and of simplified tillage crops are comparable. Winter crop yields (straw cereals) are higher under simplified tillage techniques, maybe due to the greater adaptability of these techniques. Yield differences appear significant for spring crops in favour of ploughed crops but always within 5 % between the two techniques. In certain regions (where simplified techniques are developed and controlled by farmers), yield differences for spring crops decrease. For specific regions, yields are greater under simplified tillage, such as maize in Aquitaine.

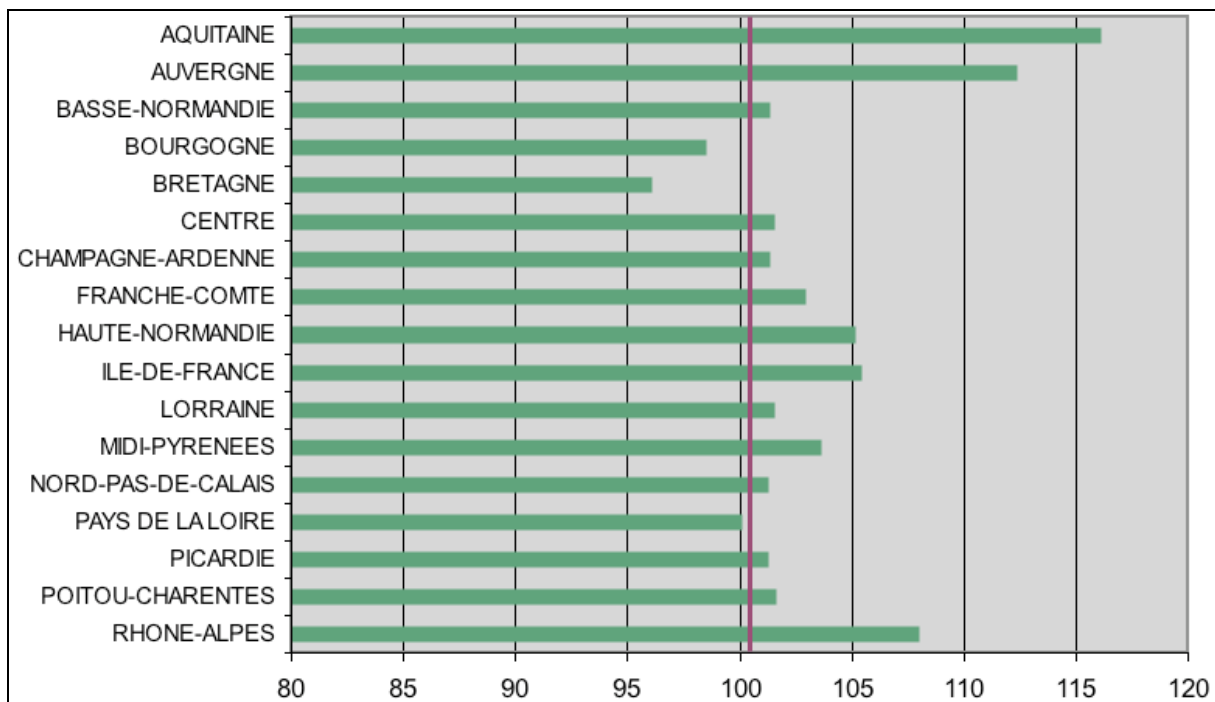


Figure 3.5: Average yield of field crops in France 2006



Source: SCEES, 2006

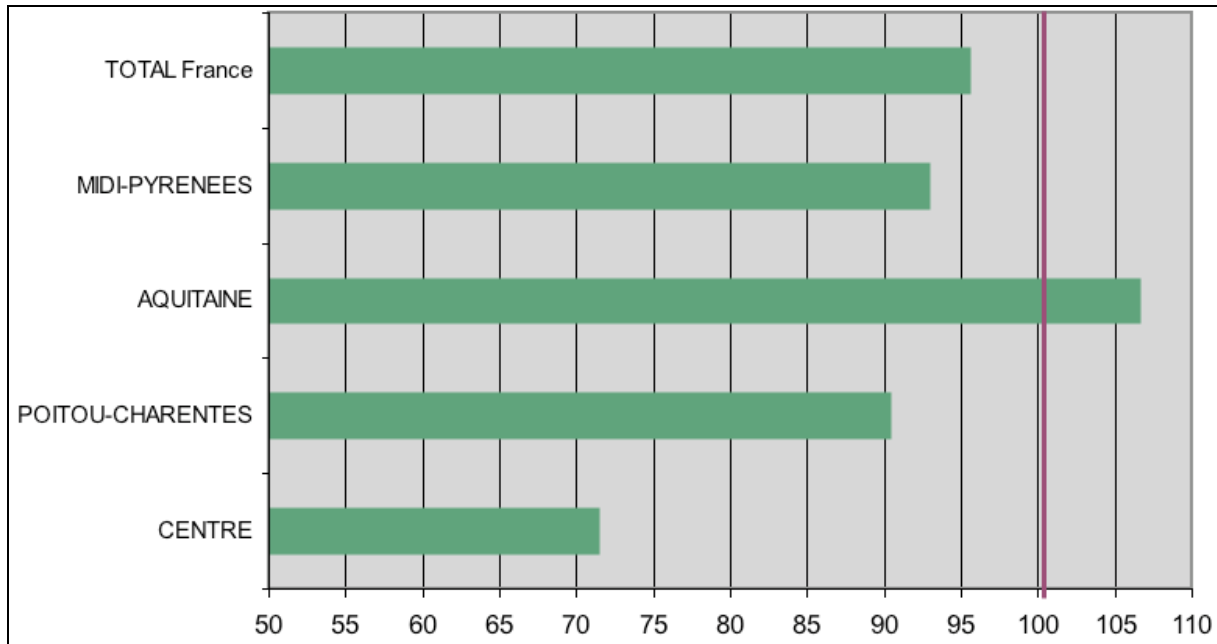
Figure 3.6: Comparison of the average yield of simplified cultivation methods, with ploughing (base 100), for common wheat per region in France 2006



Source: SCEES, 2006



Figure 3.7: Comparison of average yield of simplified tillage with ploughing (base 100), for grain maize per region in France 2006



Source: SCEES, 2006

3.5.3 Herbicide use

The number of **herbicide treatments is higher** under simplified tillage techniques (Figure 3.8). There are, on average, and all cultures, 0.3 additional treatments with a herbicide compared to farmers using a plough. This gap is 0.3 treatments for wheat and 0.7 for rape. **Alternative to herbicides remains the exception.** Mechanical weeding covers 7 % of annual crops in 2006 because it is costly to implement (see details results at farm level specific chapter). Another solution to fight against weeds is the management of the rotation (in alternating winter crops and spring, grasses, to cut the cycle of certain weeds (Chapelle-Barry, 2008).

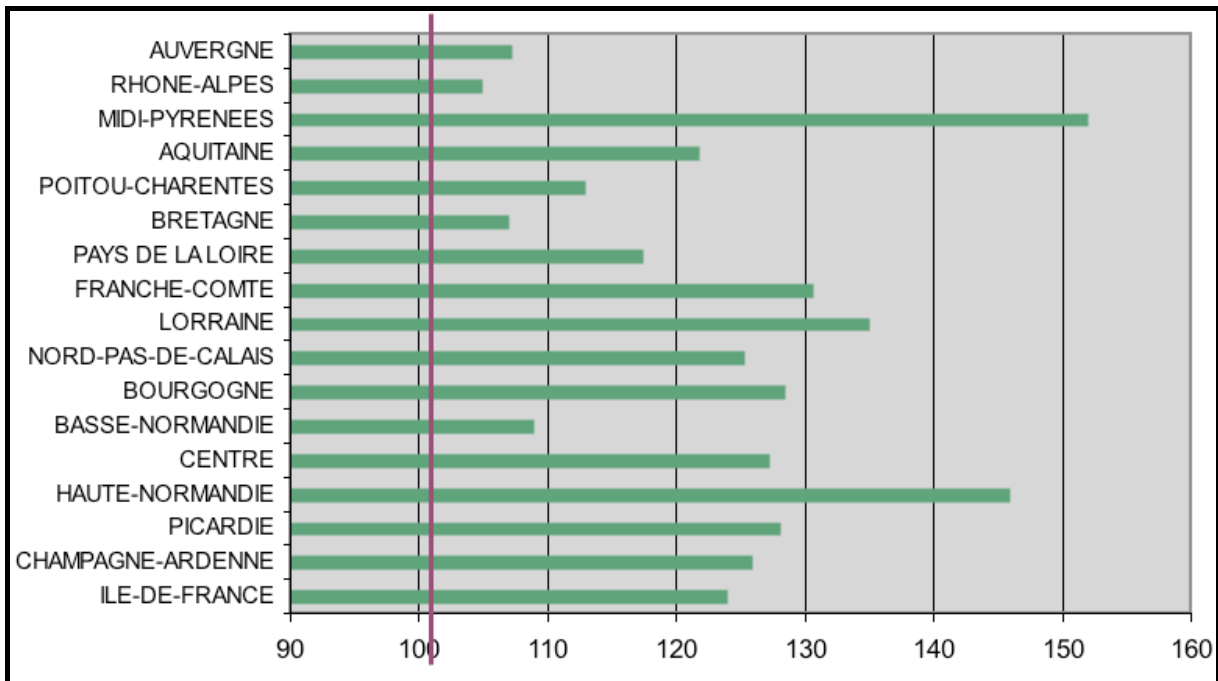


Figure 3.8: Average number of herbicide treatments of field crops in France 2006



Source: SCEES, 2006

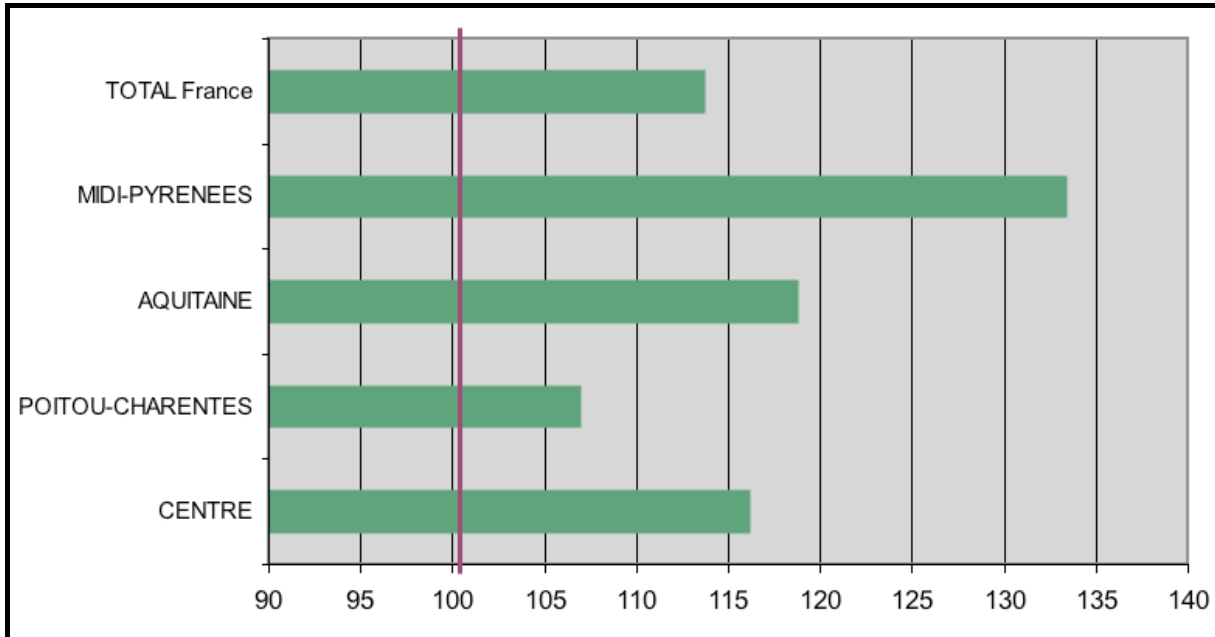
Figure 3.9: Comparison of average number of herbicide treatment of simplified cultivation methods, with ploughing (base 100), for common wheat in France 2006



Source: SCEES, 2006



Figure 3.10: Comparison of average number of herbicide treatments of simplified tillage with ploughing (base 100), for grain maize per region in France 2006



Source: SCEES, 2006

3.6 Other practices applied for soil conservation

3.6.1 Buffer strips

In France the total area of buffer strips has increased since 2005 as a consequence of the application of cross compliance and of the French GAECs. According to a rough estimate, approximately **423,000 ha** had been planted in France along rivers after the introduction of cross compliance, but no up-to-date statistics are yet available.

More details on the implementation of grass buffer strips in France are given in the policy chapter.

As for other types of buffer strips, the land reform measures (*'remembrement'*), aimed at increasing field size and group the parcels of each farmer, have contributed to the destruction of many of hedgerows during the period 1960-1980. In some regions as *Haute-Normandy* or *Picardie* these measures have lead to the emergence of soil erosion where the problem had not previously occurred.

Despite **one third of the existing French hedgerows is situated along riverbanks**, most of the new hedgerows implemented since 1981 are located in arable lands and open landscapes. **About 3,000 km of hedgerows are implemented each year in France**, which represents approximately 5 % of the total hedge length. **However, the new plantations do not compensate for the removals.**

**Table 3.12: Development of hedgerow length**

Sources	Period covered by survey	Total area or length	Development	In %
TERUTI Survey	1982-1990	376,000 - 359,000 ha	-2,125 ha/year	-5 %
TERUTI Survey	1993-2003	590,000 - 608,000 ha	+1,800 ha/year	+3 %
IFN Inventory	1 st cycle (~1975)	1,244,110 km	-45,000 km/year	-43 %
IFN Inventory	2 nd cycle (~1987)	707,605 km		

Source: Teruti, 1990; IFN, 1987

3.6.2 Agro-forestry

Agro-forestry implemented in crop farming system is quiet new in France. The main objective is to product high quality timber. The implementation of agroforestry is realised under the '*circulaire*' DGPEI/SPM/C2007-4021 of 3 April 2007.

1,000 ha of agro-forestry (mainly chestnuts, poplars and pear trees) have been planted in 2007 and 2008 in 20 departments under a national program.

3.6.3 Organic farming

In 1993, the budget provided by the French government for conversion aids to organic farming was still very modest in comparison to other EU-countries.

In December 1997, a plan to stimulate and improve organic production, distribution and sales was launched with subsidies totalling 12.3 million Euros. The goal was to convert one million hectares of farmland and increase the number of organic producers to 25,000 by the year 2005. In order to achieve this goal, financial support for farm conversion was increased, and support was extended to marketing initiatives as well as to training and research.

Despite the efforts, in 2005, there were only **11,402 organic farms** in France (+3 % compared to 2004) managing **560,838 hectares (2 % of the agricultural land)**.

The highest growth rates of growth for organic farming were noted in Pays de la Loire (+15.2 % of the surface), Poitou-Charentes (+9.3 %) and Centre (+9.1 %). The region with the largest area under organic management is Midi-Pyrénées with almost 70,000 hectares.

The main crop productions are grasslands (62 %), cereals, seed rapes (22 %) and vineyards (3 %).

In the framework of the 'Grenelle de l'Environnement', the ministry of agriculture has fixed an objective of 20 % of the UAA in organic farming in 2020.

3.6.4 Terraces

Terraces were traditional landscape features in South of France, along the Mediterranean coast and in the Rhône valley, particularly for **fruit productions and vineyards**. The majority of these terraces were **abandoned** in the last centuries and are now covered by forests and shrublands.

Terraces are still managed in some specific vineyards as Collioure in Roussillon.

No statistical data are available to estimate the agricultural surfaces covered by terraces.



3.6.5 Contour farming

No statistical data are available to estimate the implementation of this technique.

3.7 Conclusions

Table 3.13 below summarizes the main conclusions concerning the impact of the farming system and practices on soil erosion. The consequences of the current trends on soil erosion are derived based on the effects of each practice as detailed in WP1.









Furthermore, Figure 3.11 depicts some of the soil conservation measures (mainly against runoff and erosion) in use throughout the country.

Table 3.13: Farming systems and farming practices in France, trends and impacts on soil erosion

	National trend (1970-2007)	Effects	Recent development	Consequences of the current trend on soil erosion
Mixed farm	Reduction	Reduction of grasslands		---
Crop rotation	Simplification			--
Annual crop	Expansion	Increase of ploughed area		--
Spring crop	Expansion	High potential of bare soils	Spring crop surface decrease	--
Soil cover	Low level of implementation	Extension of bare soil	Development of cover crops	---
Parcel size	Expansion	Increase of length of the parcels		--
Tillage	Implementation of reduced and no-tillage	Reduction of run-off and erosion	Significant increase of simplified	+++
Agroforestry	1,000 ha implemented	No impact	Area increase	
Buffer strips	423,000 ha implanted	Located mainly along water ways	Area increased since 2005	+ (talweg implementation)
Organic farming	Only 2 % of UAA	Mainly grassland areas (62 %)	Objective: 20 % UAA in 2020	+ ?
Hedgerow plantation	3,000 km implemented/year but more destroyed	Planted hedgerow = 5 % of the total hedge length	New plantation do not compensate hedgerow removals	-
Terrace	Abandoned			-



Figure 3.11: Some of the landscape features in use in France to reduce run-off and erosion

	
<p>Grassy strip on a talweg</p>	<p>Fascine (Yves Le Bissonnais)</p>
	
<p>Buffer zone (infiltration) downstream of a plot</p>	<p>Grassed drainage (Yves Le Bissonnais)</p>
	
<p>Buffer (grassy) strip along waterway</p>	<p>Hedges across to the slope</p>
	
<p>Gripper ditcher (Christian Longueval)</p>	<p>3 different crops on long slope parcels</p>

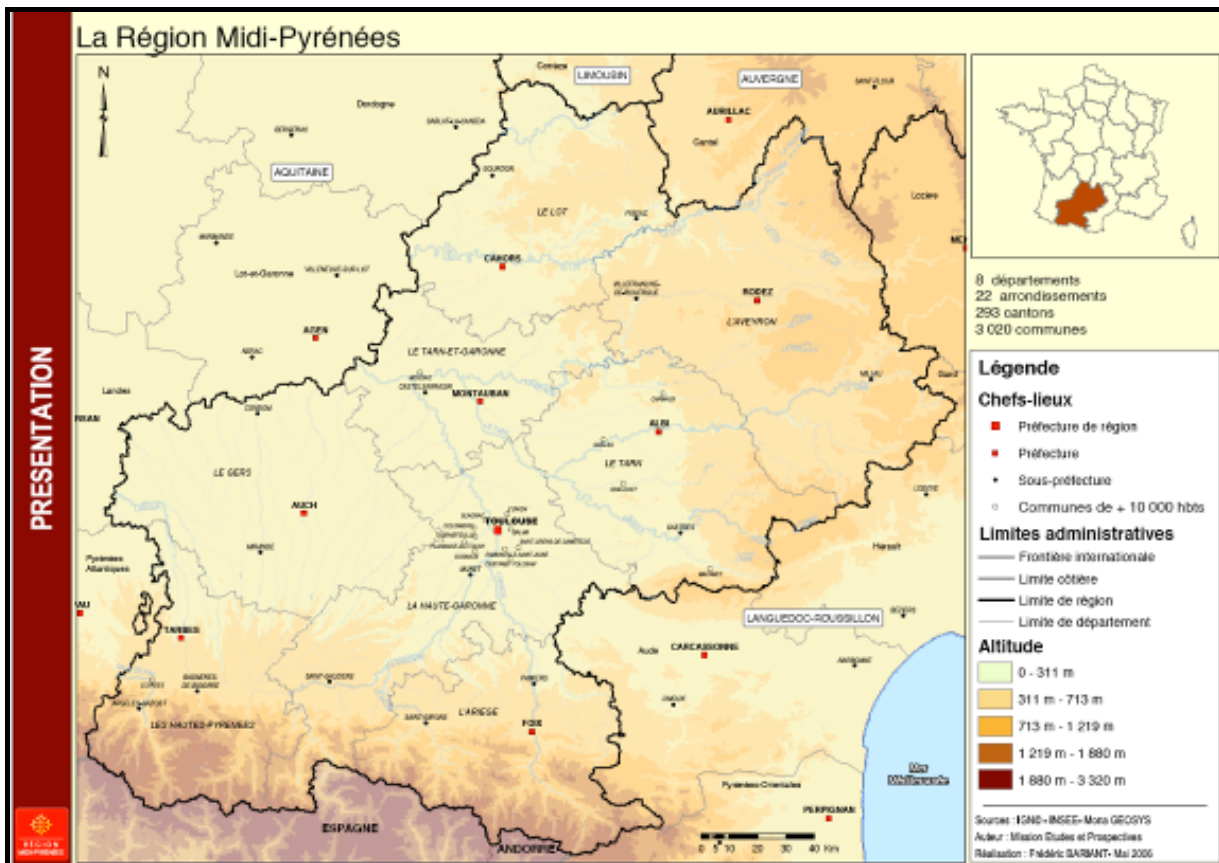


4 Midi-Pyrénées

4.1 Overview

The region of Midi-Pyrénées is located in the south of France with a border with Spain. It is the largest region in France with a total area of 45,348 km², representing 8.3 % of the total surface of France. Midi-Pyrénées is divided into 8 departments: Ariège, Haute-Garonne, Lot, Tarn, Tarn and Garonne, Aveyron, Gers and Hautes Pyrénées. Toulouse is the administrative centre of the region but also of Haute-Garonne.

Map 4.1: Region of Midi-Pyrénées



Source: Regional Council

Midi-Pyrénées hosts 2,755,000 inhabitants (latest data: 2006), representing 5 % of the total French population, with an average density of 56 inhabitants per km². However, excluding the weight of Toulouse, the pressure of the population in the rest of the region is very low. Some areas even approach the threshold of desertification. (Chambre d'Agriculture Midi-Pyrénées, 2006).

4.2 Soils

The regional chamber of agriculture of Midi-Pyrénées has delimited 48 soil-landscape cartographic units according to the nature of soils (bedrock), geomorphology, climate and vegetation (Bornand *et al.*, 1989).



Based on relief and altitude only, however, the Midi-Pyrénées region can be divided into just three large groups (See map below):

- **Midi-Pyrénées Central Basin**
- **Massif Central Southwest border**
- **Pyrénées**

Midi-Pyrénées Central Basin is further divided in two main areas. In the Northern part, the limestone plateaus of Quercy, Causse can be found, carved by erosion. In the central part, the landscape consists of molassic hills of the Tertiary, and alluvial plains and terraces of the Quaternary.

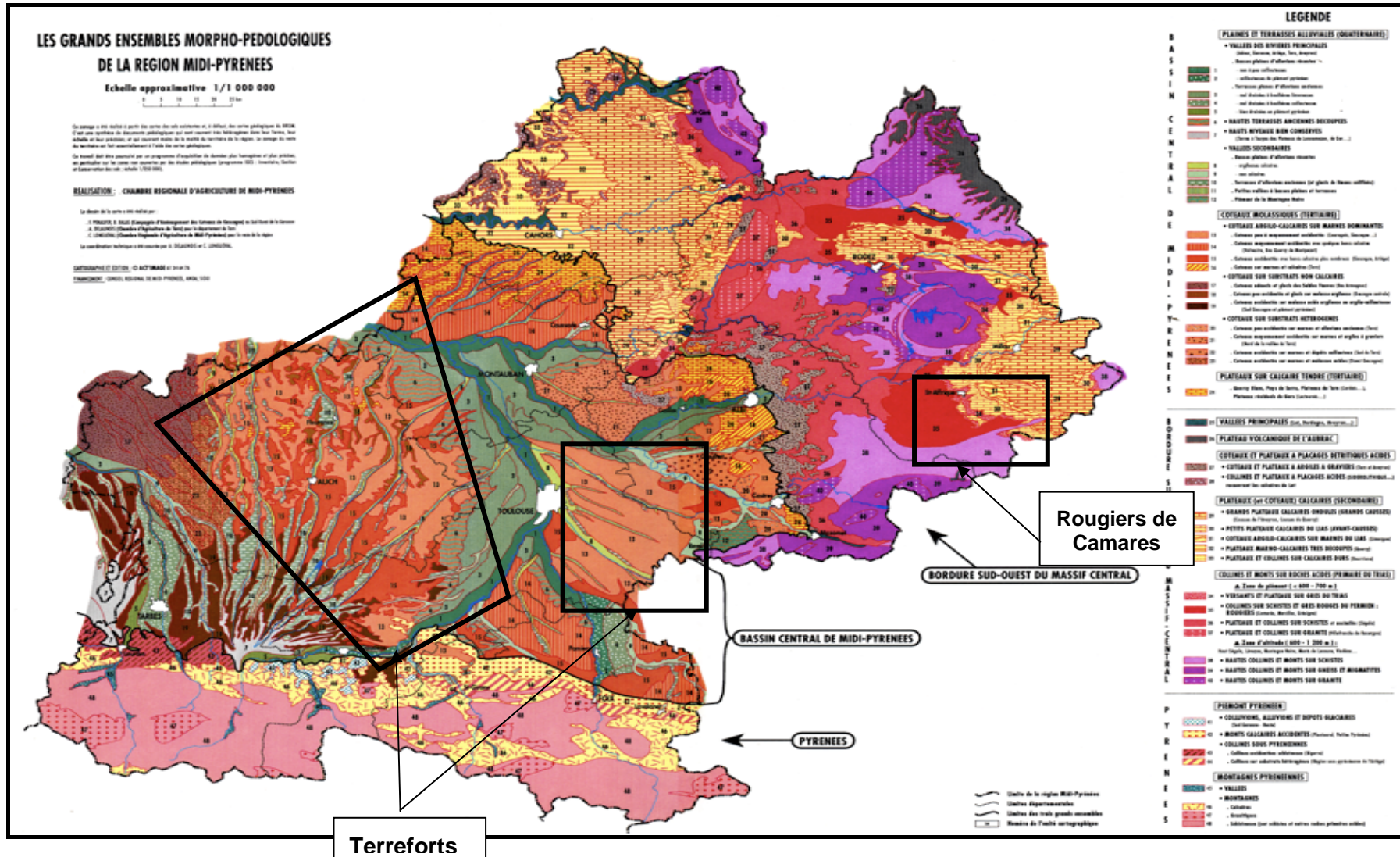
Massif Central Southwest border is divided into two main areas as well. The Northern part (the Southern occidental part of Massif Central: 300 to 1,400 metres above sea level), is composed of ancient mountains, with eroded summits (developed on acid rock of the Primary: shale, gneiss, granite), and highlands (on limestone of the Secondary). The Southern part included the mountains of Lacaune and Black Mountain.

Pyrénées represent the Southern part of the Midi-Pyrénées region. The Pyrénées are composed of: a high chain (peaked at over 3,000 m) and a low chain of mountains (pré-Pyrénées). The rocks are mainly composed of Pyrenean outcrops of the Primary (shale, granite) and of the Secondary (limestone).

Each unit is divided into **sub-group** and **subsystem** (See map below). Because of the wide variety of soils types, only soils (sub-group or subsystem) where soil erosion problems are important will be detailed hereafter: **Terreforts** and **Rougiers de Camarès**.



Map 4.2: Main morpho-pedologic classes of Midi-Pyrénées





- Terreforts

Terreforts are **clay-limestone hills on dominant marne**. The Tertiary clay-limestone hills cover a widespread area in the Midi-Pyrénées central basin (Map 4.2). Soils are clayey and calcareous (calcasol) especially on the low slope gradient areas where they are also deep. At the top of hills or on steep slopes, more superficial soils such as on marne (calcasols, rendosols) can be found.

Terreforts characterize several agricultural districts: **Lauragais (Haute-Garonne department)** and Coteaux du Gers (**Gers** département).

- Rougiers de Camarès

Rougiers de Camarès are **hills** on shale and red gres of Permien. This unit is characterised by bedrock geological **red color** composed primarily by fine layers of shale and sandstone. These soils are not so advanced. Colluviaux deep soils (colluviosols) are located at the slope bottom. They are not very deep, gravelly and often quite rich in sands. These fine layers are friable rock, **very sensitive to erosion** and forming a landscape with a high number of gullies.

4.3 Climate

Oceanic and Mediterranean fluxes clash constantly to create the peculiar climate of Midi-Pyrénées. The Oceanic climate brings along gentle winters (4 to 6 °C) and most of the rainfall, but it is the Mediterranean climate that provides high summer heat (20 to 22 °C) and sunny autumn. Rainfall is highly variable (600 to 700 mm in the centre of the region, more than 1,100 mm in the 'high margins' of the mountains of Lacaune, Aubrac or Pyrénées).

Almost the entire region is marked by a severe drought during the summer. The proximity of mountains often causes a 'cooling' effect in spring and autumn, which translates into 'early or late' frosts.

On the other hand, the mountain borders collect nearly 40 % of total rain that is released throughout the summer drought.

4.4 Land use and farming systems

4.4.1 Agriculture statistics

Midi-Pyrénées is the first French region concerning the number of holdings: **47,580** in 2007.

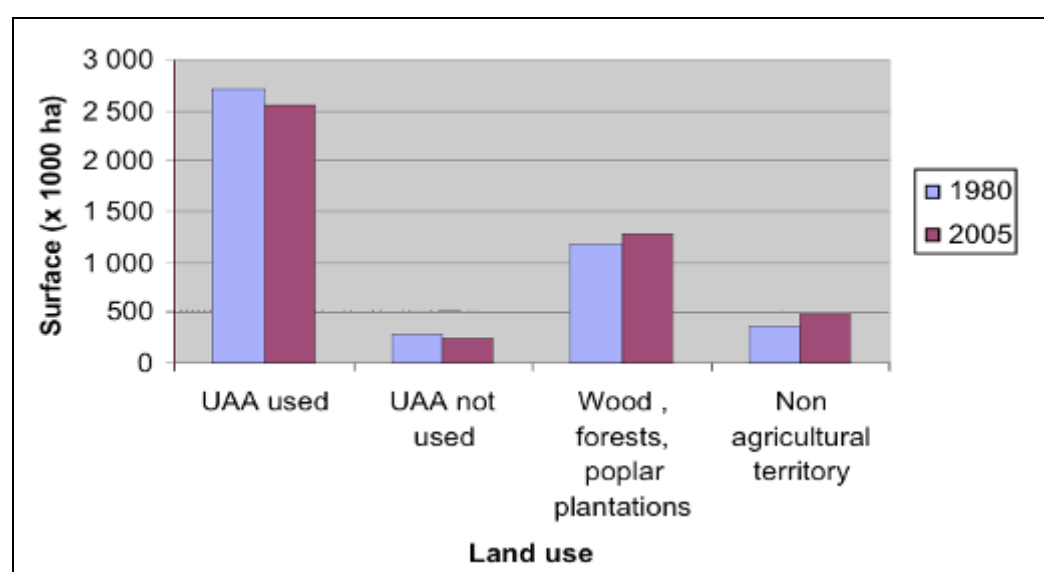
Cattle breeding, sheep breeding (24 % of the national livestock in Midi-Pyrénées) and cereal crops are the three main agricultural activities in Midi-Pyrénées. Vineyard, orchards, vegetables and tobacco are also renowned crops in the region (Agreste Midi-Pyrénées, 2008).

In 20 years, **42 % of the farms disappeared** consequently to farmer retirement (Agreste Midi-Pyrénées, 2008). The smaller farms and the least profitable were the first affected and land abandoned in favour of forest and non-agricultural territories.

**Table 4.1: Development of land use of Midi-Pyrénées 1980-2007**

Unit: 1,000 ha	1980	1990	2000	2005	2007	Development 1980-2007
UAA	2,724	2,657	2,591	2,559	2,543	-181
UAA non utilised	292	271	240	235	-	-57
Woods, forests, poplar plantations	1,174	1,198	1,267	1,278	1,281	+107
Non agricultural territory	369	433	461	488	-	+119
TOTAL surface	4,560	4,560	4,560	4,560	4,560	

Source: Agreste, Midi-Pyrénées)

Figure 4.1: Development of the land use in Midi-Pyrénées between 1980 and 2005

Source: Agreste, Midi-Pyrénées)

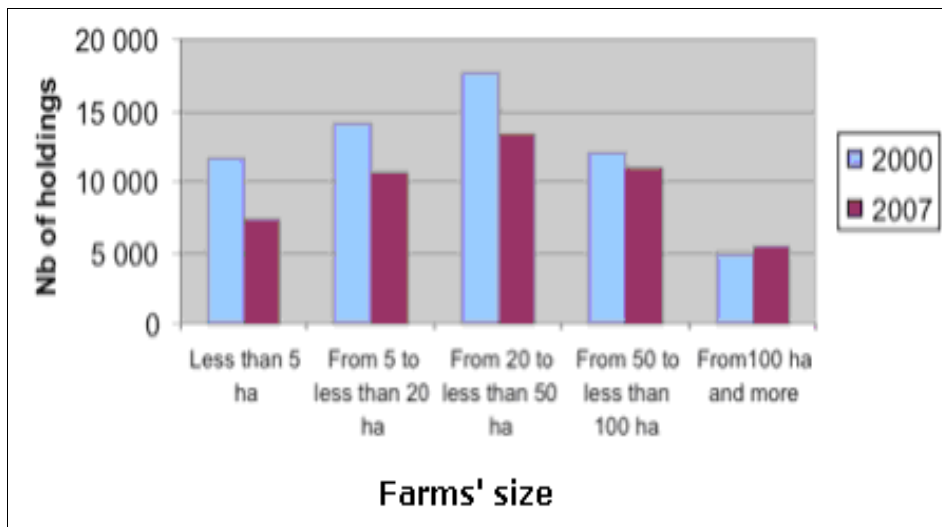
In less than 30 years (1980-2007), 181,000 ha of UAA were lost while the forest area increased of 107,000 ha. At the same time, construction of infrastructures (agglomeration of Toulouse, transports, dams) covered 119,000 ha of land.

Although afforestations can be considered as positive for soil protection and carbon storage, yet they are mainly located in mountains areas still covered by grasslands, therefore having little effect on erosion protection in agricultural areas. Indeed, plots where erosion risk is very high are not devoted to forest plantation, in particular due to the low proportion of aids compared to cereal crop margins (expert judgment).

Opposite of the number of holdings, farm size is on the rise. Their surface increased by 28 % from 1970 to 1988 and by 44 % (18 ha) from 1988 to 2000. In 2007, average farm size was 49 ha (39 ha in 2000). Holdings of over 100 ha (11 % of all the farms) are rising in dimensions with an increase of 3.3 % per year. These large farms managed 42 % of the regional agriculture area.



Figure 4.2: Distribution of holdings in Midi-Pyrénées according to their size

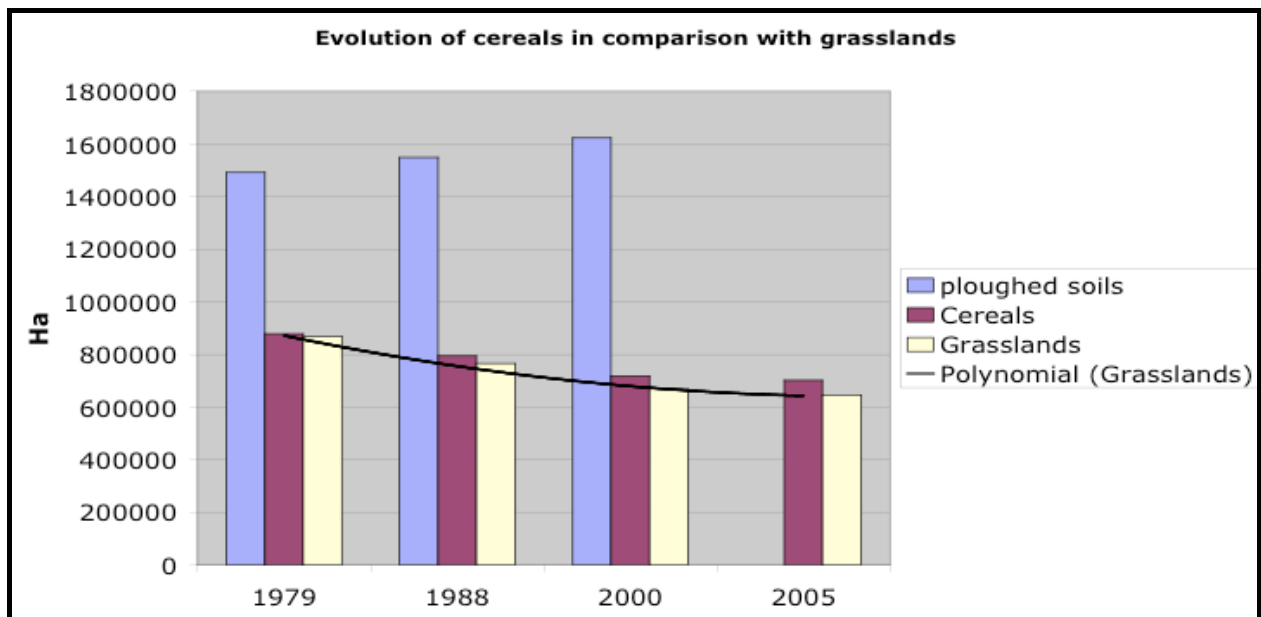


Source: Agreste, Midi-Pyrénées

Concerning land use, Midi-Pyrénées follows the national trend of **loss of permanent grasslands in favour of annual crops**. Annual crops (cereals and oilseeds) occupied 972,250 ha, whereas permanent crops and grasslands covered only 646,814 ha in 2005.

This difference constitutes a significant development in comparison with previous years where their repartition was equal.

Figure 4.3: Development of cereals in comparison with grasslands



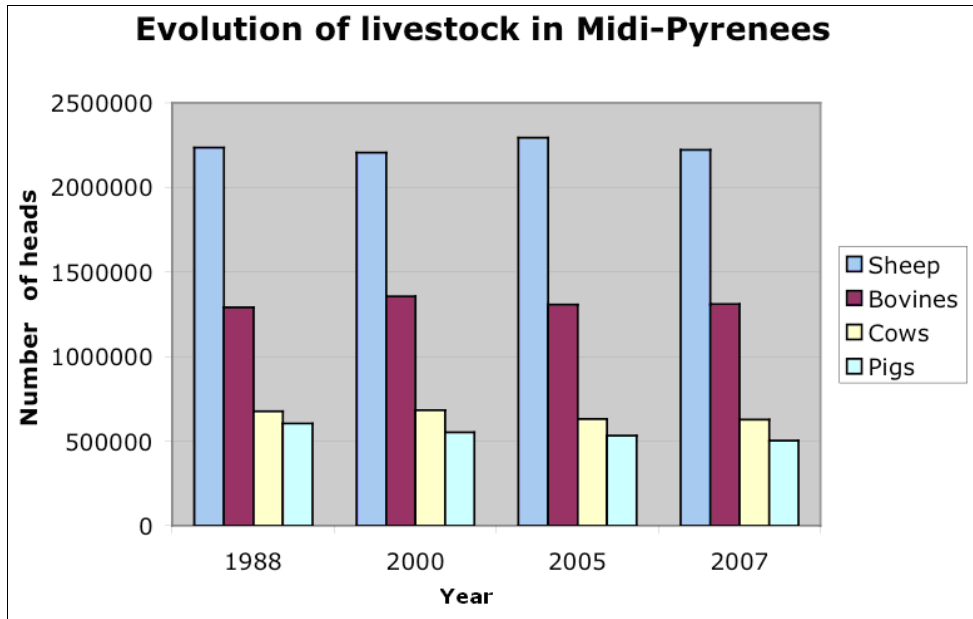
Source: Agreste, 2005, no data available for ploughed soils in 2005

With the decrease of permanent grasslands, cattle breeding, sheep breeding and pigs were also accompanied by a slow decrease as the national trend (Agreste, 2005) (Figure 4.4). Within the bovine reproductive livestock, this decline is marked for meat cows and dairy cattle (6.4 %). On the other hand, heifers nursemaids are more numerous (2.1 %). In the opposite, within the ovine breeders, the decline concerns essentially ewes nursemaids.



As for the dairy ewes, among which 97 % of the potential is located in the **Aveyron** and **Tarn** for the manufacturing of **Roquefort**, their numbers is still stationary. It represents half of the French herd. This trend endorses the **specialisation** of areas devoted to livestock.

Figure 4.4: Development of livestock of Midi-Pyrénées



Source: Agreste, Midi-Pyrénées

In the centre of the region, a large zone of cereals crops stretches from North of Hautes-Pyrénées to South of Tarn. The main field crops in Midi-Pyrénées are:

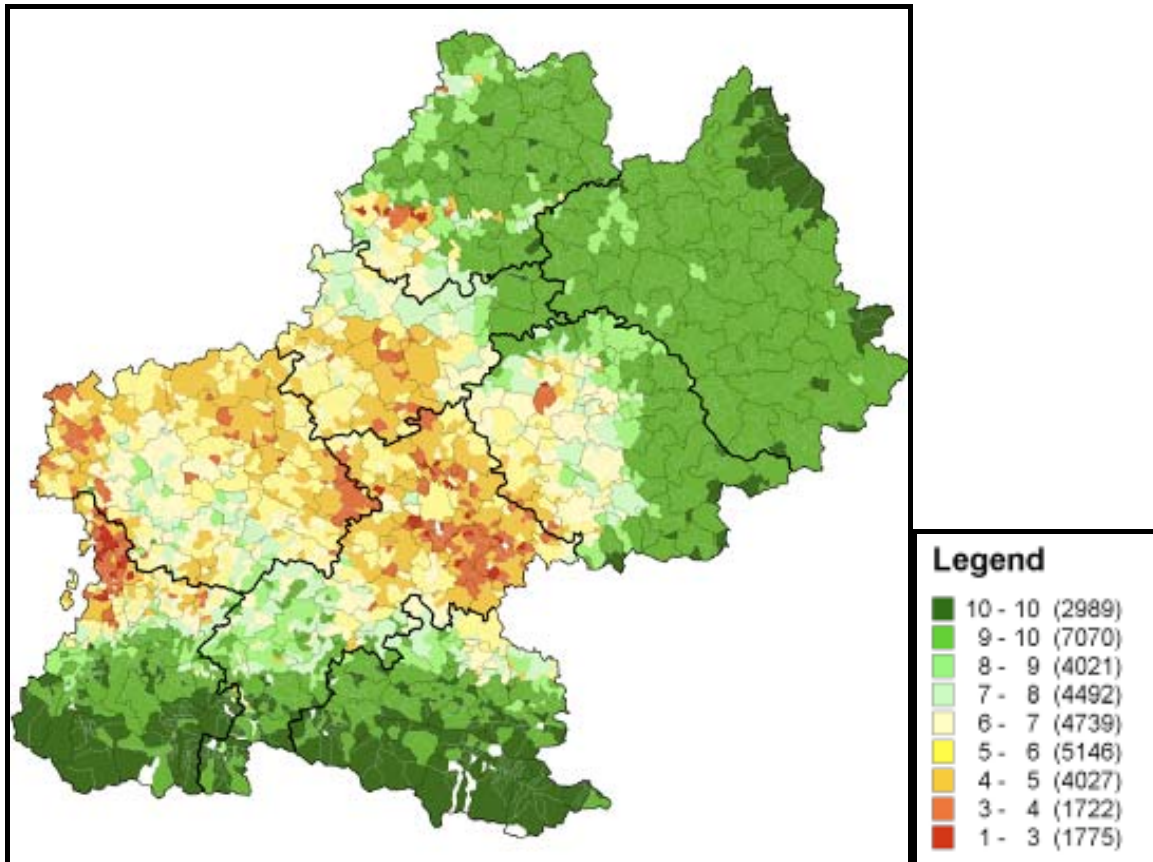
- Winter crops: **winter wheat, durum wheat**, barley, oats and **rape**;
- Spring crops: **maize, fodder maize, sunflower**, soya, pea and sorghum.

The rest of the region is mainly reserved to fodder crops and livestock.

This point confirms that Midi-Pyrénées is a specialised region. The map below concerning crop diversity shows that some departments are specialised in field crops (Haute-Garonne, Gers, and Tarn). This **increases the erosion risk due both to short crop rotation and to long inter crop time**.



Map 4.3: Diversity of crops and share of permanent grassland by commune (Midi-Pyrénées), 2000



Source: Pointereau *and* Bisault, 2006

The 'crop diversity' indicator (Pointereau and Bisault, 2006) goes from 1 (monoculture) to 10 (large rotation and/or large surface of grasslands) for each farm and each municipality. This indicator was also used to deal with the data of the agricultural practices survey.

70 % of farms in Midi-Pyrénées cultivate **cereals** (Table 4.2). The cereals and oilseeds area (894,786 ha) decreased by 16 % from 1989 to 2007. Conversely, **durum wheat** area increased by 155 % (28 % of national surfaces) even though **winter wheat** lost 17,000 ha. **Maize** area decreased by 33 % since 1989 but more rapidly from 2005.

Due to the high demand of **oilseeds** products, the surface of **rape** and, in a lower proportion **sunflower** have highly increased in Midi-Pyrénées between 1989 and 2006. This explains the increase of **ploughed areas** (see paragraph on tillage below) until 1999 for the whole region, that brought along an **increase of erosion**. Local trends, such as the decrease of cereal surfaces in Massif-Central and the increase in the Garonne Valley, are not visible from national statistics.

The most severe erosion is observed on spring crops (Bruno, 2004). However, **spring crops area started to decrease in 2004** following the economical context favourable to straw cereals, the impact of the 2003 drought and also the restrictions put in place on irrigation (Midi-Pyrénées takes the second position of regions for irrigated crops, mainly grain maize). Comparatively, winter crop area increased since 2004, mainly due to durum wheat area and rape expansion (SCEES, 2007).

Spring crops were more important than winter crops until 2006, essentially due to **maize** and **sunflower**. Table 4.2 and Figure 4.5 below shows the development of winter and spring crops from 1989 to 2007.

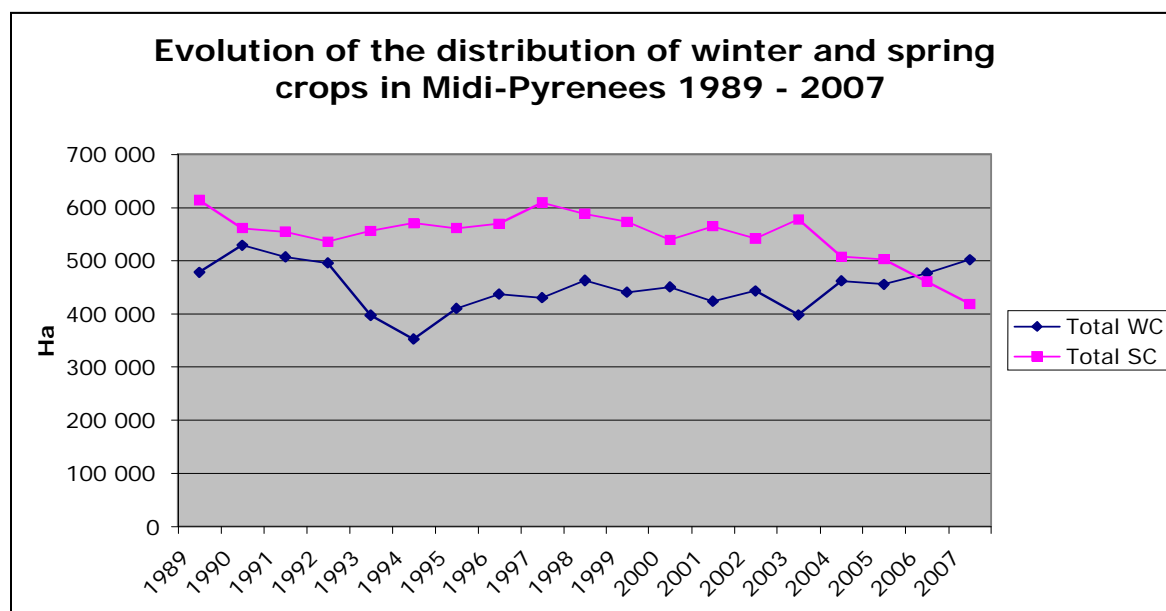


Table 4.2: Development of winter crops and spring crops 1989-2007

Crop areas (Ha)	1989	2007	Difference 1989/2007	Trend
Common wheat	229,000	212,400	-16,600	-7 %
Durum wheat	52,000	129,360	80,600	155 %
Barley	149,840	91,010	-57,640	-38 %
Oat	18,850	8,760	-9,815	-52 %
Rape	25,700	34,270	27,460	107 %
Total winter crops	477,379	476,126	24,023	5 %
Maize	262,552	175,050	-87,502	-33 %
Fodder maize	62,600	40,450	-22,150	-35 %
Sorghum	46,925	20,030	-26,895	-57 %
Sunflower	171,444	154,340	-17,104	-10 %
Soya	49,037	15,980	-33,057	-67 %
Pea	21,095	12,810	-8,285	-39 %
Total spring crops	613,653	418,660	-194,993	-32 %
Total crops	1,091,032	894,786	-170,970	-16 %

Source: SCEES, 2007

Figure 4.5: Development of the distribution of winter and spring crops in Midi-Pyrénées



Note: Winter crops: bread wheat, durum wheat, barley, oats and rape; spring crops: maize, fodder maize, sunflower, soya, pea and sorghum.

Source: SCEES, 2007

In conclusion: The recent trend towards specialisation at farms scale has resulted in the creation of **specialised geographical areas**: grazing systems in the mountains (Pyrénées and Massif-Central) and arable crop systems in the Garonne valley and the Coteaux.



This specialisation of arable crop has contributed to **reduce crop diversity** and to accelerate erosion phenomena (Table 4.3). **Spring crops** used to occupy a larger area in Midi-Pyrénées (half of the field crop). The **transformation** and reduction **grassland surfaces** in the centre of the region intensify this erosion, especially **on steep slope areas**.

Table 4.3: Agricultural trends in Midi-Pyrénées and consequences on soil erosion

Themes	Trends	Impacts	Consequences of the trends on soil erosion
Mixed farm	Reduction	Reduction of grasslands	-
Field crop	Expansion and specialisation	Reduction of grasslands	-
Spring crop	Expansion and specialisation	High potential of bare soils	---
Slope surface utilisation	Implementation and expansion of field crops on steep slope areas	Soil tillage and bare soil (potential) on steep slope	--

Legend: --- very high negative impact, -- high negative impact, - medium negative impact

4.4.2 Farming practices

Topography (slopes), soil types (texture and superficial structure) and the climatic regime (rainfall intensity) are the main intrinsic factors of erosion in Midi-Pyrénées. However, parcel size increase and a more intensive agriculture as prompted by the agricultural orientation Law of 1968 **lead to the frequent creation of hill side-wide parcels with one single crop covering the entire slope (from crest to valley)** (Bruno, 2004).

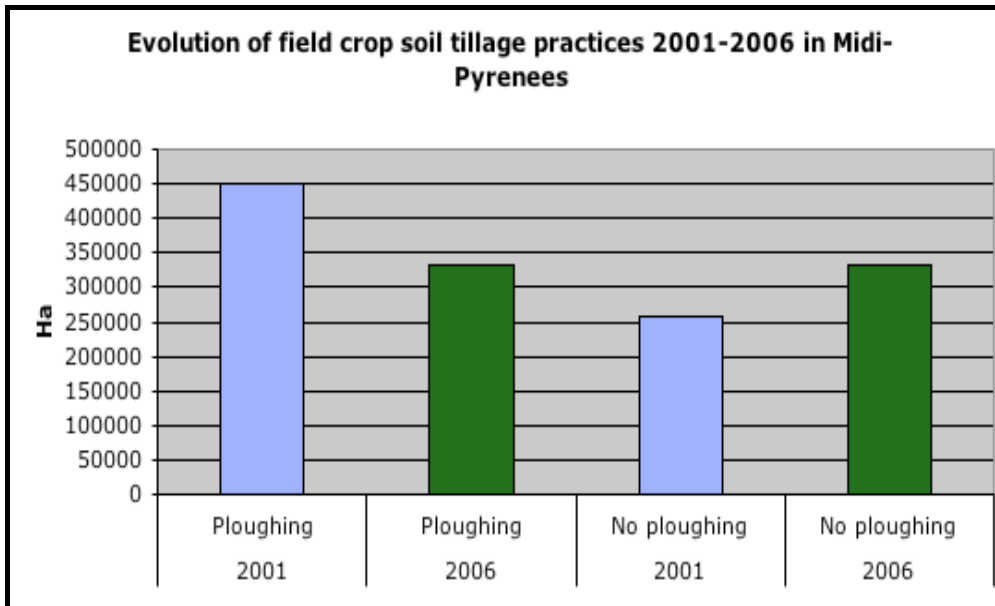
Soil tillage

Since 1979, the **ploughed** area (spring and winter crops) in Midi-Pyrénées has increased (see paragraph above) at the expenses of grasslands. In the same time **ploughing in the sense of slope** has been developed on these field crops. This practice increases the risk of erosion.

Based on the cultural practice surveys (2001 and 2006) an overview of soil tillage practices at regional scale was derived as shown in the figures below.



Figure 4.6: Development of field crop soil tillage practices (ploughing or no-ploughing) in Midi-Pyrénées



Source: SCEES Cultural Practice surveys 2001-2006

The figure above shows the development of field crop soil tillage practices from 2001 to 2006 in Midi-Pyrénées. The development in percentage is:

- **-26 % for ploughing area**
- **+29 % for no-ploughing area**

The percentage of no-tillage area is not included in these figures because the survey on no-tillage was modified in 2006. Furthermore as already mentioned, the percentage of direct sowing is known to be very low (**less than 1.5 % of the UAA**) in 2006.

The figure also shows that ploughing areas were higher than not ploughed areas in 2001. In 2006, **ploughing and not ploughed areas are in balance**.

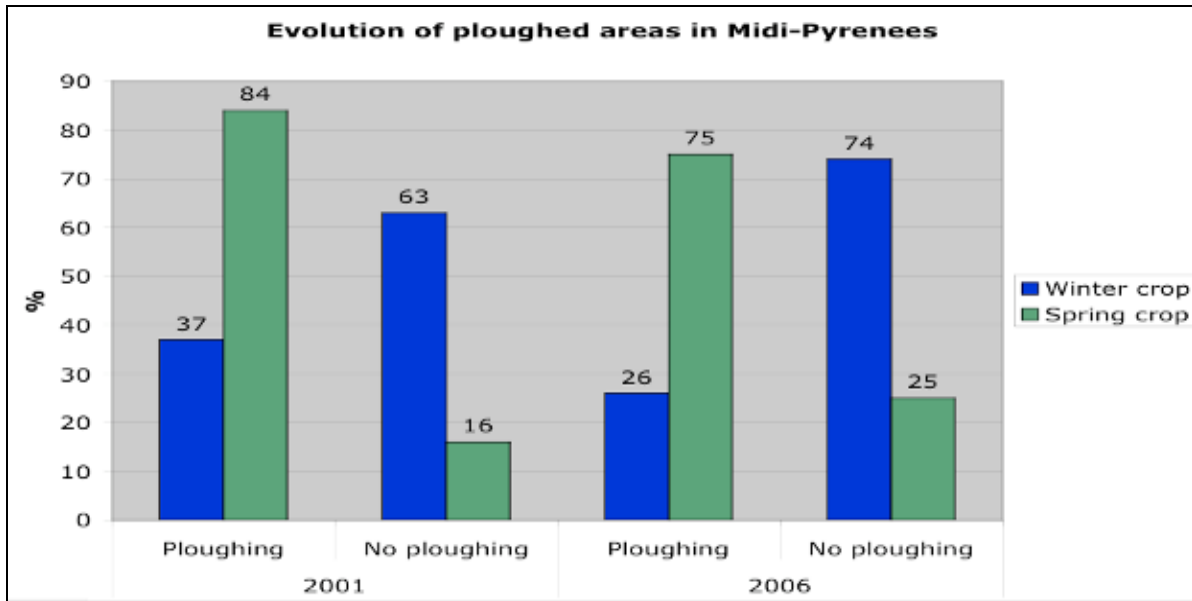
A breakdown of these figures by type of crop (Figure 4.7 and Figure 4.7) reveals that the **winter crops** are less and less ploughed, especially durum wheat. The percentage of no-ploughing for common wheat is lower than durum wheat but in development from 2001 to 2006.

Yet, ploughing is still largely practiced on spring crops such as **maize and sunflower**. The high level of skills required and the limited technical extension available explain the low percentage of no-ploughing on the spring crops.

In 2006, the not ploughed area represented **74 % of the total winter crop area** and only **25 % of the total spring crop area**, even if the spring crop ploughed area shrank by 9 % in five years (Figure 4.7). The percentage of **no-tillage** is very low and concerned **less than 1 % of the total field crops area** in 2006. In 2006, **only winter crops were concern by this practice**.

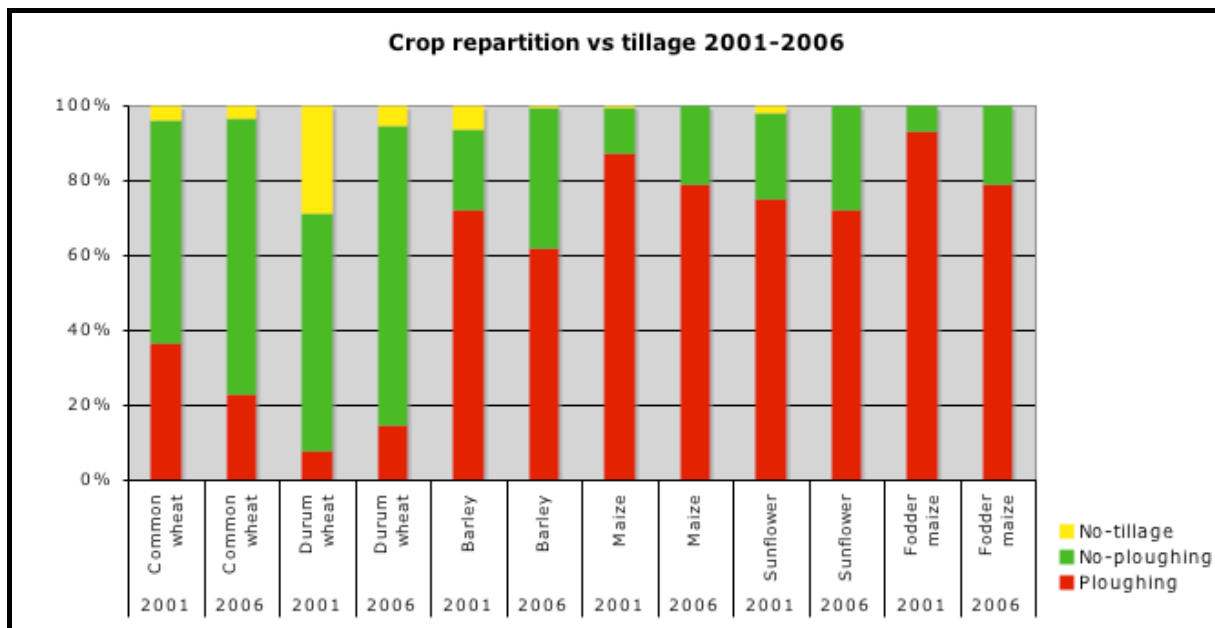


Figure 4.7: Development of ploughed and non ploughed area in function of winter and spring crops 2001 and 2006



Source: SCEES Cultural Practice Surveys 2001-2006

Figure 4.8: Development of soil tillage practices per crop in Midi-Pyrénées 2001-2006



Source: SCEES Cultural Practice Surveys 2001

Crop rotation and winter soil cover management

Crop rotations have suffered a certain degree of simplification in Midi-Pyrénées since 1992 mainly due to the first CAP reform that promoted an increase of spring crops. Farmers were incentivised to implement **biennial crop rotations** such as wheat/sunflower, instead of longer ones (Bruno, 2004). Also industrial crops were heavily subsidised such as soya, sorghum, rape, or pea and essentially sunflower. Moreover, due a recent succession of dry seasons, farmers changed their cropping pattern for cultures that well **adapted to dry conditions**, as sunflower or sorghum (NRDP 2007-2013, regional version, Midi-Pyrénées, 2007).



With these short and spring-crop-oriented rotations, the average intercrop duration increased (Table 4.4). With a biennial crop rotation (wheat/sunflower), soil remains bare **for nine months**, including the **risky thunderstorms spring**.

Table 4.4: Indicative intercrop duration for field crops in Midi-Pyrénées

Field crops	Harvest of preceding crop	Seed bed of culture	Duration of intercrop (month)
Rape	01-15/07/05	16-31/08/05	1,5
Bread wheat	16-31/08/05	16-31/10/05	2,0
Durum wheat	01-15/08/05	01-15/11/05	3,0
Winter barley	16-31/07/05	01-15/10/05	2,5
Maize	16-30/09/05	16-30/04/06	7,0
Pea	16-31/07/05	16-31/03/06	8,0
Fodder maize	16-31/08/05	01-15/05/06	8,5
Sunflower	16-31/07/05	16-30/04/06	9,0

Source: Agreste primeur, 2008

Most of the time soil is bare between two crops in the rotation. This trend increases the erosion risk as well.

4.4.3 Conclusions

The current Midi-Pyrénées agricultural context (land use and farming practices) and trends show a high erosion risk (see table below). The only positive trend seems to be the progressive implementation of simplified tillage techniques.

Table 4.5: Farming systems and farming practices in Midi-Pyrénées, trends and potential impacts on soil erosion

	Current trends	Impacts	Consequences of the trend on soil erosion
Mixed farms	Reduction of their number	Reduction of grasslands	--
Crop rotation	Simplification	Loss of biodiversity	-
Annual crop	Expansion	Reduction of grasslands	-
Spring crop	Expansion	High potential of bare soils	-
Soil cover	Reduction	Extension of bare soil on steep slopes and during the high rainfall intensity period	---
Parcel size	Enlargement	Large parcel which covers the entire side (steep slopes)	--
Tillage	Implementation of reduced and no-tillage on winter crop	Potential reduction of run-off and erosion	++

Legend: --- very high negative impact, -- highly negative impact, - medium negative impact, ++ highly positive impact



4.5 Soil erosion

4.5.1 Regional initiatives to combat erosion

At the end of the 1950's, several papers reported a worsening of water erosion on agricultural soils in the 'Terrefort' near Toulouse (Brunet, 1957, in Le Bissonnais *et al.*, 2002).

The first studies and initiatives to stop erosion begun at the beginning of the 80's, in the department of Haute-Garonne, directed by the Chamber of Agriculture and research institutes. From 1983 to 1988: studies were realised on water erosion by Chamber of Agriculture (31) and Orstom on Lauragais hillsides. Between 1987-1988 and 1992-1993, experiments were carried out by JC Revel on mechanical erosion.

In 1992 a regional group on erosion was created, bringing together research and agricultural development actors.

From 1993 to 1996, several cultural techniques were tested to limit erosion risk. An integrated anti-erosion plan was introduced in the first French agri-environment program and field interventions were done in Midi-Pyrénées on Rougiers de Camarès.

In 1996, a regional department was set up and structured in three sections dedicated to territorial and holding surveys, field demonstrations (on cultivation techniques, grass strips, no-ploughing) and communications.

In 1998, a regional group on simplified tillage techniques was also set up.

4.5.2 Erosion and risk assessment at regional scale

Current status

In Midi-Pyrénées, **mechanical and water erosion** are particularly severe. The latter occurs **especially in spring time and on spring crops, and when soil is bare**.

Soil structure (clay-limestone) of Midi-Pyrénées Southwest hillsides is relatively stable, but the **heavy rain storm intensity**, combined with **steep slopes** and **slope lengths** produce **run-off** that reaches a **sufficient speed to excavate the soil**. With high intensity storms, up to 180 m³ ha⁻¹ of soil can be displaced on a slope with gradient of 20 % (Bruno and Fox 2004).

Gully erosion or intergullies (wheeled tractor and tools footprint) and **diffuse erosion** (seed bed congestion) are frequent, whereas the highest risk of erosion in spring is located on:

- **limono leached soil-sandy-clay soils, sensitive to crusting;**
- **clay soils with limestone outcrops on the higher slopes;**
- **colluvial limono -clay soil at the bottom of slope** (Bruno, 2004).

The maintenance of soil fertility remains also an important issue. The low thickness of topsoil on the steep slopes decreases by the year causing a **loss of soil and fertility**. Yet, most of the damage is caused by **muddy flows on public properties**, as examined in the next paragraph.

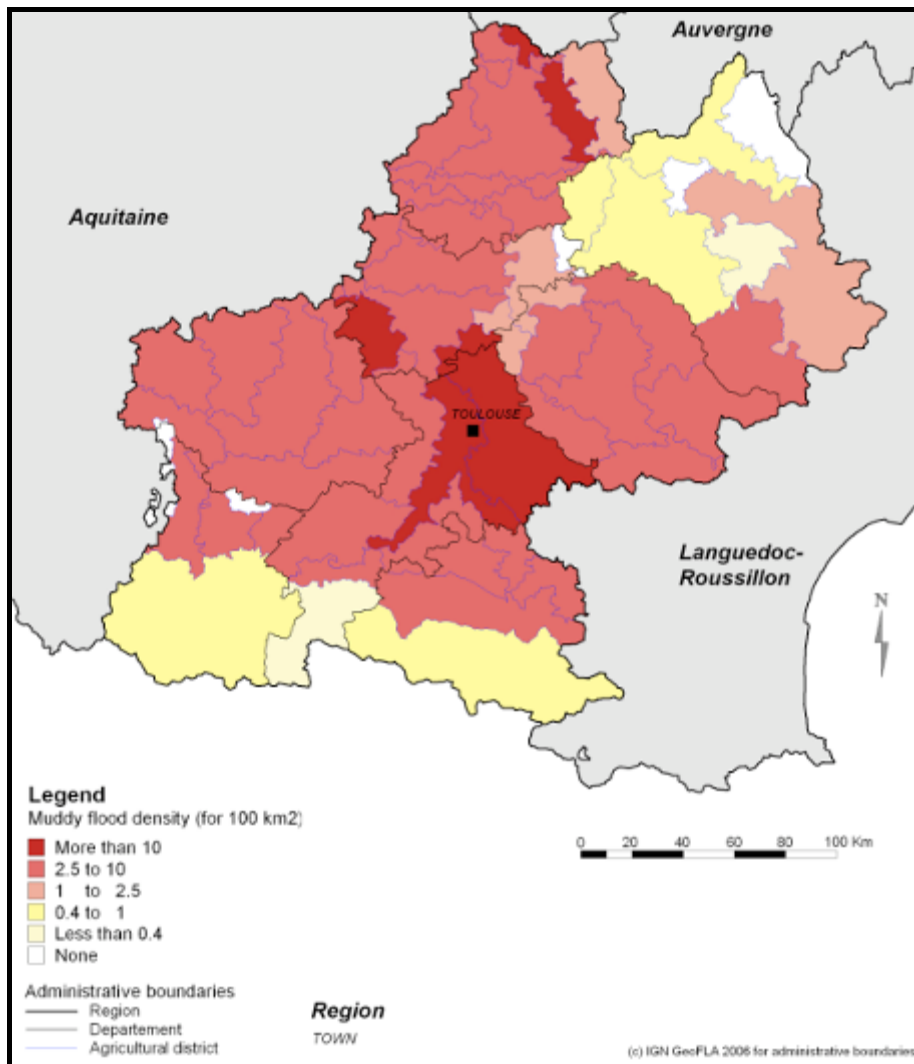
Muddy flows

The most harmful consequences of erosion are muddy flows. They are considered as a natural calamity, eligible for compensation, but seasonal and linked to the rainfall distribution and the state of soil cover. The Institut français de l'environnement (IFEN, French Institute for the Environment) analysed this phenomenon between 1985 and 2000 and distinguished 4 groups of regions in function of their muddy flows density. A database was also established regarding natural calamities and **cartography of the muddy flows density drawn up** (Map 4.4).



Midi-Pyrénées is classified in group 2 with an average of **34 % of the events**. This represents **3.4 to 4.4 muddy flows per 100 km²**.

Map 4.4: Muddy flow density in Midi-Pyrénées 1985-2001



Source: muddy flow database, INRA, 1985-2001; elaborated by Solagro, 2008

The above map shows that muddy flows **affect the whole region, with the exception of Pyrénées and Northeast, where muddy flows are less frequent (<0.4 per 100 km²)**,

Despite Midi-Pyrénées is classified in group 2, the central part of **the region, including agricultural district of Lauragais, is affected by more than 10 muddy flows per 100 km²**.

Erosion on Terreforts and Rougiers de Camarès

Terreforts are present in several agricultural districts such as **Lauragais (Haute-Garonne département)** and Coteaux du Gers (**Gers département**).

In **Lauragais**, from a physical point of view, the hillside is the functional unity, subdivided in several plots until few years ago. Nowadays, **hillside slopes are cultivated by a single upholder, and ploughed in the sense of slope** (Le Bissonnais *et al.*, 2003). These slopes undergo a continue process of **water and mechanical erosion** (due to the soil ploughing). In a very short time, soil is transported downhill and agronomic potential declines as a result of the loss of organic matter. Mechanical erosion is immediately followed by a water erosion. Soil is then often transported beyond the parcel, on public streets or properties.



Figure 4.9: Two examples of water erosion in Terrefrots zones



In the Rougiès of Camarès areas, instead, **80 % of the lands are affected by water erosion**. Environmental fragility is a primary cause for that, but inappropriate farming systems greatly contribute. In Midi-Pyrénées a soil conservation program, including forage selection and adaptation of cultural systems and land management, was recently introduced to reduce the problem (B. Barthès *et al.*, 1998).

Figure 4.10: Erosion on maize plot, Rougiers de Camarès



The table below summarizes the proportional risk of erosion on Terrefrots and Rougiers de Camarès.



Table 4.6: Erosion risk and driving forces in Terreforts and Rougiers de Camarès

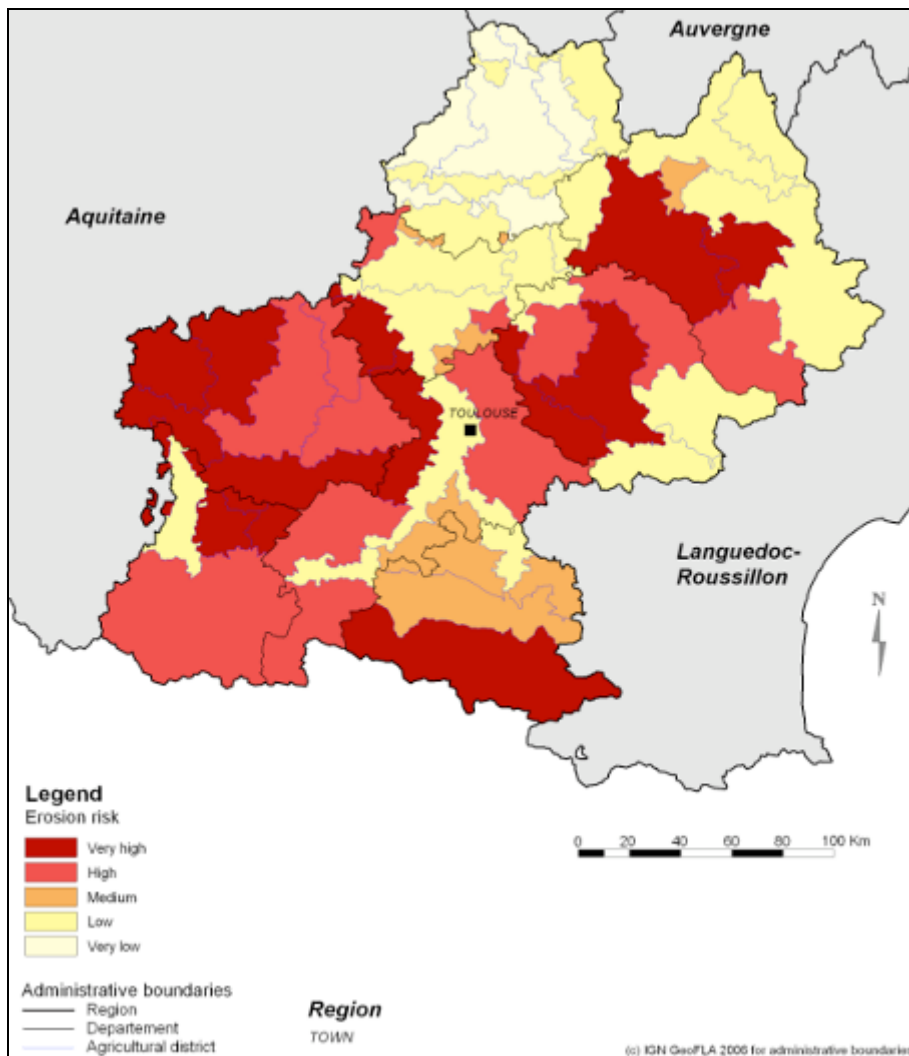
Subsystem	UAA/total area	Fodder surface/UAA	Arable crop surface/UAA	Slope gradient	Structural stability	Erosion risk
Terreforts	75 %	10 %	89 %	Medium – high	High	Very high
Rougiers de Camarès	52 %	77 %	22 %	Medium - high	Very low	Very high

Source: main morpho-pedologic classes of Midi-Pyrénées, Longueval *et al.*, 1995

Results of the MESALES model

The application of the MESALES model (paragraph 2.4.3) at Midi-Pyrénées, confirms the relevance of the erosion phenomena in the region (Map 4.5), especially at spring time.

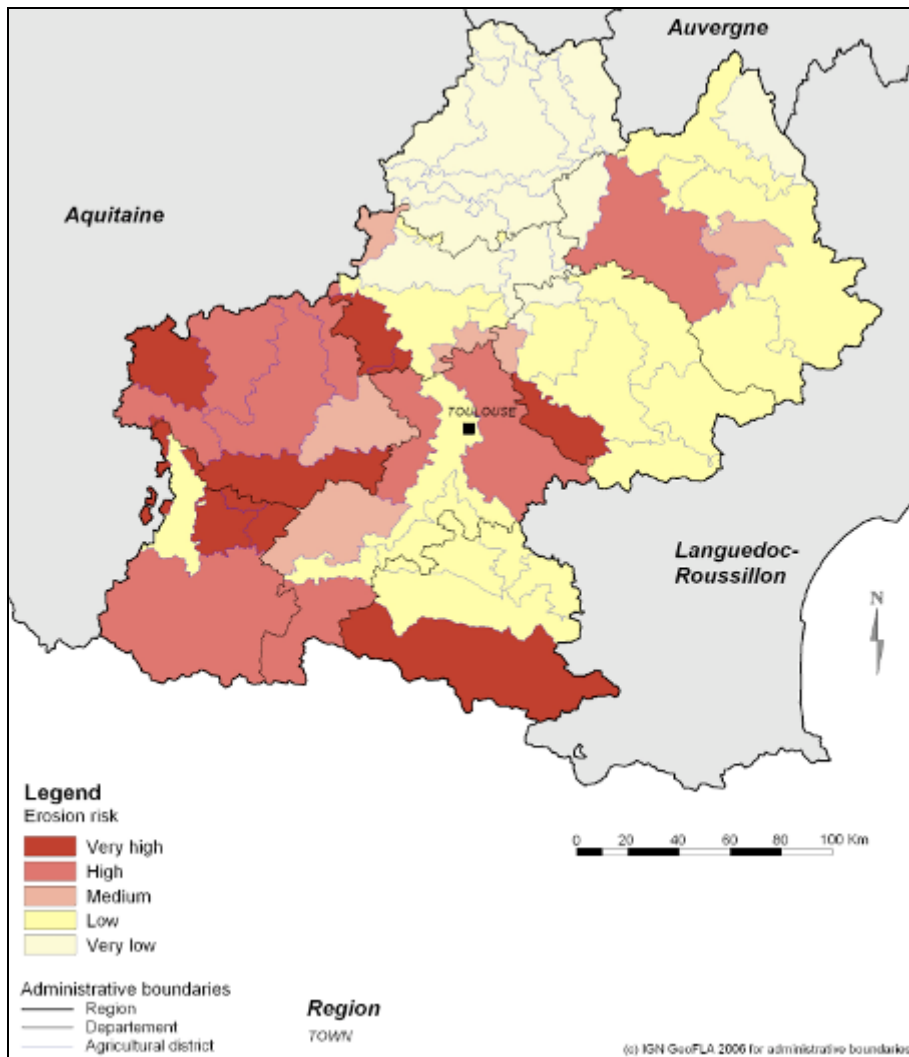
Map 4.5: Annual erosion risk in Midi-Pyrénées



Source: INRA-IFEN, 2002, modelling performed by Solagro, 2008



Map 4.6: Seasonal (spring) erosion risk in Midi-Pyrénées



Source: INRA-IFEN, 2002, modelling performed by Solagro, 2008

The model also confirms that the highest risk of erosion is located on the soils listed in paragraph 0.

As a consequence, erosion risk is maximum in:

- Pyrénées (mountains area);
- Gers (Agriculture & Terreforts area);
- Haute-Garonne (see appendix C presentation of the erosion risk assessment for the agricultural district of Lauragais: Agriculture & Terreforts area);
- Tarn (Agriculture & Terreforts area);
- South of Aveyron (Agriculture & Rougiers de Camarès).

The above illustration shows soil conservation problems in the study area.



5 The farm level analysis

5.1 Methodology and tools

5.1.1 Typology of specific farming systems and farm location

In the study area, as presented in paragraph 4.4.2, and coherently with the literature findings of SoCo Work Package (WP) 1, soil erosion in agriculture is mainly combated with the use of conservation agriculture (CA) techniques.

However, due to the technical complexity of this farming concept and of the related practices, farmers tend to adapt the single techniques according to their experience or capacity, the machinery at their disposal and the local environmental conditions. Often, implementation is gradual in space and time and several steps (years) are necessary before the new system is fully applied. Indeed, farmers tend to use **reduced tillage** soon after abandoning ploughing and implement the most advanced tillage techniques such as soil cover by crop residues, cover crops, as well as no-tillage only in a more mature phase.

The choice of tillage system is often also related to crop categories: winter crops or spring crop. In fact, no-tillage is easier to implement on winter crops (cereals and rape).

A **transition period** is required in any case for both the farmers and the environment to reach a new equilibrium. **Five years** is the average. It represents the necessary time for the soil biodiversity and other main soil parameters (porosity and rainfall infiltration, soil organic matter, gradient of nutrients, pH, etc.) to reach stability.

Given the many factors and parameters involved, a typology of farms was therefore built up in order to study farms applying CA techniques.

Experts' advice and literature review suggested designing such typology of farms according to the level of implementation of the CA techniques (i.e. between conventional agriculture and the most advanced CA).

The following steps were identified:

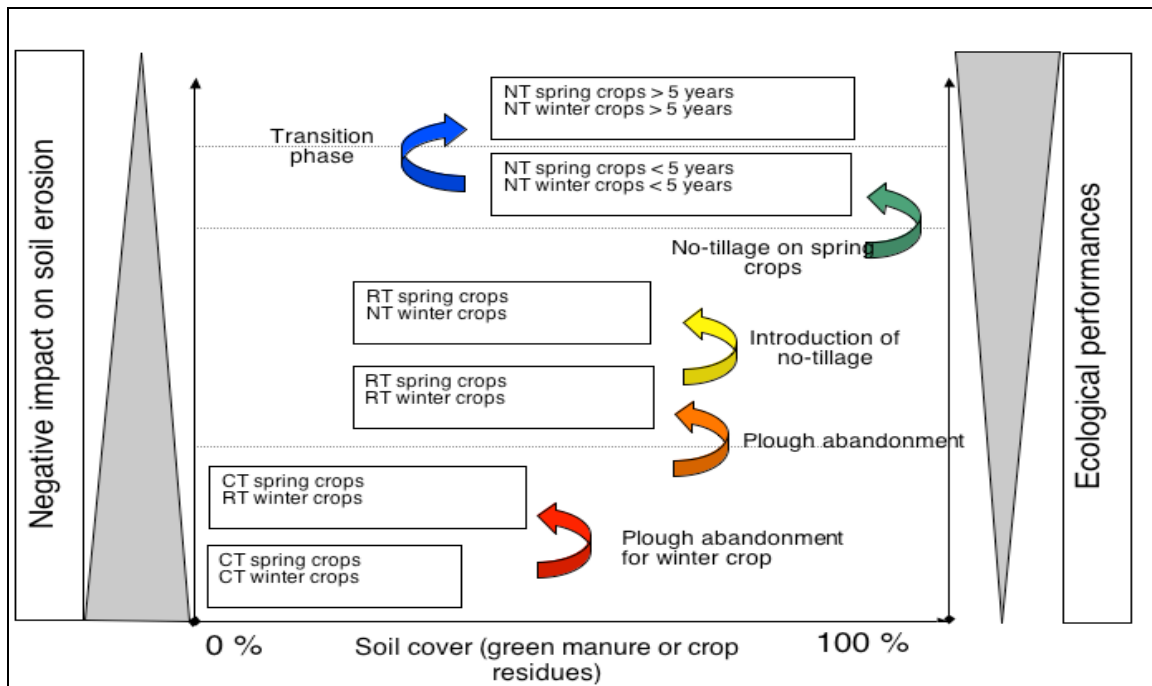
- **Phase 1 ('abandonment of ploughing on winter crops')**: Implementation of simplified tillage techniques (reduced tillage) on winter crops.
- **Phase 2 ('abandonment of ploughing')**: Implementation of simplified tillage techniques (reduced tillage) on spring crops.
- **Phase 3 ('introduction of no-tillage')**: Implementation of simplified tillage techniques (no-tillage) on winter crops.
- **Phase 4 ('No-tillage on spring crops')**: Implementation of simplified tillage techniques (no-tillage) on spring crops.
- **Phase 5 ('End of transition phase')**: No-tillage applied for more than 5 years.

Based on SoCo WP1 findings, the figure below describes the **potential impact and environmental performance of CA on soil erosion**.

A small group of 14 representative farms was selected according to the above typology. Clearly, these farms have different types of soils and motivations for applying CA.



Figure 5.1: Typology of farms for the French case study



5.1.2 Environmental performance model (Dialecte)

A specific software model called Dialecte was used to assess the environmental performance of the farms sampled. The model applies to almost any farming system and it's based on the analysis of forty different environmental indicators that can be adjusted according to a qualitative estimate of the surveyor.

In particular, a N balance as well as an overall performance on the soil domain of the techniques applied was assessed for the farms inquired.

Dialecte uses several complementary means to describe the relations existing between the agricultural production systems and their ecological impact:

- an overall approach at farm level to evaluate the capacity of the production system to limit the risk of damage to the environment. Operatively, the complexity of the farm and the management of inputs, as well as 20 indicators are taken into account;
- a thematic approach to the environment which evaluates the potential impact of the farm on each of the components of the environment:
- **water**: use of water resources (irrigation), pollution of water with nitrates and pesticides, etc.;
- **soil**: the types of crops and the land uses throughout the year (links with erosion and water pollution; the impact of pesticides on the biological life in the soil; the turbidity of the water, nitrates and phosphates), organic and chemical fertilisation, erosion limitation, type of CA tillage (no- or reduced tillage);
- **biodiversity**: the proportion of ecological infrastructures, percent of temporary and permanent grasslands;
- **consumption of non-renewable natural resources**: direct energy (electricity, fuel)

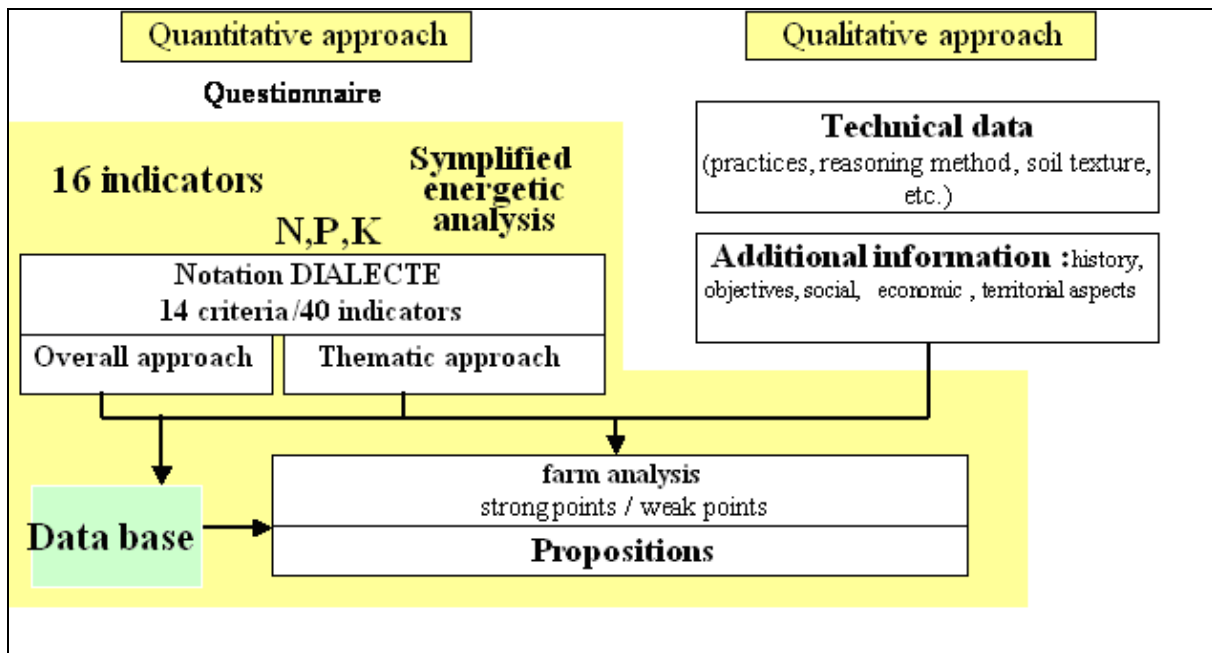


and indirect energy (energy required to produce the farm inputs: mineral fertilisers, pesticides, purchase of feedstuff for livestock, mechanisation), mineral resources such as phosphates and potash, stored resources such as water for irrigation, etc.

DIALECTE consists of:

- a survey questionnaire intended to collect essentially quantitative data (crop surfaces and yields, livestock, crop practices, husbandry management, production, etc.);
- a computerised spreadsheet for determining the agro-environmental indicators of the global approach and the thematic approach, the Nitrogen soil surface balance (CORPEN methodology) and simplified energetic analysis of the farm;
- a database, that can be made available over the internet.

Figure 5.2: Presentation of the Dialecte model



In the present study, Dialecte input parameters were derived from local cultural data and from the farmers inquiry.

5.2 Results

5.2.1 Farms investigated

The fourteen farms studied cover 2,610 ha of UAA in four departments. The UAA of each farm varies from 50 to 385 ha. The average of UAA per farm is 189 ha and the average labour units 1.8.

According to the aforementioned typology (Figure 5.1), each farm is classified into 5 phases in function of their tillage techniques utilised (Table 5.1 and Table 5.2).

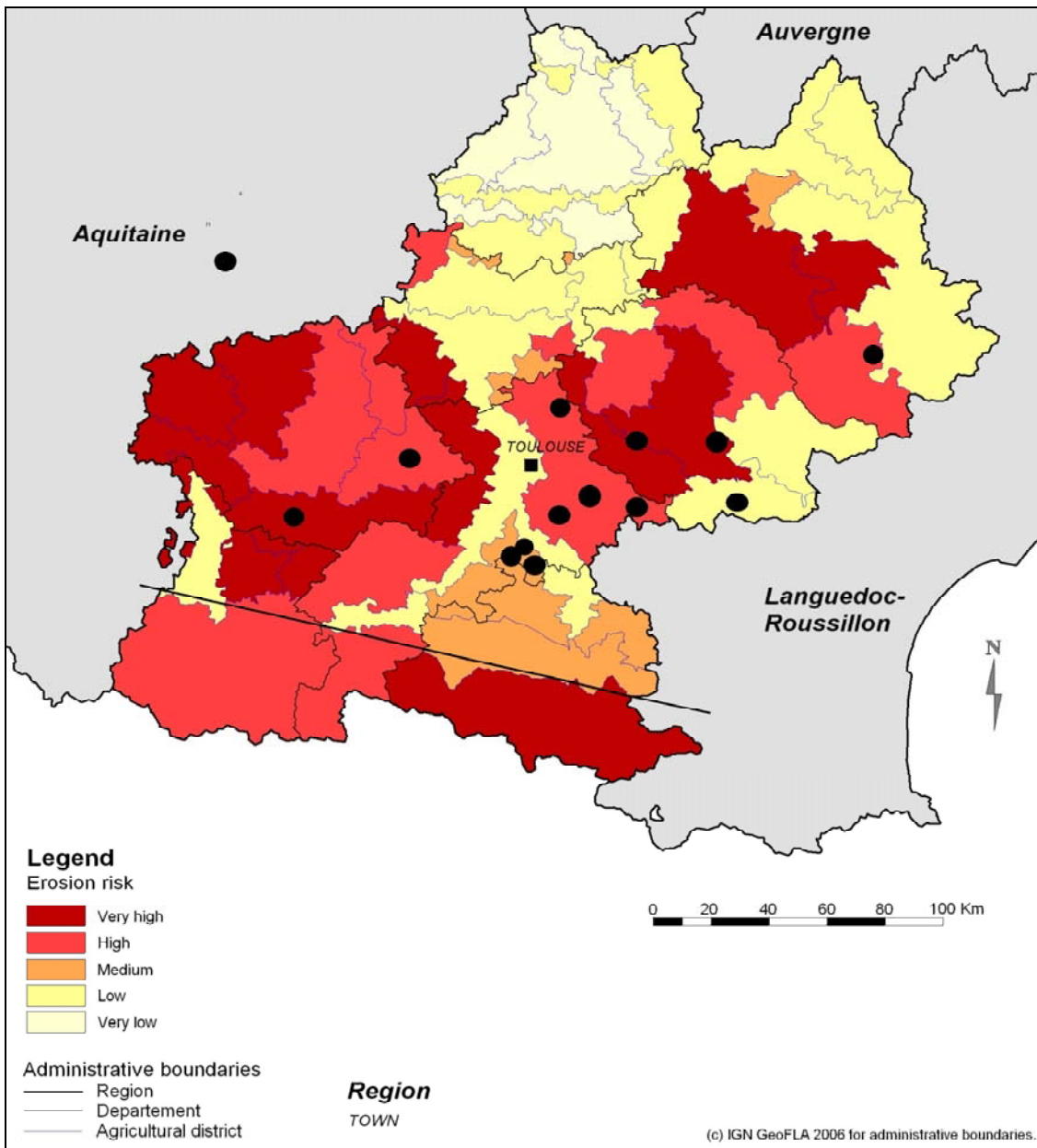
The indicators used to characterize the different systems are:

- Soil types
- Tillage practices
- Cover crops
- Crop rotation



The surveyed farms are located in medium, high and very high risk erosion area (see map below).

Map 5.1: Sampled farms location



**Table 5.1: General description of the farms surveyed**

	Type of production	UAA (Ha)	Labour unit	Zoning	Soil type	Cover crop	Erosion risk
Farm 1	Mixed cropping	170	2	Vulnerable and urban zone	Hillside clay-limestone and loamy-clay	NO	MEDIUM
Farm 2	Mixed cropping	146	1	Vulnerable and urban zone	Plain Clay-limestone and heterogeneous type of soils	NO	MEDIUM
Farm 3	Mixed cropping	97	1	None	Hillside clay-limestone and loamy-clay	YES	HIGH
Farm 4	Mixed cropping	330	2	None	Hillside clay-limestone	YES	HIGH
Farm 5	Dairy ewe	230	3	RNP	Rougiers (hillside of pelites, shale and sandstone)	YES	HIGH
Farm 6	Dairy cow	148	2	None	Hillside clay-limestone and loamy-clay	YES	HIGH
Farm 7	Dairy cow	50	2	None	Hillside clay-limestone and siliceous-clay (acid, stony)	YES	MEDIUM
Farm 8	Mixed cropping	110	1	None	Hillside clay-limestone	NO, residues on ground	HIGH
Farm 9	Mixed cropping	200	2	Vulnerable zone	Plain loamy-clay and heterogeneous types of soil	YES+ residues	MEDIUM
Farm 10	Mixed cropping	164	1	Vulnerable zone	Hillside clay-limestone and clay-siliceous	NO, residues on ground	HIGH
Farm 11	Mixed cropping	385	3	Vulnerable zone	Plain loamy-clay and hillside clay-limestone	YES+ residues	LOW
Farm 12	Mixed cropping	177	2	Vulnerable and urban zone	Hillside clay-limestone	YES	MEDIUM
Farm 13	Mixed cropping	287	1	None	Hillside clay-limestone	NO, residues on ground	HIGH
Farm 14	Dairy cow	116	2	None	Plain loamy-clay	YES	LOW



Table 5.2: Description of production systems


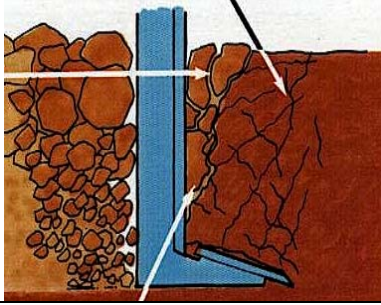


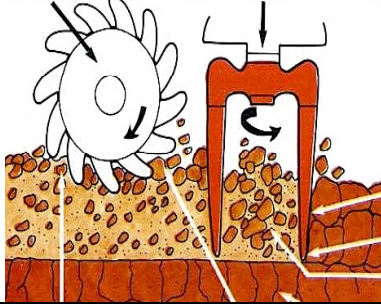

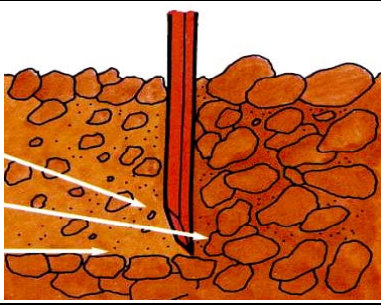

	UAA (Ha)	Soil types	Practices	Cover crop	Crop rotation (years)	% winter field crops	% spring field crops
Farm 1	170	Hillside clay-limestone and loamy-clay	Ploughing on WC every 3 years – Ploughing on SC	NO	2	49	36
Farm 2	146	Plain clay-limestone and heterogeneous types of soil	Reduced tillage (deep) on WC (Chisel +rotary harrow) Ploughing on SC	NO	2	61	32
Farm 3	97	Hillside clay-limestone and loamy-clay	Reduced tillage (Cultivator and disc harrow on WC and Rotary harrow on SC)	YES	2 in dry conditions, 3 in irrigated conditions	50	35
Farm 4	330	Hillside clay-limestone	Reduced tillage Agrisem and Cultimulch harrow on WC and SC	YES	3	61	31
Farm 5	283	Hillside sandstone and pélites, rougiers	Reduced tillage (shallow): Horsch on WC and Decompaction + Cover crop on SC	YES	7	20	6
Farm 6	148	Hillside clay-limestone and loamy-clay	Reduced tillage (deep): Disc tiller and Perrain plough (Strip till on SC)	YES	2 on dry conditions, 3 in irrigated conditions	33	36
Farm 7	50	Hillside clay-limestone and siliceous clay	Reduced tillage (shallow): Horsch on WC and decompaction on SC	YES	4 or 7 with temporary grassland	27	24
Farm 8	110	Hillside clay-limestone	No-tillage on WC and reduced tillage (Cultivator with horizontal axis) on SC	NO (residues on ground)	2	27	54
Farm 9	200	Plain loamy-clay and heterogeneous types of soil	No-tillage on WC and decompaction on SC	Yes + residues	6 in dry conditions, 2 in irrigated conditions	50	50
Farm 10	164	Hillside clay-limestone and clay-siliceous	No-tillage on WC and SC (Single seed drilling for sunflower and rape)	NO (residues on ground)	6	54	34
Farm 11	385	Plain loamy-clay and hillside clay-limestone	No-tillage on WC and SC	Yes + residues	4 or 5 following types of soil and their utilisation	64	23
Farm 12	177	Hillside clay-limestone	No-tillage on WC and SC	YES	6	49	41
Farm 13	287	Hillside clay-limestone	No-tillage on WC and SC	NO (residues on ground)	4	50	50
Farm 14	116	Plain loamy-clay	No-tillage on WC and SC	YES	3 or 5 with temporary grassland	3	37

Note: WC=Winter Crops, SC=Spring Crops



The machinery used for reduced tillage and no-tillage as found during the survey are presented in the table below.

Table 5.3: Soil tillage machinery used in reduced and no-tillage in the sampled farms

Soil tillage machinery	Type of action	Utilisation
		<p>Decompactor used for reduced tillage or no-tillage (not systematically) to crack the soil (30 to 40 cm).</p>
	<p>Fragmentation of the surface layer and seeding</p>	<p>Horsch: It is a tool for sowing in one pass connected to the power take-off of the tractor (reduced tillage). It fragments the soil surface layer (3-5 cm), and then drops the seeds.</p>
		<p>The rotary harrow is used for reduced tillage for fragmenting the surface (5-15 cm). It is a tool connected to the power take-off of the tractor and breaks up soil aggregates heavily.</p>
		<p>The spike harrow is used for reduced tillage to refine the surface before seeding. It is a tool not too aggressive for soil aggregates</p>
		<p>Disc openers with row cleaners use for no-tillage</p>



5.2.2 Farmers motivation for CA

Motivations between farmers to swap production system to CA are very diversified. The survey has shown that the main reasons for farmers to change are three (see appendix 16).

- **economical motivation**
- **agricultural motivation**
- **environmental motivation**

Broadly speaking, the **environmental** motivation is not the first and only those who have suffered significant **losses** (land or yields) and/or have steep slopes (between 20 to 30 %) with soil types prone to erosion have put forward this motivation.

Six farmers chose CA with an **economic** motivation (savings on fuel costs, mechanisation, and working time). The four breeders of this survey, for example, have reduced their working time due to direct sowing on grasslands.

Six farmers have chosen to apply CA based on its **agronomic** performance because they consider the soil at the basis of production. Restoration of the soil structure and fertility, promotion of soil biological life (earthworms) and restoration of a better water infiltration into the soil are the main motivations. Two of them have highlighted the crop rotation effects as beneficial.

Table 5.4: Farmers' motivations for implementing CA

	Economic	Agronomic	Environmental
Farm 1	Labour time - Fuel		
Farm 2	Consumption of resources	Soil fertility - Soil structure	
Farm 3	Fuel - Labour time	Soil life (Earthworms)	
Farm 4	Labour time	Loss soil working	Erosion
Farm 5	Farm equipment (care and repair materials)		Less problems - Erosion
Farm 6	Fuel Labour time	Soil structure - Soil life (Earthworms)	Erosion
Farm 7	Labour time		
Farm 8	Labour time - Fuel - consumption of resources	Behavior of crops	Erosion
Farm 9	Labour time	Soil structure - Organic matter	
Farm 10	Labour time		Erosion
Farm 11	Farm equipment	Soil - Soil life (Earthworms) - Organic	
Farm 12	Labour time	Soil life (Earthworms) - Saving water irrigation	Erosion
Farm 13		Organic matter Crop rotation	Erosion
Farm 14	Consumption of resources	Soil fertility - Soil structure	

Note: The colours in the first column indicate the typology level

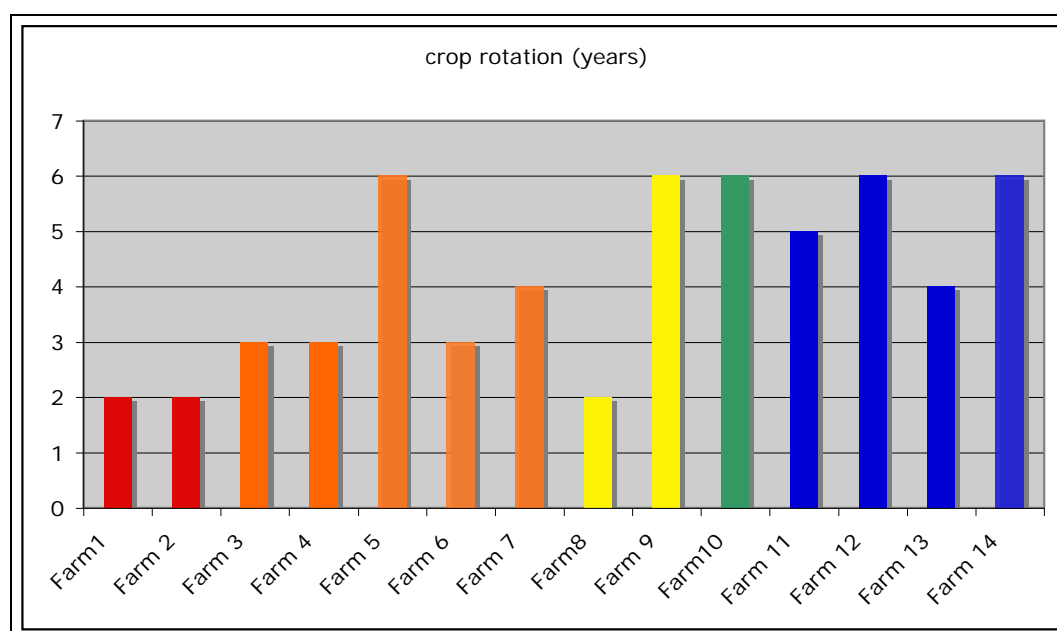
Source: farm inquiries

Given to the **lack of local references**, system change is a **risk to the farmer**. Whatever the motivation, it is important that farmers can **exchange and share experiences** so that the first motivation is not necessarily economic but more agronomic or environmental.

In most of the farms surveyed, the switch to **no-tillage** techniques resulted in an **extension and diversification of crop rotations** (see figure below).



Figure 5.3: Crop rotations (number of years) in the sampled farms



5.2.3 Effect on soil erosion

Inquired farmers suffer from one or more soil degradation symptoms listed in Table 5.5. The damage intensity is different depending on the configuration of farms (topography, soil types, practices, etc.). Only salinisation and salt crusts are not identified in these farms. These symptoms are not specific to the region of Midi-Pyrénées.

Table 5.5: Soil degradation symptoms occurring in the area and on farms

Symptom	Occurring in the area	Occurring on my farm
Soil run-off from field onto roads	X	X (7/14 farms)
Forms of water erosion: rills, gullies	X	X (9/14 farms)
Slumping caused by instable soil	X	X (5/14 farms)
Soil being blown by wind onto roads (over blowing)	X	X (4/14 farms)
Compaction of soil causing lower infiltration rates	X	X (8/14 farms)
Crusting/sealing	X	X (10/14 farms)
Changes in plant growth caused by salinisation		-
Loss of topsoil	X	X (13/14 farms)
Salt crusts (salinisation)		-
Other symptoms of damages to soils	X	X (2/14 farms)

Source: Farmers inquiry



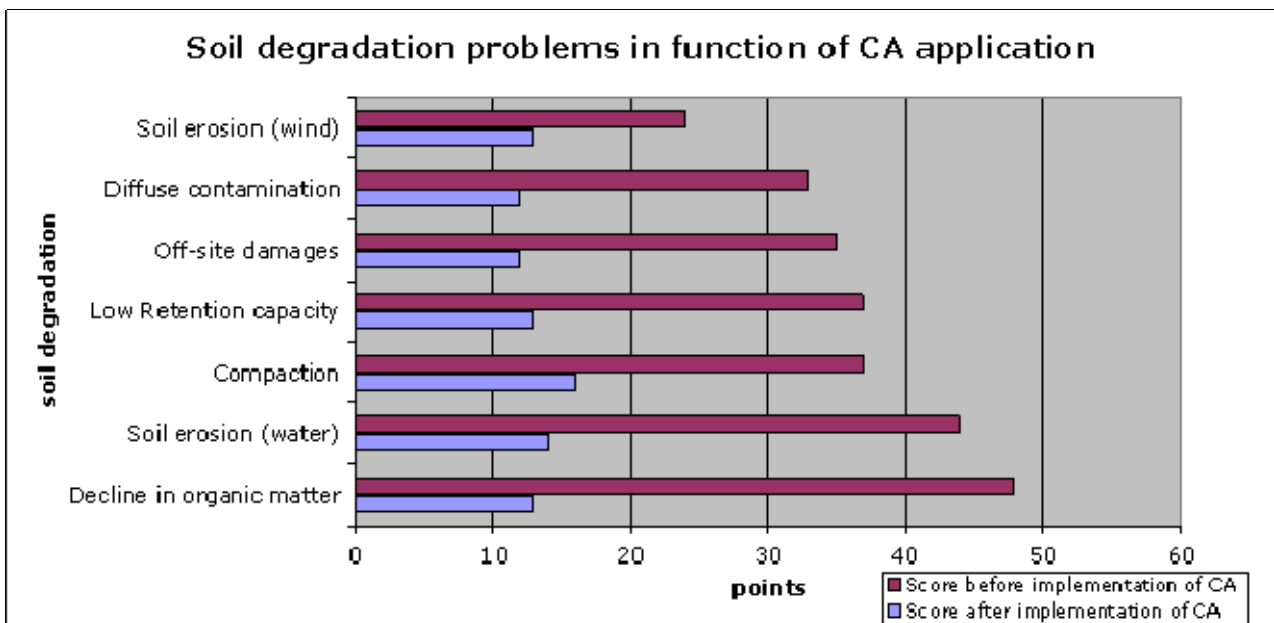
The first observations are:

- All farms are affected by soil degradation problems
- Symptoms the most visible are:
 - **Decline in organic matter**
 - **Water erosion**
 - **Compaction**
- Degradation problems are random depending on farms but remain at high level

This Figure 5.4 below shows the impact of the CA on soil degradation problems as perceived by the farmers. Indeed, **all farms** that changed their systems **have significantly reduced their problems of soil degradation**.

Once more, the techniques applied and results achieved vary from farm to farm and yet degradation problems are less and less serious.

Figure 5.4: Soil degradation severity before and after conservation agriculture implementation



Source: Farmers inquiry

5.2.4 Soil cover

The investigation highlighted that three different types of soil cover are currently in use in Midi-Pyrénées:

- **Straw residues on soil:** this technique requires a systematic rotation of winter and spring crops. After the winter crop harvest, straws are spread over the soil evenly or homogeneously to have the complete coverage of the surface. Generally, a straw spreader is used to do this work;
- **Regrowth** (as rape): A spontaneous coverage that is equally effective to limit erosion;
- **Cover crops:** Investigations have shown that there are different types of coverage, cover crops with a single crop or a mixture of crops.



For single crops, oat, sunflower or horse bean are the most used for different reasons. Oats has an important coverage and competitive power against weeds, but retains a very wet soil, unfavourable for maize. Horse bean is good for soil structure and nitrogen fixation. Sunflower is interesting for its root pivot.

In mixed crops, several types of combinations exist. Farmers highlighted benefits and downsides of some of the most used:

- **Mustard + Phacelia+ horse bean + oat** (easy destruction of Phacelia and dark colour for soil warming; good permanent cover for oat; mechanical destruction with frost for mustard and horse bean)
- **Oat + fodder pea + horse bean + sunflower** (good for soil structure, promotes biological life)
- **Sunflower + vetch + fenugreek + Phacelia** (very good for roots, increases organic matter; problems of destruction with frost for sunflower and fenugreek; problem of regrowth; vetch has a good coverage power)
- **Oat + horse bean**, classical mix.

Table 5.6: Type of soil cover used in the sampled farms

<p>cover of Phacelia + horse bean + mustard implemented in crop residues (straw)</p>	<p>cover of rape re-growth</p>
<p>Soil cover by crop residues (Straw crushed)</p>	<p>Zoom on straw crushed</p>

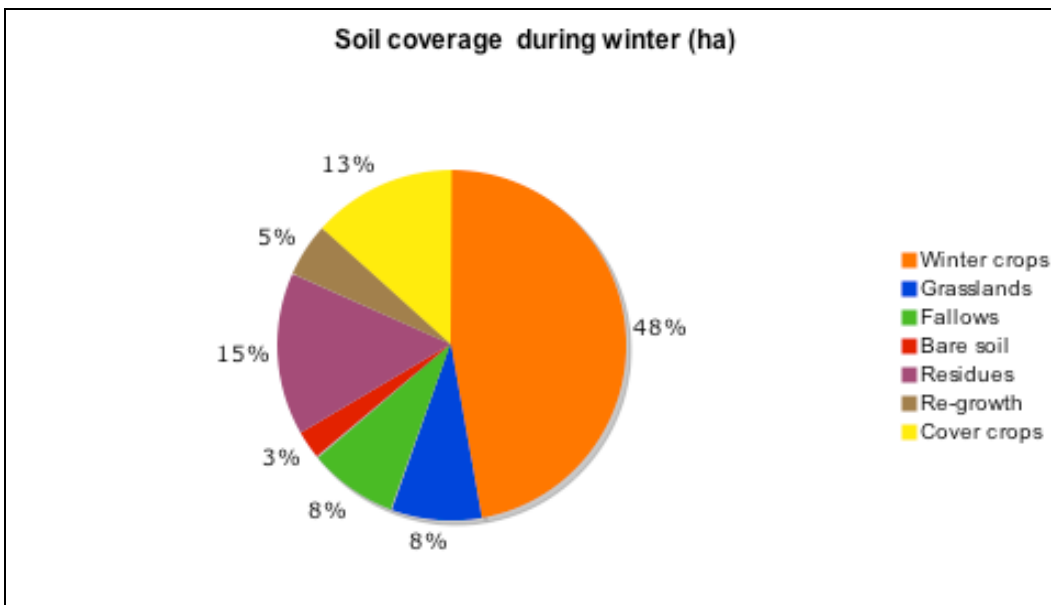


Figure 5.5 below shows the percentage of hectares under each soil protection type. These percentages are calculated on the basis of the total number of hectare of all farms surveyed (2,610 ha).

This figure shows that the **winter crop percentage is important (1,390 ha)**, providing soil **coverage during a large part of the year, especially during the most violent rainy period (autumn and spring)**. **Residues are slightly higher than cover crops (2 %)**. From the point of view of erosion, residues are very interesting. This cover type is inexpensive, requires less working time and is as effective as a cover crop. Straws must be spread evenly.

Fallow is 8 % of the total number of hectare. This cover is often fixed and placed in steep slopes or on less fertile plots. **Bare soil covers 3 % and concerns holdings in phase 1 which do not use any type of cover crops**. Thus, the surveyed farms have good winter soil coverage. These farms operate all types of cover and prove the effectiveness of these techniques.

Figure 5.5: Soil coverage during winter



Source: Sampled farms



Drawbacks are also present in the choice of cover crops and might justify the reluctance of some farmers in using them:

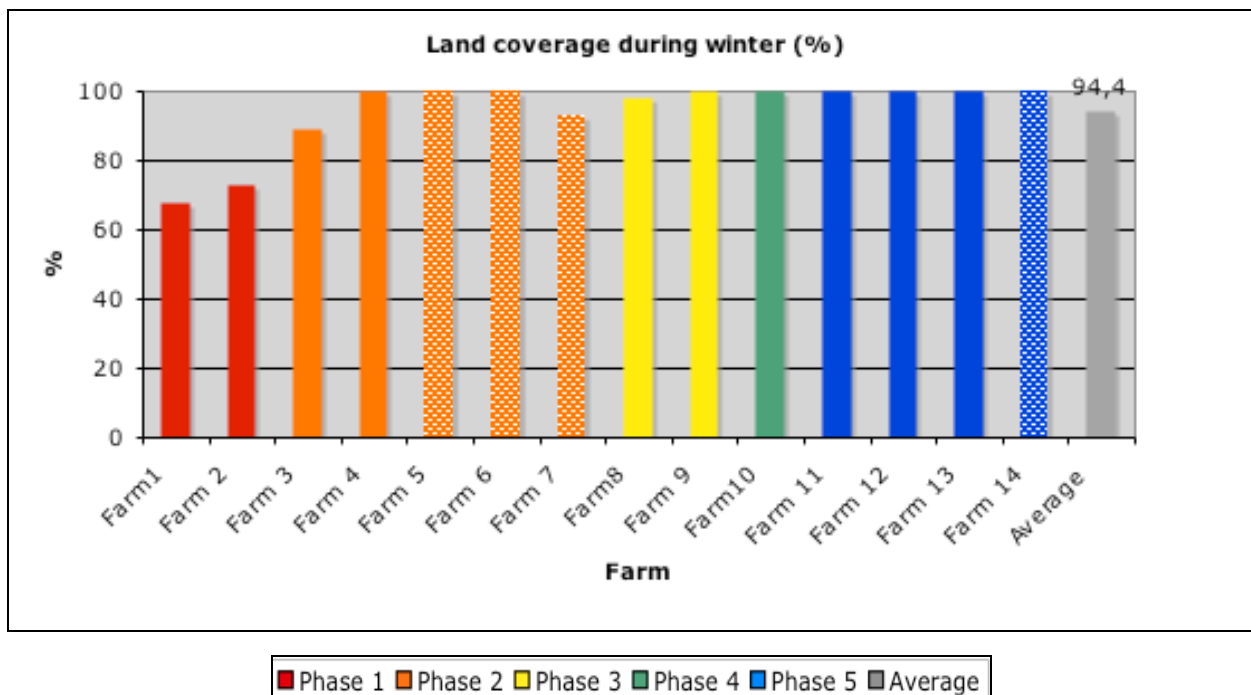
- **Seed cost** is generally high and cannot be recovered through harvest. Only farmers in mixed crop-livestock can make profit from livestock.
- The **choice of cover crop** most adapted to local conditions to benefit of frost destruction is not easy.
- The **date of destruction** may not be optimal to soil types and climate thus delaying planting of spring crops.
- The **utilisation of herbicides** as glyphosate is important for cover crop destruction when mechanical destruction is not used.

Furthermore, farmers interviewed highlighted that cover crops might penalize the next crop because in wet years water soil circulation is insufficient and the number of slugs generally increase. In dry years, vice-versa, cover crops may contribute to water shortages for the main crops as they pump water from the ground.

Results of Dialecte related to soil cover

By use of the Dialecte model, the 'soil coverage in winter' parameter was calculated and it is shown in the figure below.

Figure 5.6: Soil covered in winter in function of different phases



Note: Hatched bars indicate mixed-livestock farms

Source: Farmers inquiry

Figure 5.6 shows that farms 1 and 2 (in phase 1) have the lowest percentage of coverage in winter. From the survey results, it is quite clear that this is due to:

- No implementation of cover crops
- Burying straws for winter crops

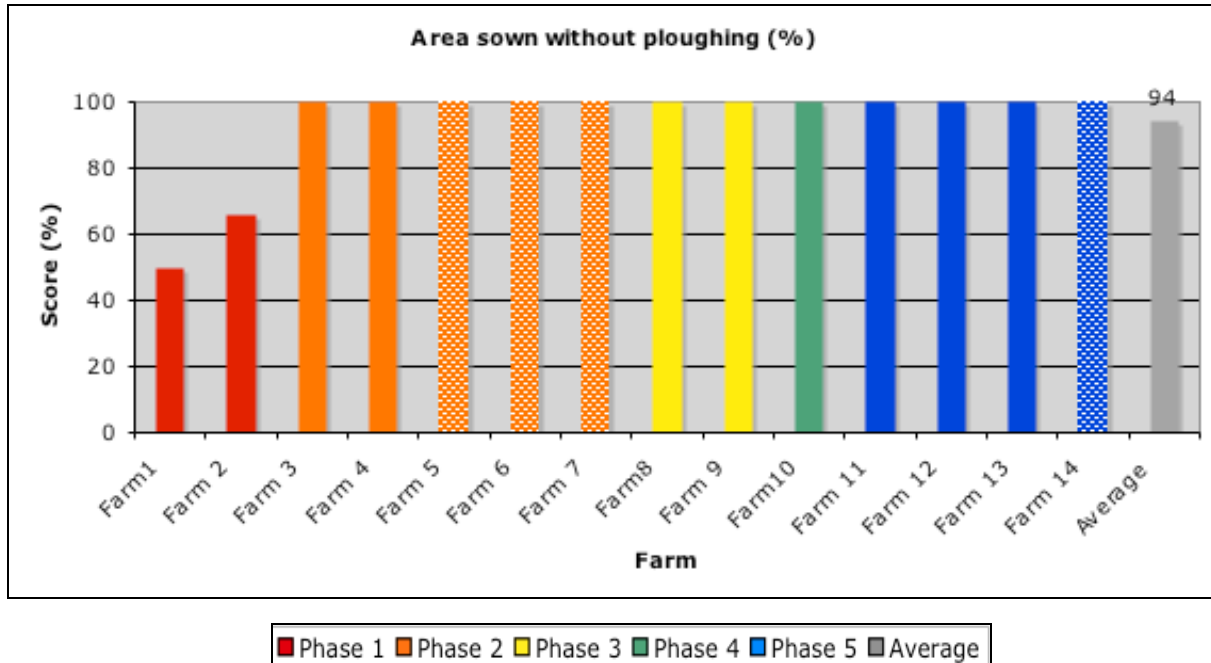
Indeed, farms in phase 2 (essentially mixed crop-livestock farming) have 100 % of their soil covered in winter except farm 3 and 7 due to seeding problem, which were not fully explained. Generally, mixed crop-livestock farms have a better coverage than others because of grasslands and temporary meadows.



A complete soil cover in winter for farms in phase 2 indicates that they leave vegetation residues on the surface or make use of cover crops. Both are **major factors in reducing erosion risk** (Ouvry, Le Bissonnais, 2008), given a **coverage rate of at least 30 to 40 %**.

The other parameter assessed with Dialecte, the area sown without ploughing, is represented in Figure 5.7.

Figure 5.7: Area sown without ploughing



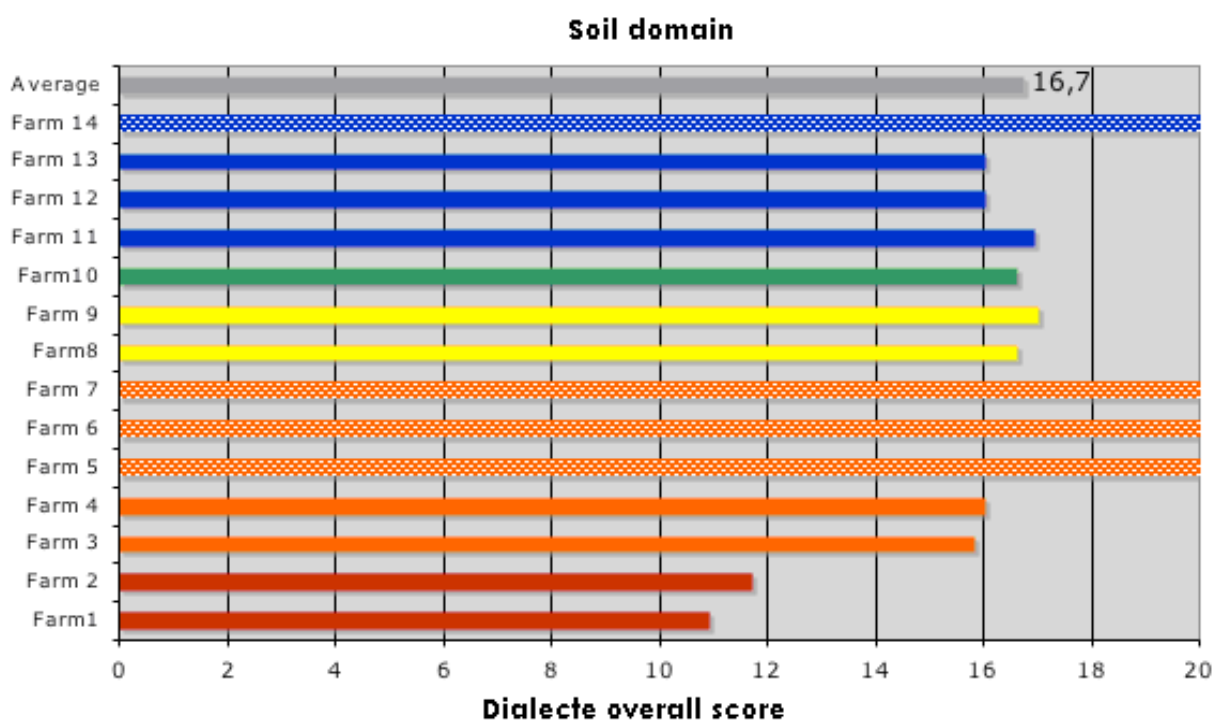
Source: Farmers inquiry

In all phases, except phase 1, the surface is sown without ploughing on winter and spring crops. Farmers in phase 1 use ploughing for spring crops and sometimes for winter crops, such as in farm 1 where ploughing is used every three years.

By combining the parameters 'percentage of land covered in winter' and 'percentage of area sown without ploughing', just presented, with 'the percentage of grasslands in the UAA;', 'the percentage of temporary meadows in the UAA' and 'the percentage of organic matter provision', a more complete picture of the environmental performance of CA can be assessed in the soil domain (Figure 5.8).



Figure 5.8: Dialecte global performance of CA in the soil domain for each farm surveyed



Source: Farmers inquiry

Farms with livestock achieve the best score (100 %) because of their area devoted to grassland and temporary meadows. For mixed crop farms, the score is high and much greater than the two farms in phase 1. The latter use residues on ground with winter crops (durum and common wheat), a common practice in the region for winter crops, but this is not systematic and use of crop rotation is not widespread.

5.2.5 Soil quality

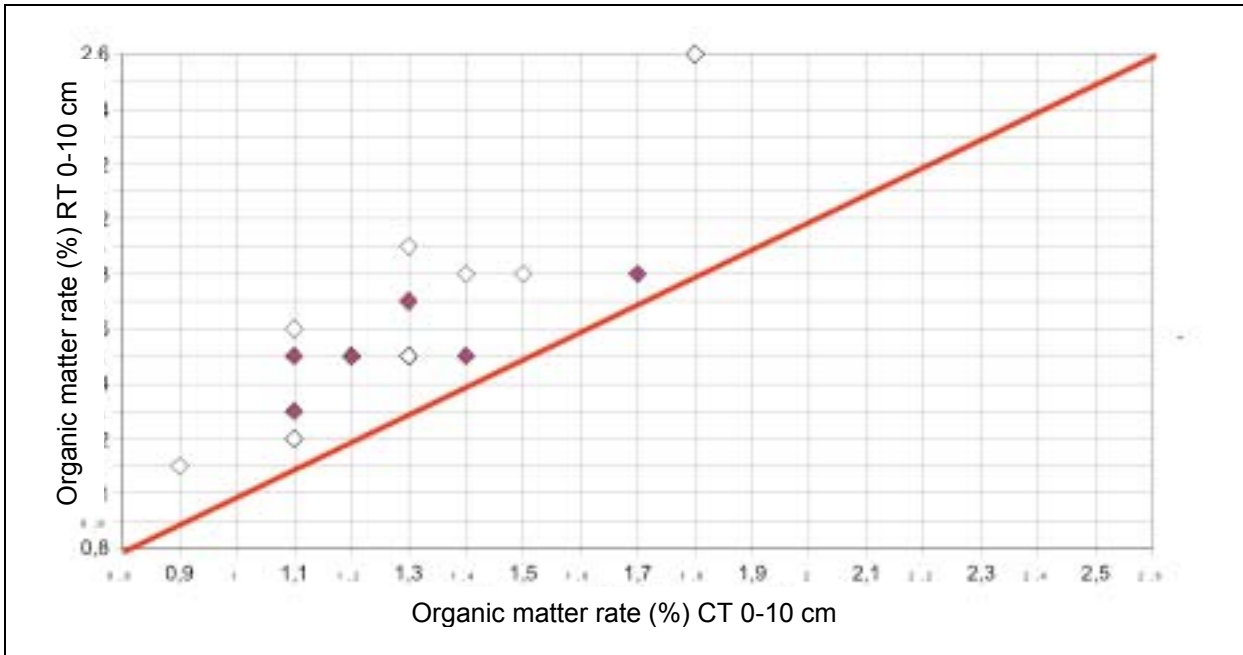
Except farms 1 and 2, all farmers noted an improvement of organic matter, of the biological activity in the soil and a reduction of soil degradation by erosion after the introduction of CA.

The results observed by the farmers surveyed are confirmed by those obtained on 19 plots in Midi-Pyrénées comparing impact of tillage techniques (ploughing and reduced tillage) on soil quality (between 2001 and 2004). This study showed (Longueval, 2008):

- an increase in organic matter in the first 10 centimetres (see figure below) visible after 4 years (average rate of organic matter: 1.31 % in ploughing plots, 1.64 % in no-ploughing plots, 2.2 % in superficial reduced tillage);
- an increase (+39.5 %) in microbial biomass (175 mg C/kg in ploughing plots, 241 mg C/kg in no-ploughing plots);
- an increase (+19 %) in the number of earthworms burrows (439 burrows/m² in ploughing plots, 524 burrows/m² in no-ploughing plots).



Figure 5.9: Comparison of organic matter rate within the first 10 cm as affected by the tillage techniques



Plough = CT and reduced tillage = RT
Source: Longueval, 2008

5.2.6 Effect on use of chemicals

Fertilizers (Nitrogen), pesticides and herbicides were all considered to assess performance of CA techniques in the use of chemicals in the surveyed farms.

The nitrogen balance was calculated by use of the 'Corpen' soil balance method (in the Dialecte model), which takes into account the contribution given by:

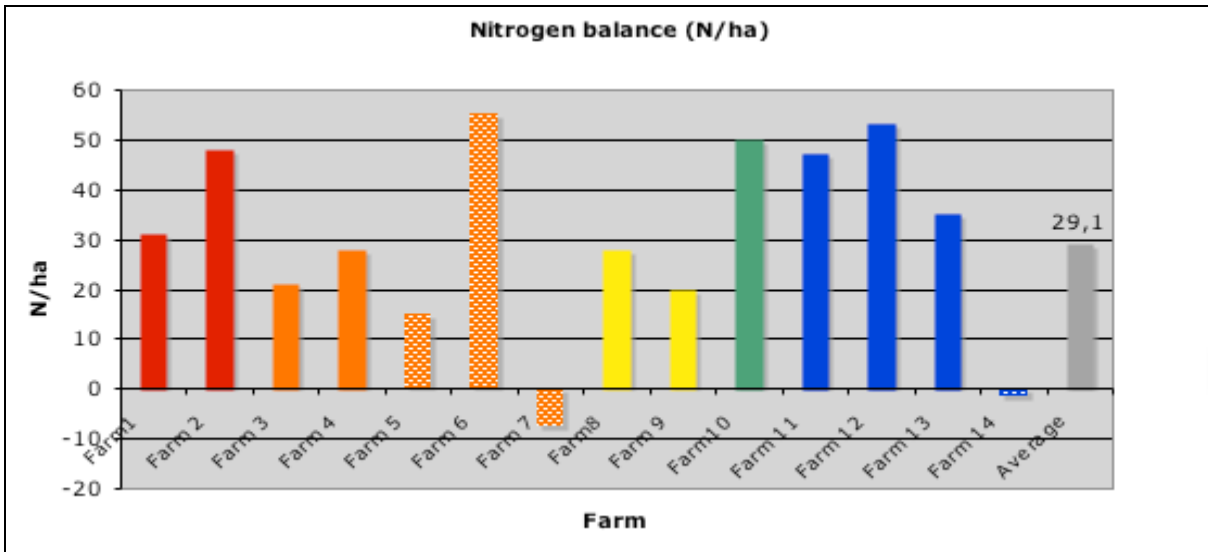
- Animals
- Chemical fertilizer
- Crops export outputs
- Legumes

Figure 5.10 below shows for each farm the amount of N input into the environment per hectare. It is estimated that for the area under study, a maximum of 40 kg N/ha can be accepted in order not to have water pollution.

The average rate of nitrogen in the farms surveyed is equal to 29.1 kg N/ha.



Figure 5.10: Nitrogen balance per hectare



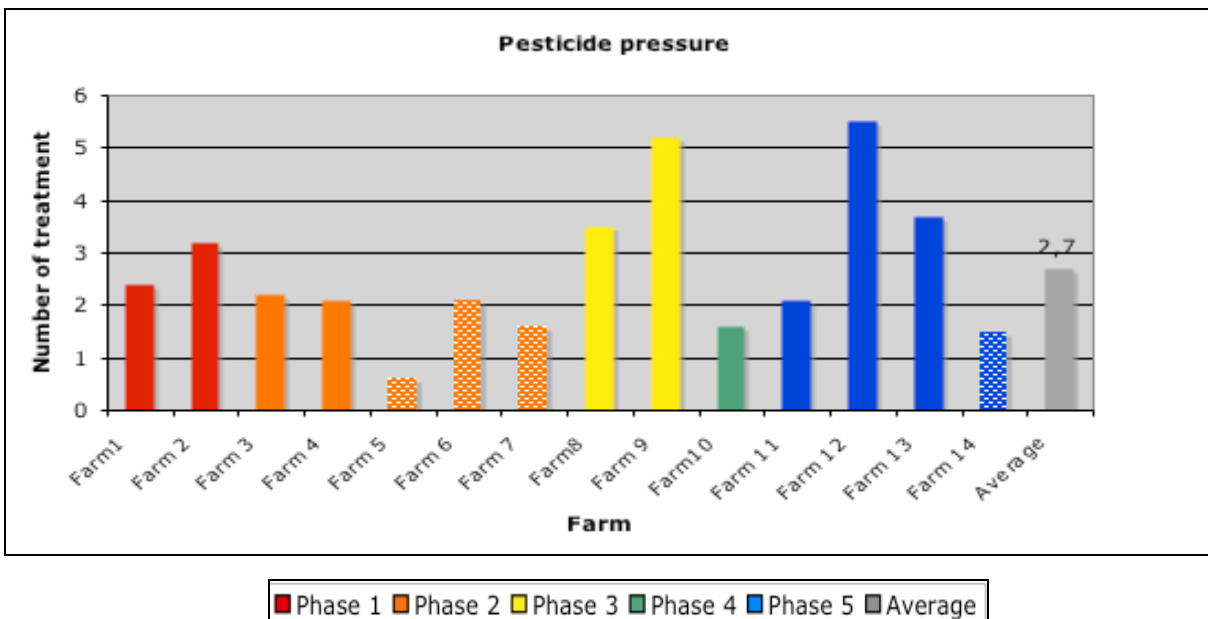
Source: Farmers inquiry

The share of legumes in the cropping pattern of farms is between 10 and 58 % depending of the crop rotation. The incorporation of legumes in cereal rotations brings the necessary nitrogen for the development of arable crops by means of N₂-fixation. The reduction of fertilisers allows saving energy and reducing N₂O emissions.

However, the large heterogeneity of the results leads to the conclusion that here N balance is in no relation with CA practices.

As for the pesticides, an indicator presenting the average number of treatments was calculated: the results is 2.7 on average for all farms. Figure 5.11 below shows an increase of treatments in phase 3 corresponding to an increase use of herbicides as weed killers. Farms 8 and 9 are in transition and do not take risk for crop protection. But there are farms under direct sowing as of many years that have a number of treatments quite high, especially those that have cover crops.

Figure 5.11: Pesticide pressure, average number of treatments by farm



■ Phase 1 ■ Phase 2 ■ Phase 3 ■ Phase 4 ■ Phase 5 ■ Average

Source: Farmers inquiry



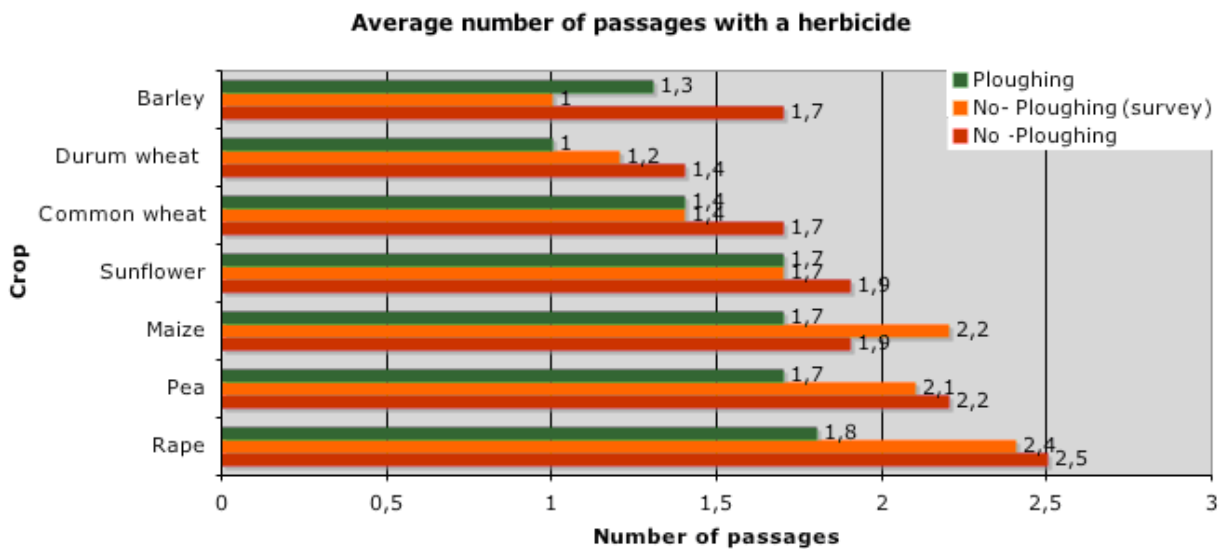
Those results are heterogeneous and depend of several factors:

- **Historic plot**
- **Knowledge and skills of the farmer**
- **Type of crop**
- **Implementation of cover crops or not**
- **Problem of resistance**

The link between pesticides pressure and soil conservation practices, however, is often not clear. Farmers declared to use doses of fungicides and insecticides much lower than the suggested quantities (between 20 to 50 %), confirming the literature evidence that links the use of CA with enhanced biological activity in the environment.

Regarding the herbicide use, no-tillage makes weeding operations more difficult and requires **more attention** and **more competence in weed management**.

Figure 5.12: Average number of passages with herbicide, Agreste



Source: for green and red: SCEES, 2006; for orange: Farm enquiry

Figure 5.12 shows the average number of passages with herbicide on field crops in no-tillage and in ploughing. The inquiry showed that number of passages is substantially the same than the average literature values in no-tillage, except for maize. But it is also fairly similar to the number of treatments done under ploughing (sunflower, common wheat).

Rape is quite an exception to that as it suffers from weed competition for the available nitrogen. If there are too many weeds, the rape yield may fall significantly. That is why the number of herbicide treatments is greater.

On the contrary, common wheat or durum wheat have good coverage capacities and are alternated with spring crops. Therefore, wheat happens to be a clean crop even after the first herbicide passage.

The **increased use of herbicides is due essentially to the need to destroy cover crops**. Indeed, the survey showed that farmers **implement mixed cover crops and use total herbicides for destruction**, especially glyphosate in full dose (2 L depending of the formulation, round up most of the time). However, some species are destroyed by frost and do not necessitate the use of herbicides at all.

The price of herbicide is currently high except for glyphosate and this explains its systematic consumption. Cover crops mechanical destruction is still possible but usually avoided as it represents a relevant cost and working time for all farms (see table below).



Table 5.7: Illustration of mechanical alternative for weed control

<p>Cage roller combine with cut-away disc</p>	<p>Zoom on cage roller</p>
<p>Weeding harrow</p>	<p>Hoeing machines (associated with low volume sprayer)</p>

These observations highlight the existence of a problem linked to the possible wrong application of CA techniques: the advantages of covering the soil through cover crops are partially or totally offset by the widespread use of herbicides.

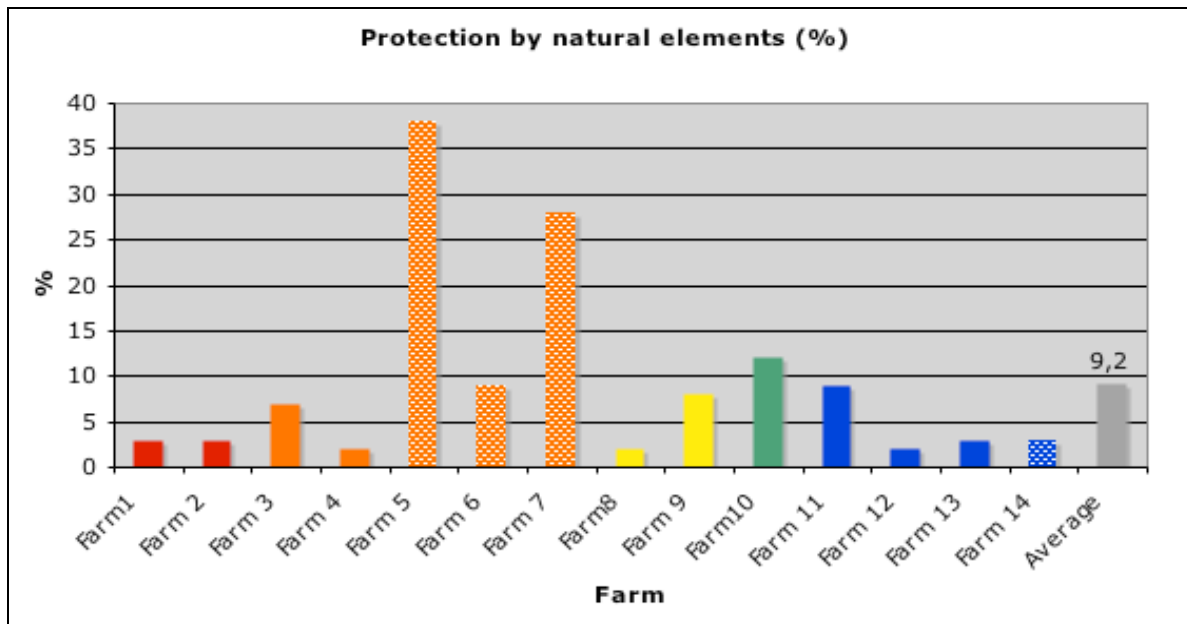
It was reported that to destroy 50 hectare of cover crops, local farmers might need more than 200 litres of glyphosate.

5.2.7 Ecological infrastructures

Figure 5.13 shows the percentage of ecological infrastructures (natural elements as hedges or grass strips allowing the creation of ecological corridor) in the surveyed farms. The average percentage is 9,2 % of the UAA. Farm 7 and 5 are the richest in such infrastructures because of local policies and of the relevant soil erosion risk (Rougiers de Camares). However, no direct link with the use of CA can be established



Figure 5.13: Ecological infrastructures in % of the UAA



Source: Farmers inquiry

5.2.8 Conclusion

Sampled farms show that there is a direct effect of CA techniques on soil protection. Both **no-tillage and reduced tillage appear as good solutions to fight erosion (in relation to soil cover management) and the decline of organic matter**. Soil cover (by cover crops or residues) proved essential to avoid bare soil, a major factor favouring runoff and soil degradation.

Some problems were highlighted in the use of **herbicides (higher in simplified tillage techniques)** for both weeding and cover crop destruction purposes. Local concern on the nitrogen balance was also evidenced, but no connection with conservation agriculture implementation can be established.

5.3 Economic performance of CA

The analysis on the economic performance of CA focused on the following five main topics:

- **Yields**
- **Mechanisation costs**
- **Labour time**
- **Fuel and energy consumption**
- **Investments**

Results of the inquiry have been compared to data from the producing costs study in Midi-Pyrénées in the framework of the regional observatory of simplified tillage techniques, and the technical bibliography of Midi-Pyrénées region.

5.3.1 Yields

Yields of the sampled farms were compared with average yields in Midi-Pyrénées in ploughing or no-ploughing conditions for the 2006-2007 campaign (SCEES, 2006) and the results are shown in Figure 5.14.

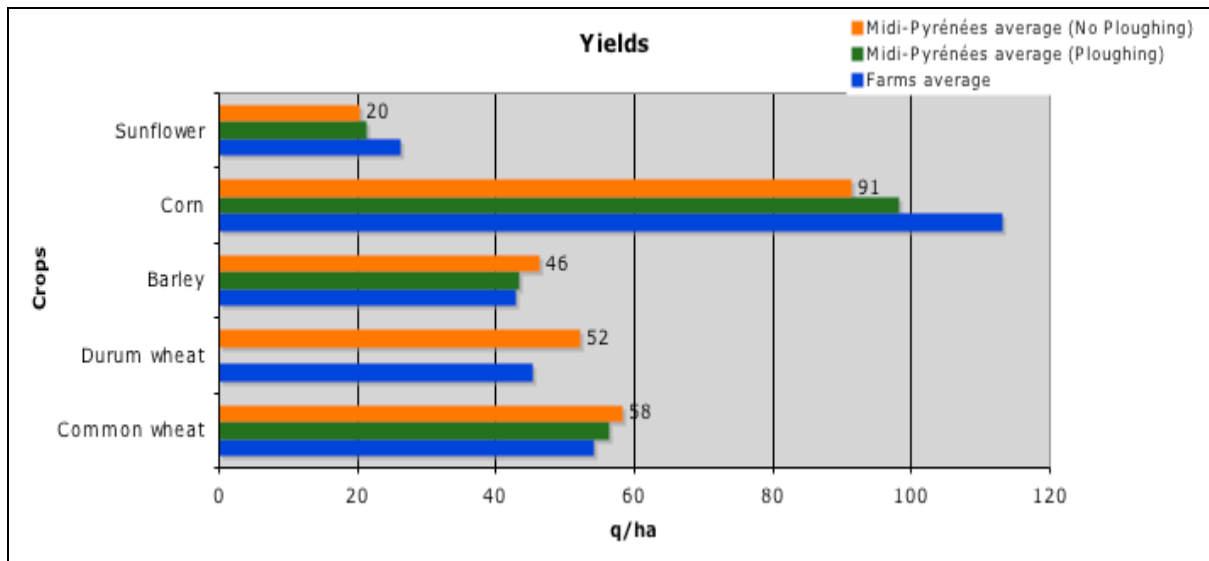


Winter crop yields of sampled farms are lower than average yields of Midi-Pyrénées in ploughing system and no-ploughing system. Nevertheless the differences are small (0.4 t/ha for common wheat; 0.3 t/ha for barley).

On the contrary, **spring crops yields (corn and sunflower) of sampled farms are above the average in ploughing system and no-ploughing system.** The differences for maize are relevant (2.1 t/ha). The gap for sunflower is about 0.6 t/ha.

Sampled farms have a **high degree of skills on spring crops**, which, according to the farmers' survey, are more difficult to cultivate in no-ploughing system.

Figure 5.14: Comparing yields 2006-2007



Source: SCEES, 2006; Sampled farms

The chart shows that yields of no-ploughing systems are comparable to **ploughing systems**.

5.3.2 Mechanisation costs

In ploughing systems, mechanisation costs represent about **45 % of the production cost of a tonne of wheat**. The seeding phase alone (soil preparation and sowing) accounts for about **60 % of mechanisation costs** (Labreuche, 2007).

In no-ploughing systems, the reduction of mechanisation costs is one of the main factors to maintain or improve income.

Table 5.8: Mechanisation (in €/ha) costs in function of tillage types

Farm types	Minimum	Maximum	Average
Ploughing in Midi-Pyrénées	210	357	272
No-ploughing in Midi-Pyrénées	110	471	245
No-ploughing in sampled farms	177	373	249
No-ploughing in Midi-Pyrénées/Ploughing (%)			-10 %
No-ploughing in sampled farms/Ploughing (%)			-8.5 %

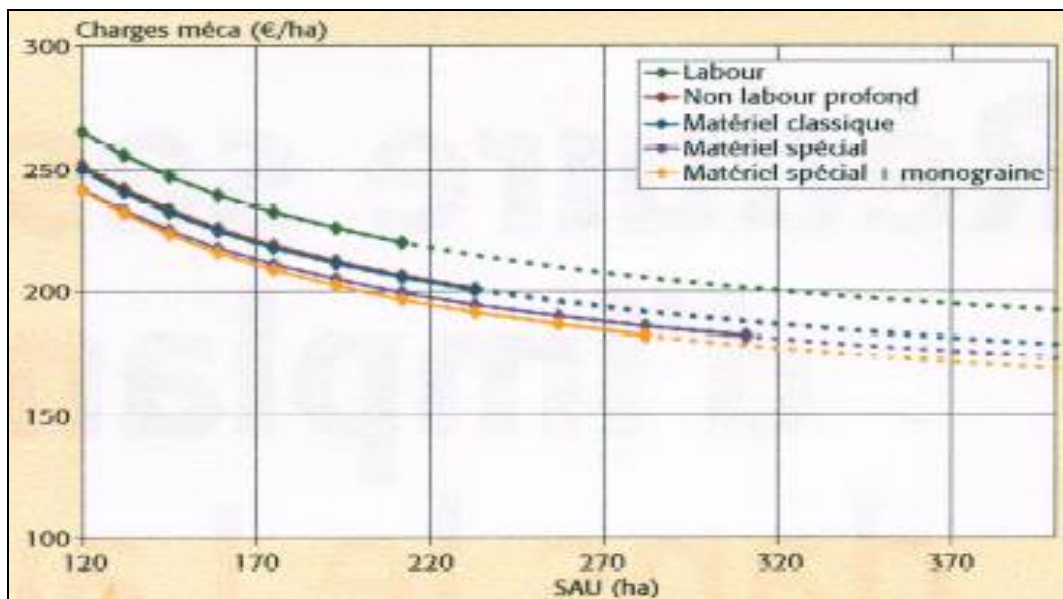
Source: Longueval, 2007 and Farmers survey

Table 5.8 shows that **mechanisation costs in no-ploughing system (sampled farms) are lower than in ploughing systems (-8.5 %)**.



These data confirm literature findings as shown below for the Lauragais district.

Figure 5.15: Mechanisation costs for five machinery parks (soil preparation and seeding), for five different implementation modes and related to UAA in Lauragais



Note: Green = plough; red = reduced tillage (deep); Blue = reduced tillage (shallow); Violet = reduced tillage (shallow) with specific drill only for cereals; Yellow: reduced tillage (shallow) with specific drill for cereals and single seed

Source: Crochet *et al.*, 2007

Figure 5.15 shows that mechanisation costs with or without specific machinery are lower in reduced tillage (deep or shallow) than ploughing. Compared to plough based system, the establishment of the reduced tillage techniques can reduce the cost of **10 €/ha and the labour time of 25 minutes/ha**. The use of drill (well adapted to reduced tillage conditions: crop residues at soil surface) can save **20 €/ha and 60 minutes/ha** compared to plough based systems.

It is interesting to note that **mechanisation costs decrease depending on the extent of the surface. The larger the area, the more mechanisation costs decrease.**

5.3.3 Energy consumption and efficiency

Fuel (for mechanisation), irrigation, NPK and crop protection were considered in the calculation of the direct and indirect energy consumptions for the sampled farms.

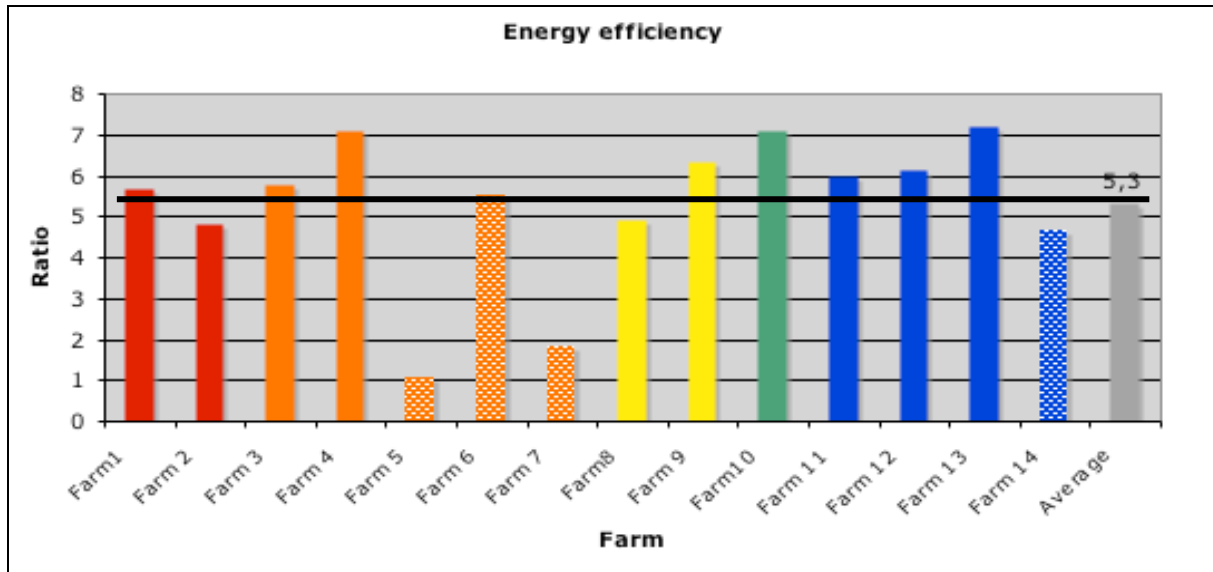
All the farmers declared that their energy consumptions (fuel, electricity and gas as forms of direct energy and fertilizers, crop protection, mechanisation as forms of indirect energy) decreased after converting their productions to CA.

However, the largest energy consumption factor concerns the use of fertilizers (N mainly) while crop protection concerns a very low percentage of consumption. No links have been decisive established between consumption of nitrogen (and nitrogen balance) and implementation of simplified cultivation techniques.

The energetic efficiency is the ratio between energy produced and energy consumed. The average **energetic efficiency** of 'cereals' farms in France is around **5.8** (calculated in 2006 by SOLAGRO on the basis of a survey on energy consumption and emissions of greenhouse gases on more than 900 farms in the country). Comparatively, most of the cereals sampled farms (Figure 5.16) are above that average (except those who are in mixed-livestock farming).



Figure 5.16: Energy efficiency per farm

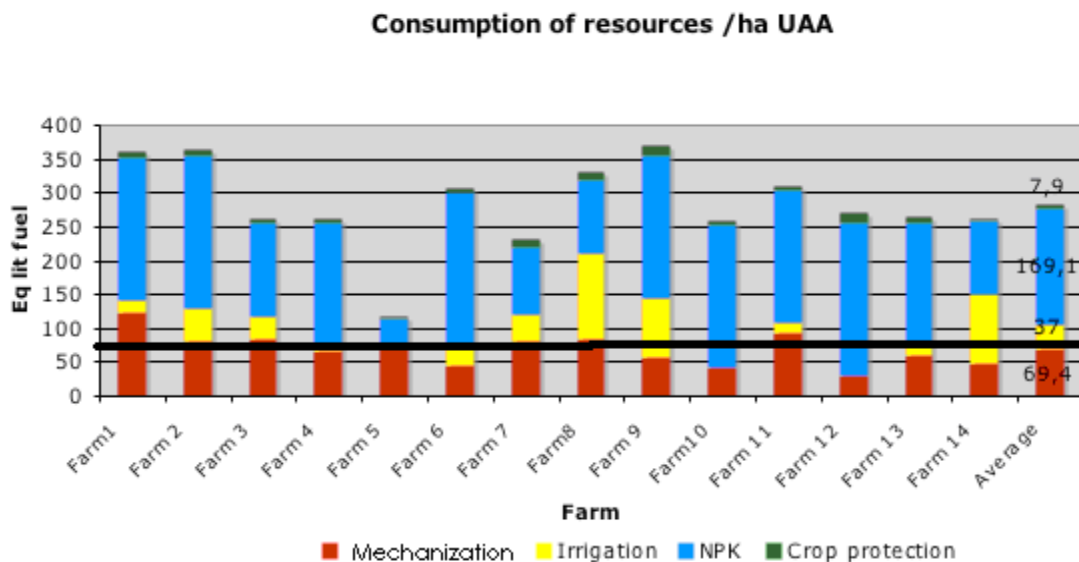


Note: dark line = average energetic efficiency in France = 5,8; Source SOLAGRO - PLANETE average L annual crops, 2006
Source: Sampled farms

5.3.4 Fuel consumption

In sampled farms, as represented in Figure 5.17 below, the average fuel consumption is about 60 l/ha/year for soil preparation, sowing and harvest, but it's just 35 l/ha/year in the surveyed farms under no-tillage conditions compared to a national average for 'cereals' farms of around 70 l/ha/year (PLANETE⁴).

Figure 5.17: Energy consumption expressed in equivalent litre of fuel per farm



Note: dark line = average of energy consumption in cereal farms = 70 EqF/ha; Source SOLAGRO - PLANETE average for annual crops, 2006
Source: Sampled farms

⁴ Planete is a tool developed by Solagro and other partners to analyze the energy fluxes in the farm systems, along with an estimate of the GHG production



The table below presents the fuel savings of CA systems by crops in Midi-Pyrénées and France. Winter crops generally allow for more savings compared to spring crops where cultivation needs more superficial tillage operations.

Table 5.9: Fuel savings in Midi-Pyrénées and France (l/ha) as affected by tillage systems

Tillage systems	Midi-Pyrénées			France
	Durum wheat	Sunflower	Corn	Average
RT/CT	11.3	23	45	20-40

Note: CT= conventional tillage; RT = reduced tillage
Source: Longueval, 2007

5.3.5 Labour time

The inquiry data showed that, in **ploughing** systems, **labour time estimated by farmers was 1h - 1h30/ha** depending of soil types. In **reduced tillage** (cultivators, cover crop, rotary harrow, tiller, etc.), they declared an estimated labour time of about **40 to 45 minutes per hectare**; and in **direct sowing in general 30 minutes per hectare**. These figures match perfectly with those found in literature, as illustrated by the table below.

The use of specialised seeding equipment (as for no-tillage) reduced significantly the labour time, around one hour per hectare (Labreuche, 2007).

Table 5.10: Comparative literature labour times for annual crop implementation as affected by seeding techniques

	Ploughing	No-ploughing with classic material	No-ploughing with seed drill on disc tiller	No-ploughing with seed drill on tooth tiller	No-tillage
Total labour (time/ha)	2h 00	1h 50	50 min	45 min	31 min
Sowing labour (time/ha)	1h 05	30 min	20 min	18 min	28 min

Source: Arvalis info, 2007

Table 5.11 focuses on the Midi-Pyrénées region. This table shows a relevant reduction of labour time in winter crops (cereal straw), up to 68 % under no-tillage, compared to conventional tillage.

**Table 5.11: Labour time (hours) in Midi-Pyrénées, as affected by tillage systems**

	Midi-Pyrénées, France		
Crops	Cereal straw	Sunflower	Corn
CT	3h45	4h	4h
RT-d		3h20	3h
RT-s	2h30	2h	
NT	1h10		
RT-d/CT (%)		-20 %	-25 %
RT-s/CT (%)	-33 %	-50 %	
NT/CT (%)	-68 %		

Note: CT= conventional tillage; RT-d = deep reduced tillage; RT-s = surface reduced tillage; NT= no-tillage

Source: Longueval, 2006

5.3.6 Conclusions

Out of the fourteen surveyed farms, six pointed to the **economic motivations (mainly farms in phases 1, 2 and 3)** as the factor for having changed production system in favour of CA. Indeed, the pursuit of a less expensive, faster production, with no relevant impacts on yields, is one of the strongest arguments for the adoption of **reduced tillage techniques for these farms**.

However, this is not the reason for farms having swapped to no-tillage systems, where instead, soil conservation is the main driver.

It should also be noted that mostly large farms (> 200 ha) are interested by CA techniques. By use of these techniques, they reduce labour costs for the preparation of the soil. This is an important phenomenon because of the farms size steady increase.

Combined with other benefits such as reduction of mechanisation and fuel oil costs, the benefits of implementing CA techniques, along with the other landscape soil conservation measures, are clear, especially for large farms.

The recent strong increase in the market price of cereals might also push gross margins upward, especially for farmers who are in direct sowing or reduced tillage systems.

For small farms (less than 100 ha), the cost of machinery for CA techniques (especially direct seed drills for no-tillage) is very relevant and difficult to face economically.

The **transition period** remains the weak point for CA techniques, especially no-tillage. The length of the transition phase may vary (5 years or less), depending on the farm conditions (soil and climate) and on the farmer's skills. During this time, there will possible be positive effects on the economy. The seeding material is still very expensive and remains an costly investment for farmers.

The **most advanced systems** (no-tillage, soil cover and long/diversified crop rotations) reduce economic risks (after the transitional phase) by:

- restoring the soil to buffer the inter-annual climate variability and thereby ensure consistent high yields;
- reducing the share of each crop (diversifying crop rotation) thus reducing the economic sensitivity of farms to changes in market prices.



6 Soil conservation policies

6.1 Overview

In the current approach, soil degradation (mainly focused in France on water erosion and decline of soil organic matter) is addressed directly by a few measures within the agricultural and environmental policies, and indirectly by a greater number of measures targeting other environmental issues such as water quality. These policies include mandatory and voluntary optional mechanisms, and emanate at all policy levels, from European Directives to local-level initiatives.

At the European level, the policies whose main topics are water erosion and decline of soil organic matter are

- the Framework for Good Agricultural and Environmental Conditions (GAEC);
- the proposal for the Soil Framework Directive.

GAEC is a component of the cross compliance (regulatory policy of the CAP), along with the 'Statutory Management Requirements' (SMR). The proposal for the Soil Framework Directive comes from the Soil Thematic Theme Strategy (COM(2006) 231), adopted by the Commission to ensure an adequate level of protection for all soils in Europe.

At the French level, the national decree 'Zones under environmental constraints' (ZUNC) has been identified as the key policy addressing soil conservation in France. This regulation concerns humid areas with a high potential for biodiversity, 'drinking water' areas and erosion areas. It originates in the 2006 regulation on Water (n°2006-1772 Article 21) and in the 2003 regulation on natural hazards (n°2003-699).

Indirectly, a greater number of policies, targeting other environmental issues (water quality and biodiversity) address soil degradation. Specifically, the agri-environmental measures scheme, the Nitrate Directive, the Water Framework Directives (WFD), the Less Favoured Areas (LFA) and Set-aside are here described.

Note: The agro-environmental measures of the Rural Development Plan which must support methods addressed to soil protection among the different environmental issues. But the environmental priorities are fixed by the Member State.

The Table 6.1 below offers a summary of these main identified measures.

**Table 6.1: Policies available in France, related to farming practices and water erosion**

Policy	European regulation	Reference	French denomination	Voluntary (yes or no)	Time period
GAEC standards	Cross compliance - CAP 1 st pillar	1782/2003/CE - Appendix IV	<i>BCAE</i>	No	2005 -
AEM scheme I	RDP I - CAP 2 nd pillar	1257/1999/CE - Art. 22	<i>PDRN – Mesure f - MAE (CTE-CAD)</i>	Yes	2000-2006
AEM scheme II	RDP II - CAP 2 nd pillar	1698/2005/CE - Axis II art. 36	<i>PDRH – Axe II MAE - MAETER</i>	Yes	2007-2013
Nitrate Directive	Nitrate directive	91/676/CEE	<i>Directive Nitrate</i>	No*	1991
LFA	RDP I & II - CAP 2 nd pillar	1257/1999/CE - art. 13 1698/2005/CE - Axis II art. 37	<i>ICHN</i>	Compensatory allowances	2000
Set aside	CAP 1 st pillar		<i>Gel des terres</i>	No	1993-2008
WFD	WFD	2000/60/CE	<i>Directive Cadre sur l'Eau (DCE)</i>		2008-2027
Decree 'ZUNC'	No	Décret n°2007-882 du 14/05/07	<i>Décret erosion</i>	Yes and No **	From 2008

* Some articles in the Nitrate Directive are simply advisable and non-mandatory

**The first implementation phase of the Decree 'erosion' is based on a voluntary agreement; and if a second phase is necessary, it becomes mandatory

Note: The Soil Framework Directive, once approved, could appear in this table

**Table 6.2: Policies available in France, related to farming practices and water erosion, detailed measures**

Policy	Soil cover autumn (arable crops)	Soil cover winter (arable crops)	Soil cover (perennial crops)	Crop rotation	Soil organic matter	Soil structure	Grass- land	Simplified tillage	Parcel size	Runoff harve- sting	Farmers' skills	Know-how monitoring
GAEC standards	X			X	X	X	X					
AEM scheme I	X	X	X	X	X		X	X	X	X	X	
AEM scheme II	X	X	X	X			X		X	X	X	
Nitrate Directive	X											
LFA							X					
Set aside	X	X										
WFD	X	X	X	X	X	X	X	X	X	X	X	X
Decree 'ZUNC'	X	X	X	X	X		X	X	X	X		X

Note: The Soil Framework Directive, once approved, could appear in this table and would probably fit under all the headings



6.2 Policies directly addressing soil degradation at European and French level

6.2.1 Cross compliance

Beneficiaries of the CAP Single Payment Scheme (SPS) must comply with a number of standards or, in the event of non-compliance, risk a financial penalty in the form of a reduction of the Single Payment (one percent of farms submitting claims under the Single Payment Scheme are inspected each year). Since 2007, cross compliance is also required of farmers who are not under SPS, such as viticulture or horticulture, and who agree on agro-environmental measures under contract.

As such, cross compliance is a regulatory policy measure. One set of standards, the 'Statutory Management Requirements' (SMR) is derived from nineteen items of EU legislation in the areas of the environment, public health and animal health and welfare. Of these SMR, those from the Sewage Sludge Directive (heavy metal contamination) and the Nitrate Directive are of indirect relevance to soil conservation. Only selected articles from these pieces of legislation are included as cross compliance SMR, and are listed in Appendix III of Regulation 1782/2003. For the Nitrate Directive, the mandatory presence of soil covers during autumn and winter (for specific zones where Action Plans are strengthened) is one of the points selected and included in the cross compliance (with a high penalty rate).

Another set of standards, provided in Appendix IV of the same Regulation, establishes the Framework for Good Agricultural and Environmental Conditions (GAEC). The issues in this Appendix specifically deal with soil conservation (erosion, organic matter and soil structure). The proposed standards give an indication as to the type of solutions to adopt (e.g. adaptation of soil tillage) and need to be adapted to the national or regional level.

In France, GAEC is divided into six themes (GAEC I: Implementation of a minimum area under environmental cover representing 3 % of the annual crop area; GAEC II: Non-burning of crop residues; GAEC III: Crop distribution diversity; GAEC IV: Levee irrigation systems for main crops; GAEC V: Minimum soil preservation; GAEC VI: Land preservation as permanent pasture). Apart from the establishment of grass strips in the plots (priority is given to their development along the rivers and not across the slope), the French implementation of Appendix IV will have no impact on erosion and the decline of soil organic matter (see details in Table below). GAEC VI, concerning the preservation of permanent grasslands, is not efficient and not targeted to grasslands located in zones at risk of erosion.

Indeed, mandatory agricultural practices have no effect on soil degradation issues and/or are already widely used (their implementation is no longer a sign of progress). Table 6.3 below presents the French GAEC in details.


Table 6.3: The Good Agricultural and Environmental Conditions (Cross compliance 2006)

	Title of the good agricultural practice	What is the objective?	Who is concerned?	What is controlled?	Impact on current soil erosion problems
GAEC I	Implementation of a minimal area under environmental cover	<ul style="list-style-type: none"> - Protection of soil from erosion risks and limitation of risks of diffuse pollution in soils and waters: → Implementation of grass strips along water courses on 3 % of surfaces declared in cereal and oilseed. - Improvement of soil structure 	<ul style="list-style-type: none"> - All farmers under SPS and measures of the second pillar are concerned by this measure, except the 'small producers' (producing less than 92 t of cereals). 	<p>Presence of the cover:</p> <ul style="list-style-type: none"> → Cover must be present during the minimal period from 1 May to 31 August <p>Realisation and localisation of the cover:</p> <ul style="list-style-type: none"> → Along water courses: minimum width: 5 m; maximum width: 10 m; minimum surface: 5 ares → Outside water courses: if borders of watercourses are inferior of 5 ares, grass strips must be pertinently localised: border of fixed elements, of road, on water catchments areas <p>Maintenance of the cover</p> <ul style="list-style-type: none"> → Maintenance by reaping and grinding (period defined by prefectural order) 	<ul style="list-style-type: none"> Reduction of water courses pollution (transfer mitigation) from soil particles Location of grass strips within the parcels to fight erosion problems Impact on soil organic matter will depend of the permanence (or not) of the grass strip
GAEC II	Non-burning of crop residues	<ul style="list-style-type: none"> - Preservation of SOM 	<ul style="list-style-type: none"> - Farmers under SPS and measures of the second pillar with cereal crops 	<ul style="list-style-type: none"> - Absence of traces of burning - Or existence of a dispensation 	<ul style="list-style-type: none"> No impact (this measure is largely implemented; in 2001 only 1 % of the farmers burnt straw)
GAEC III	Diversity of distribution of crops	<ul style="list-style-type: none"> - Preservation of the SOM - Improvement of the soil structure 	<ul style="list-style-type: none"> - Farmers with systems of monoculture of temporary grasslands - Farmers with other systems of 	<ul style="list-style-type: none"> - In addition to the non-cultivated fallow permanent pastures and perennial crops: at least 3 different crops (min. 5 % of the UAA) and 2 different families (min. 5 % of the UAA) 	<ul style="list-style-type: none"> No impact (this measure was in a large part yet implemented), the selected thresholds are very low and will not change the current rotations



	Title of the good agricultural practice	What is the objective?	Who is concerned?	What is controlled?	Impact on current soil erosion problems
			monoculture: management of inter-crop introducing winter cover or managing crop residues	- For the monoculture systems: winter soil cover or management of stubble are obligatory (fine grinding < 10 cm and superficial incorporation < 5 cm)	
GAEC IV	Levees irrigation system for main crops	- Preservation of the soil structure - Decrease the effects of compaction and soil losses	- All farmers benefiting from aid specific to the irrigation for a COP crop	- Respect of the norms of irrigation - Method to evaluate removed volumes	No impact on soil erosion
GAEC V	Minimal maintenance of soils	- Avoid degradation of the productive potential of the soil (Avoiding the encroachment of unwanted vegetation on agricultural land) - Concerned distribution of crops under direct aid: → Distribution of crops into production → Grasslands → Fallows → Distribution of crops into non-production	- All farmers benefiting from direct aid	- Respect of the rules by prefectural order (including soil cover)	No impact on soil erosion (except obligation of soil cover for land out of production)
GAEC VI	Maintenance of land in permanent pasture	- Preservation of diversity fauna and flora - Protection of the water resource	- All farmers benefiting from direct aid	- Dedicating a part of the UAA to grass production and other fodder crops during at least 5 years - Control occurs at the national level with the objective maintaining the ratio permanent grassland/arable land	No impact yet due to the implementation at a national level and not at the farm level. And this ratio can decrease up to 10 %



Hedges and other landscape features within the Single Payment Scheme (SPS)

Landscape elements such as hedgerows have an important role in preventing erosion. This is especially the case for hedges planted perpendicularly to the slope. Their surface has strongly declined during the 1960-1990 period, in step with the intensification of farming systems. Considering the fact that their status is not clear, the implementation of SPS and the Integrated Administration and Control System (IACS) has had some negative impact. Some farmers removed their hedges anticipating CAP controls, to ensure a maximum eligible surface.

The main impact of SPS implementation concerned how hedgerows were taken into account (IACS) in agricultural surfaces. The eligibility of surfaces is defined by Regulation 2419/2001 (Articles 5 and 22), by the working document (AGRI/2254/2003 (Article 2) and Regulation 3508/92. But this regulation is not clear. Some farmers preferred to destroy their hedges to make sure they had the maximum eligible surface, and thus avoid being penalised, in case of control.

A solution could be to integrate the protection of the unfarmed features in the GAEC. This means accepting a maximum percentage of unfarmed features (7 to 10 %) in the parcel, (rather than the current rules); and/or require a minimum surface of unfarmed features, such as the 5 % of the UAA covered by ecological infrastructure required by IOBC for integrated production. This proposal is currently being implemented in the AEM Grassland Premium, which obliges the farmer to cover 20 % of his UAA with farmed and unfarmed feature surfaces called 'Biodiversity Surfaces' ('surfaces de biodiversité') such as the hedgerows included in the UAA.)

6.2.2 Decree concerning areas under environmental constraints (French policy)

This regulation concerns the areas under environmental constraints (*Decree n°2007-882*, May 2008). It originates in the 2006 regulation on Water (n°2006-1772 Article 21) and in the 2003 regulation on natural hazards (n°2003-699). These areas are humid areas with a high potential for biodiversity (ex.: peat bogs, marsh swamps), 'drinking water' areas and erosion areas.

An erosion area is defined as 'a part of the territory that, due to the nature of soil conditions or to their occupancy, lack of vegetation cover or hedges, slope soil management, promotes:

- soil erosion that accelerates runoff, causing downstream damages,
- a diffuse erosion of agricultural soils that can jeopardise the attainment of the WDF objectives.'

These area delimitations are done by the department authorities (at NUTS 3), after consultations with the department council for the environment and natural risks, the department Chamber of Agriculture and the local committee on water and the local authorities (municipalities concerned). The local authority concerned design an action programme for each erosion area. The programme is based on recommendations concerning soil cover (temporary or permanent), soil tillage, management of crop residues, provision of organic matter, input management (fertilisers and pesticides), crop diversification (rotation and cropping plan) and preservation or implementation of structures to limit run-off (hedges, banks, ponds, 'fascine'). The action plan sets objectives according to the type of action for each party in the area concerned. If possible, objectives are defined quantitatively (number of hectares, etc.), and carry deadlines.

The department authorities put the implementation in place. During a first phase, action plan measures are submitted to farmers on the basis of voluntary compliance. Taking into account the results with regards to the established objectives, the department authorities may, three years after the publication of the action programme, decide to make mandatory some of the measures defined in the programme. During the voluntary compliance phase, farmers may

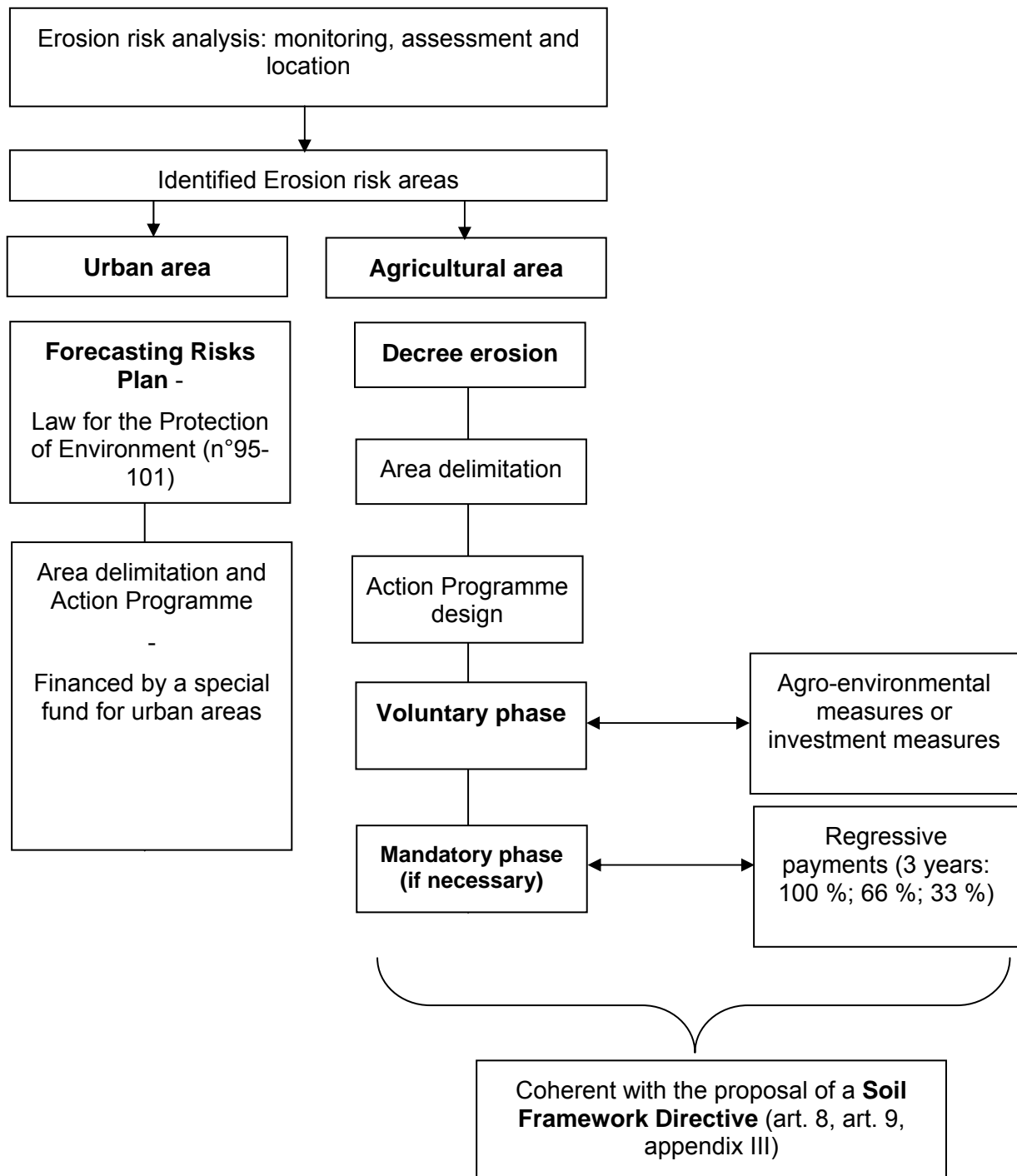


receive payments for the implementation of measures. If the mandatory phase is applied, farmers may also receive payments (payments are regressive and cancelled after three years).

This legislation (tested in 2008) is potentially very effective, complementary to the urban sector Forecasting Risks Plan and coherent with the proposal of a Soil Framework Directive (see Figure 6.1 below). The implementation of the Decree has to be helped by soil monitoring tools to be efficient (local definition of soil degradation issues and mapping system).

This measure has not been yet implemented in France.

Figure 6.1: Links between the Decree for areas under environmental constraints (including erosion) and other policies





6.3 Policies indirectly addressing soil degradation at European level

6.3.1 The Nitrate Directive

In France, the implementation of the Nitrate Directive 91/676 began in 1993 with the definition of the areas classified as Nitrate vulnerable zones, the elaboration of the code of good agricultural practices and a first Action Plan (set of measures). The current Action Plan (which is the third) covers the period 2004-2009, and is based on measures such as, periods when it is inappropriate to apply fertilisers to the land, the conditions for the application of fertilisers and the registration of the practices, the size of the livestock manure storage containers and the preservation of a minimum quantity of soil cover after harvest (autumn and winter).

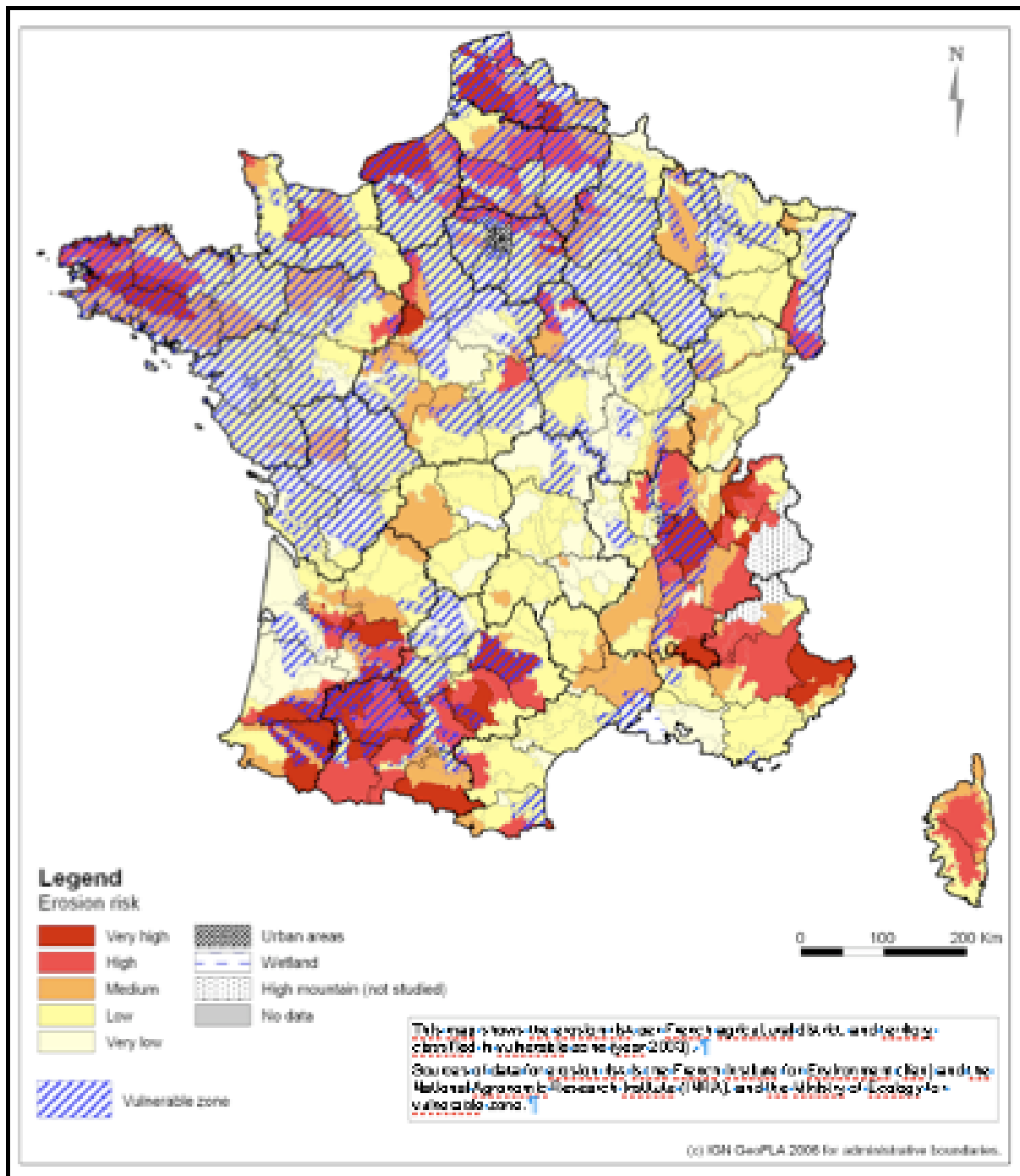
The measure concerning soil cover, whose objective is to prevent nitrogen leaching, is relevant for soil protection as well. This measure is optional in 36 departments, and mandatory in another 31 departments. Generally the measure is not implemented by farmers when it is not mandatory.

The current action plan sets an objective concerning the percentage of soil to be covered at the end of its application. Depending on the departments concerned, new measures, such as the protection of grasslands along rivers and wet grasslands, and the implementation of grass strips along riverbanks, are either advised or required. The protection or the implementation of landscape elements is recommended but not required.

At present, the Nitrate vulnerable zones cover 15 million UAA hectares (55 % of the French UAA and 60 % of arable lands). This Directive is the main force in France driving cover crop implementation. 90 % of cover crops implemented in France are located in Nitrate vulnerable zones. Approximately 1 million hectare were implemented between 2000 and 2007, (partly funded by a specific 5 year-payment plan as well as by the AEM scheme, when this measure was not compulsory)

The measures benefiting water protection can also benefit soil conservation. This is partly true considering that most of the areas at high and very high risk of erosion are located in Nitrate vulnerable zones (61.2 % of the UAA, 71.1 % of arable land and 68.8 % of spring crops, see Map 6.1 below).

Map 6.1: Annual erosion risk and vulnerable zones in France



Source: INRA-IFEN, 2002; Ministry of Ecology, 2003

The fourth Action Programme (planned for 2009-2012) is currently under debate and will be applied in June 2009. The administrative recommendation ('circulaire') GDFAR/SDER/C2008-5014, dated 26 March 2008, included a new mandatory measure, relevant for soil protection. This measure proposes a soil cover during the risky leaching period, with the objective of attaining 100 % of arable land in 2012. Soil cover can be achieved with winter crops, cover crops, regrowth of rapeseed crops or fine crushing of maize stems. Soil covers must be in place before 10 September for all crops harvested in July and August. Cover crops must be destroyed between 15 November and 1 February, depending on the climate (cover crops must reach a dry biomass of 3 tons to fix the excess of Nitrogen).



But, as far as the necessary measures are concerned, the two objectives (to prevent nitrogen leaching and soil erosion) are not exactly the same. In one case, the measure seeks to prevent nitrogen leaching, mainly in autumn, by capturing the excess nitrogen in the soil after the harvest. In the other, the aim is to prevent erosion by covering the soil both in autumn and in spring. Both measures have a common point: the implementation of a plant cover between the harvest and the following spring crop. The differences concern the mandatory period for the cover crop (between its seeding and its destruction) and the type of cover.

Among the different programmes, an increase of the proposed or required measures having a positive impact on soil protection (through soil cover), can be observed. The Nitrate Directive, with its Action Plans is, since 2000, the main force driving the implementation of soil covers. The main weakness concerns the period between February and April/May, during which a soil cover is not required and the risk of soil erosion is still high. The fourth Action Programme (2009-2012) will highly impact soil conservation, with the objective of covering 100 % of the intercropping period (September-December) in vulnerable zones (perennial crops and inter-row management are not concerned by the Nitrate Directive).

6.3.2 The Water Framework Directive

The Directive 2000/60/EC of the European Parliament and Council of 23 October 2000 establishing a framework for the entire Community (Water Framework Directive, commonly known as WFD) aims to attain, by 2015, a 'good ecological and chemical status of the surface waters', and a 'good chemical and quantitative status of the ground-water'.

However, Article 4.4 states that, under certain conditions, these objectives can be extended to 2021 and 2027. Two daughter directives provide further details on the definition of the 'good status' of water bodies. The first, adopted in 2006, establishes that no later than December 22, 2008, Member States have to determine, for the groundwater identified as being at risk, a threshold for each pollutant. The second, related to water surfaces, must be established by the end of 2008. It requires the adoption of environmental quality standards for certain substances of concern.

At present, Water Agencies (together with the departments at NUTS3) are implementing the management plans and programmes with the measures required by 2009. They are currently open to public consultation (15 April to 15 October 2008). These Action Plans, aimed at obtaining good water bodies status, are the core of master planning and water management revisions (Water Agency Frame Documents).

From the perspective of the Water Framework Directive, the soil is an interface between water bodies (rivers, ground waters, coastal waters, etc.) and different diffuse pollution (nitrogen, phosphorus, pesticides) originating in agriculture. Action Plans can propose (or, under the master planning and water management revision, impose) all the measures restricting the use and/or transfer of pollutants to water bodies.

To fight erosion, measures limiting the transfer of phosphorus (and eutrophication) were decided. However, the most relevant measures concern pollution of drinking water by Nitrate and pesticides (restrictions on the use of pesticides, limits on the transfer of pesticides by runoff, measures regarding pollution by Nitrate in agreement with the Nitrate Directive).

Some measures, such as the aid for simplified tillage techniques relevant for soil protection, and present in the Action Plans of the Water Framework Directive, have often been abandoned. Most Water Agencies have been very reluctant to promote these forms of agriculture, due to the lack of references on the transfer rate of pesticides in agriculture conservation, and to the fear of promoting more herbicide-consuming techniques (herbicides: first factor of pollution of water bodies).

The implementation of the measures has not started yet and it will be limited for financial reasons. The programme has to be adjusted to the budget of the Second Pillar (see paragraph on AEM scheme).



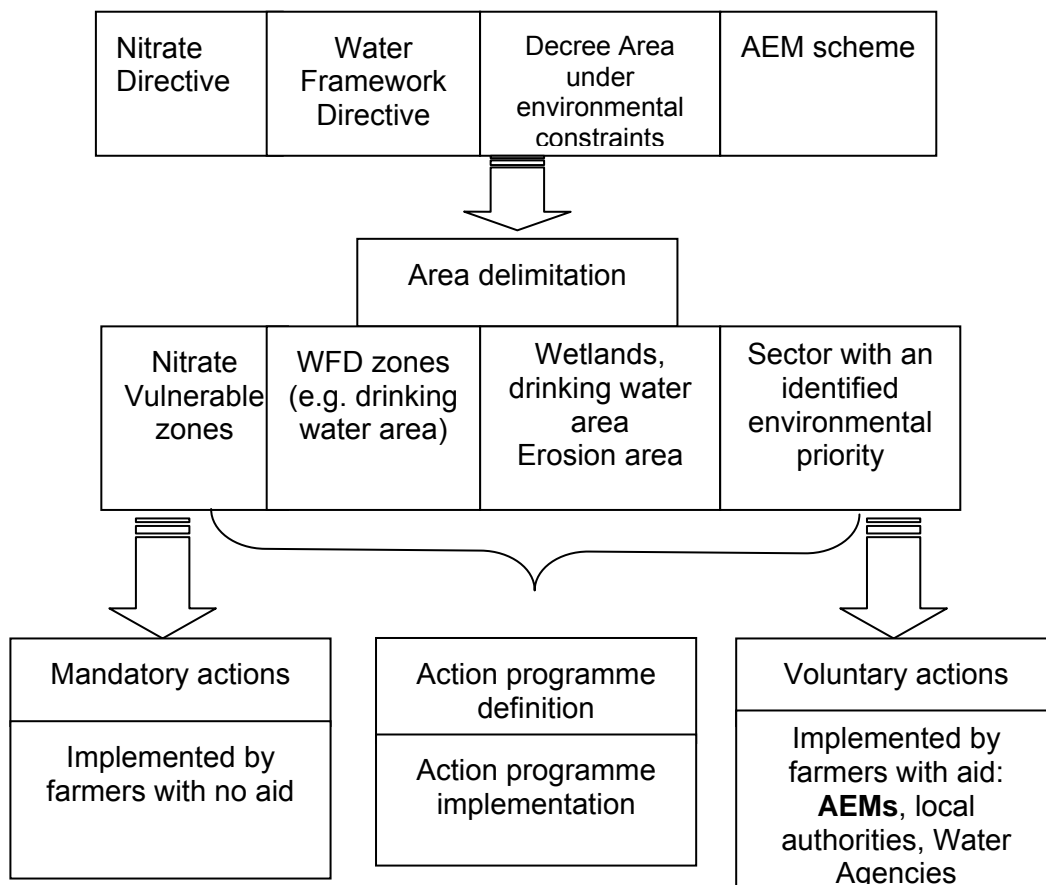
6.3.3 Agri-environment Measures (AEM)

Agri-environment measures were introduced into EU agricultural policy in 1985 (but only applied in 1990 in France) as an instrument to aid specific farming practices that help to protect the environment and preserve the countryside. With the CAP reform in 1992, the implementation of agri-environment programmes became compulsory for Member States in the framework of their rural development plans. The 2003 CAP reform maintains the obligatory nature of the agri-environment schemes for Member States, whereas they remain optional for farmers. Member States have substantially discretion in the priorities of environmental issues and on measures to implement.

Farmers who commit to adopting over a minimum five-year period environmentally-friendly farming techniques that go beyond the usual good farming practice, receive in return payments that compensate for any additional costs and loss of income that arise as a result of altered farming practices.

Four plans can be observed: Regulation 797/85 (called 'Article 19' (1990-1992)), Regulation 2078 (1993-1999), Regulation 1257/1999 (2000-2006) and Regulation 1698/2005 (2007-2013). Most European or French regulations strive to implement mandatory and optional actions (in defined areas). Most of the time, voluntary actions are backed by the AEM scheme (see Figure 6.2 below).

Figure 6.2: Description of the AEM scheme implementation



The first programme ('Article 19') was not targeted on soil issue. The issues were: biodiversity (45 % of the projects), prevent land abandonment (42 %), nitrate pollution (6 %), and prevent fire in Mediterranean areas (6 %).



Concerning the second programme (Regulation 2078), some projects were targeted on soil erosion issue as 'Rougiers de Camarès' in Aveyron or 'Bas Quercy' in Tarn and Garonne with an average annual budget of 40,000 €/year. The main measures implemented were: conversion of arable land into grassland, implementation of grass strip along river banks, hedgerow plantation.

In the third phase of the implementation of the AEM scheme in France (2000-2006), the environmental priorities were locally defined (biodiversity, water quality and quantity, eutrophication, erosion). Priorities were defined by local authorities and farmer organisations; moreover, for the first time in France, non governmental organisations for the protection of the environment were involved.

The AEM schemes also can support voluntary measures in the Nitrate vulnerable zones (installation of cover crop, protection of riverbanks with grass). During this period (2000-2006), communities and Water Agencies could also help establish the voluntary measures. These aids were independent of the AEM scheme, and no information was sent to the European Commission.

Two main schemes were implemented: the grassland payment (called 'prime à l'herbe') corresponding to 43 % of the total agri-environment payments) and the 'Farm Territorial Contract' (CTE) followed by the Sustainable Agricultural Contract (CAD), a five year contract between the farmer and the administration. In this contract, after completing a farm diagnose (environmental and economic), the farmer chose the appropriate AEMs and environmental investments, and committed to implement them.

In conclusion, the AEM under Regulation 1257/1999 have mainly been focused on existing permanent grassland management with 61 % of total agri-environment payments. The two measures focused on soil issue (cover crops and simplified tillage) represented only 5 % of the total payments.

During this phase, some of the texts mentioned in the Figure above were not yet in place (particularly the Water Framework Directive).

In the second phase of the implementation of the AEM scheme in France (2007-2013), five main points have to be taken into account:

- The evaluation of the first period of application (ex-post assessment: casting doubt on the environmental efficiency of the first phase);
- The establishment of the Water Framework Directive (and the need to fund the optional measures defined therein);
- The implementation of Natura 2000
- The reduction of the budget
- The requirement for communities and water agencies to notify their aid and programme through the AEM scheme.

According to these points, two major environmental priorities were defined at the national level: water (compliance and implementation of the Water Framework Directive) and biodiversity (compliance and implementation of the Birds and Habitats Directives). In the case of water, priorities are given to drinking water pollution by pesticides. This objective is also one of the priorities of 'The Grenelle of the environment' national public debate on the environment held in October 2007.

In addition, the local application of the AEM scheme is currently coordinated with the action programmes of Water Agencies. These programmes (called Territorial Action Plans) are collective. They concern a group of farmers located on the same territory (it is no longer possible to fund isolated farmers by signing a contract), and a main environmental priority. Implementation is coordinated at the regional level by agricultural administration. The



administrative burden is high and complex. In 2008, only few hectares were contracted due to the complexity of the procedure and the low payments compared to the new cereal prices.

At present, the AEM scheme is the main financial tool to achieve those environmental objectives. The implementation of the AEM scheme has two consequences. Firstly, direct funding of actions focused on 'non-priority' environmental themes, for example erosion, becomes difficult. Soil protection has to be included in the programme whose priority is water quality (a number of AEM concerning land cover and the establishment of buffer zones to avoid the risk of nitrate leaching and pesticides losses may be indirectly useful to fight against erosion). Secondly, programming aid within the burdensome bureaucratic AEM scheme becomes a challenge for all stakeholders (including communities and Water Agencies).

Moreover, concerning soil degradation issues, specific AEMs to aid simplified tillage techniques have been deleted (between the two periods) and the AEMs that aid linear features (hedgerow plantation, grass-strips, '*fascine*') are more complex to implement (administrative procedure) and have less funding.

6.3.4 Less favoured areas (LFA)

LFA policy was set up in 1975 as a structural policy aimed at preventing land abandonment, keeping the farming population in these areas, and preserving cultural landscapes. In this regard, the instrument was one of the first measures to address environmentally beneficial farming systems. The three types of LFA: mountainous areas, other LFAs and areas affected by specific handicaps, take into account the range of geographical differences affecting the production difficulties of EU agriculture (areas where the physical landscape gives place to higher production costs). In France, in 2005, 12,279,000 hectare were designated as LFA (41 % of UAA). About one third was mountainous areas and two thirds had handicaps other than mountainous areas (Thomas, 2005).

LFA mainly targets extensive grazing livestock systems and specific Mediterranean crops. Since 2001 compensatory payments are made on an area basis (on a head basis before 2001). LFA payments go to permanent grasslands and prevent land abandonment and natural afforestation in mountainous areas.

The impact on soil protection of the LFA scheme concerns only LFA areas where permanent grasslands can be transformed into arable lands. By helping grazing systems other than AEM, LFA payments contribute to maintain grasslands.

6.3.5 Set-aside

Set aside was introduced (in the 1992 CAP reform) in order to reduce EU cereals production at a time of high stocks, and to allow EU cereals adjust to world market conditions (note that 'small' farmers were not targeted). In exchange, the set-aside area is subsidised. This role has become much less relevant as a result of market developments and the introduction of the SPS. The foreseeable demand and supply situation for cereals, including the demand linked to the fulfilment of the biofuel target set by the EU, argues for mobilizing land which is presently kept out of production through the compulsory set aside scheme.

The 2003 CAP reform specified that set-aside land could be cultivated for non-food production. The minimum time for set-aside land is one year, and in some countries it can be up to 5 years.

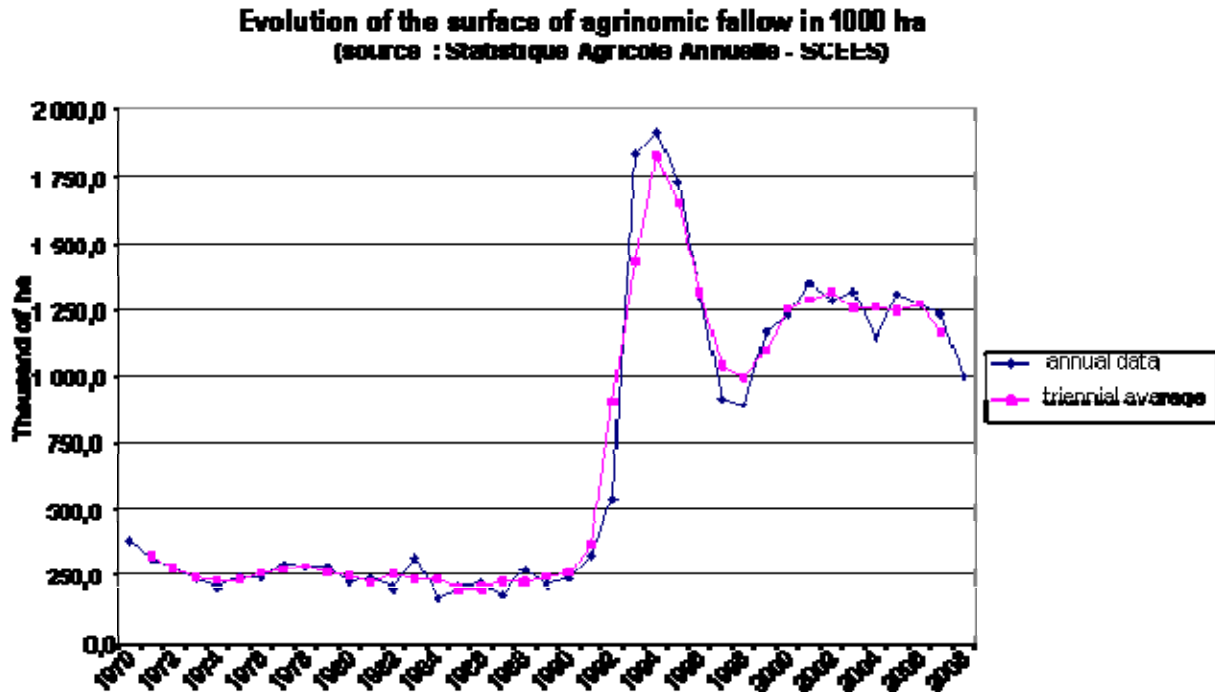
Set-aside land or 'fallow' land can be ascribed to three types of land use:

- The agronomic fallow, cultivated for green manure or buffer areas (to limit runoff), important in the past in terms of surface.
- The set-aside, uncultivated.
- The set-aside, cultivated with energy crops or industrial crops.



Figure 6.3 shows that before the implementation of the set-aside in 1993, an agronomic fallow covered around 250,000 ha. With set-aside, the surface of fallows reached a peak of 1,900,000 ha in 1993. It thereafter decreased, as the compulsory set-aside rate decreased (from 15 % of crop surfaces in 1993 and 1994, to 12 % in 1995, to 10 % in 1996, 5 % in 1997 and 1998, and 10 % later) and industrial and energy crops were introduced in the set-aside (789,091 ha in 2006, source: Ministry of Agriculture). With a 0 % rate (of compulsory set-aside) in 2008 and 2009, the surface will further decrease.

Figure 6.3: Development of the surface of agronomic fallow



Source: SAA – Agreste

Agronomic fallows are mainly located in regions where field crops are the main production, such as the *Centre* (169,000 ha in 2003), *Midi-Pyrénées* (120,000 ha), *Poitou-Charentes* (91,000ha), *Aquitaine* (89,000 ha) and *Pays de Loire* (74,000 ha). In the northern regions the percentage of industrial crops implemented as set-aside is high and can cover all the land set aside.

Industrial set-aside lands covered 789,091 ha in 2006, mainly with energy crops (rape, sugar beet). These industrial set-aside lands increase every year.

The environmental benefits of agronomic fallow land for soil protection are important, considering this land is mainly located in intensive specialised crop systems and that it is always covered. However, the surface of agronomic fallow land will decrease in the future, when set-aside will cease to exist. Benefits for soil protection will depend on their rate and on how they are located with regards to water catchment areas. If the agronomic fallow land is situated only along riverbanks (to achieve the target of 3 % of arable land in environmental cover), its impact will be very limited. If part of the agronomic fallow land surface is implemented in the talwegs (or other important surfaces to limit runoff) its impact will be important.



6.3.6 The National envelope

Ever since the first CAP pillar was reformed in 2003 (1782/2003-CE), its article 69 is enforceable. This measure, called the 'national envelope', allows each Member State to use up to 10 % of the total national fund (targeted in Article 41 of the First Pillar) to provide an 'additional payment' for particular types of agriculture which are relevant to environmental protection or to its improvement, or to the improvement of the quality of agricultural products and of their marketing. The 'National envelope' concerns the payments of the 1st Pillar that do not require co-funding. This type of agriculture is defined by the Committee, in accordance with the proceedings targeted in Article 144, paragraph 2. Conservation agriculture could be one of the types of agriculture concerned by this Article.

This study does not develop the Article in detail because it is not applied in France.

6.4 Soil Framework Directive (proposal)

Different EU policies (for instance on water, waste, chemicals, industrial pollution prevention, nature protection, pesticides, agriculture) contribute to soil protection. But as these policies have other aims and other scopes of action, they are not sufficient to ensure an adequate level of protection for all soils in Europe. For all these reasons, the Commission adopted a Soil Thematic Theme Strategy (COM(2006) 231) and a proposal for a Soil Framework Directive (COM(2006) 232) on 22 September 2006, to protect soils across the EU. The Strategy and the proposal have been sent to the other European Institutions for the ensuing steps in the decision-making process.

The current proposal for a Soil Framework Directive (P6-TA(2007)0509) contains the following actions:

- Article 8: Identification of priority areas in need of special protection against erosion, organic matter decline, loss of soil biodiversity, compaction, salinisation, landslides, desertification or acidification.
- Article 9: Programmes implementing measures to combat erosion, organic matter decline, compaction, salinisation and landslides.
- Appendix III: Possible measures to combat erosion (Change arable land into grassland; Planting of hedgerows, groups of trees and afforestation; Restriction of construction works in very vulnerable sites; Adequate crops/crop rotations and catch and interim crops; Application of compost; Reduced tillage; Mulching; Use of winter cover, buffer strips and hedgerows; Proper use of machinery; Construction and preservation of terraces; Prevention of fires; Restriction of inappropriate practices on hill slopes; Coastal management techniques).

To be efficient, the implementation of this Framework Directive has to be aided by soil monitoring tools (local definition of soil degradation issues and mapping system).

Awareness of the importance of soil degradation must be raised at the national level. The agreement on a Soil Framework Directive could raise awareness on the importance of soil degradation as well. However, at least 10 years are needed between the adoption by EU 27 of the Soil Framework Directive and the implementation of the first actions by farmers. It is therefore important that Member States adopt this new policy as soon as possible.



6.5 Conclusions

There are no specific regulations or policies for soil conservation and conservation agriculture. French agri-environment policy focuses mainly (i) on water quality issues (Nitrate and Water Framework Directives), and (ii) on biodiversity issues, with the Habitat and Bird Directives.

The current French AEM scheme targets these 2 objectives. This is also consistent with the requirements linked to cross compliance and objectives of the Water Framework Directives (apart from maintaining grasslands and the establishment of grass strips in the plots, the French implementation of GAEC, will have no impact on erosion and the decline of soil organic matter). At present, funding actions for 'non-priority' environmental themes, for example erosion, becomes difficult, and programming aid within the burdensome bureaucratic AEM scheme structure becomes a challenge for all stakeholders including communities and Water Agencies).

The Nitrate Directive, with its Action Plans, is since 2000 the main force driving the implementation of soil covers. It can be observed in the different programmes that there is an increase of the optional and required measures having a positive impact on soil protection (through soil cover). The fourth Action Programme (2009-2012) will highly impact soil conservation with the aim of covering 100 % of the intercropping period (September-December) in vulnerable zones (perennial crops and inter-row management are not concerned by the Nitrate Directive). Moreover, considering that 65 % of the areas at high and very high risk of erosion areas are located in Nitrate vulnerable zones, the Nitrate Directive can also be used to (partially) address erosion issues.

Set-aside could be an efficient tool by introducing soil covers in intensive cereal areas even if it was not always located at the best place to prevent erosion. But with a 0 % rate of compulsory set-aside in 2008 and 2009, the surface will further decrease). In future, the benefits of agronomic fallow land for soil protection will depend on their rate and how they are located with regards to water catchment areas; particularly in intensive and productive agricultural areas as the North of France where high erosion risk is observed.

The national Decree (n°2007-882 of 14 May 2007) concerning 'zones under environmental constraints' (including the 'agricultural erosion areas' tested in 2008 in Seine-Maritime department) is potentially very effective, and complementary to the Forecasting Risks Plan of the urbane sector, and coherent with the proposal of a Soil Framework Directive.

Simplified tillage techniques have been developed even with a low support from the AEM of the Rural Development Plan (2000-2006), due to financial interest for the farmers.



7 Policy: effectiveness and main actors

7.1 Strengths and weaknesses of the existing policies

Soil protection is a particular component of the overall approach of environmental policy. The soil belongs to private owners, and generally farmers feel responsible for their soil and deem negatively soil conservation policy coming from European Policies. On the other hand, it must be considered that the reaction time of soils (degradation or improvement) is not compatible with the 'short term policies', (improving soil quality represents a time scale of 5-20 years). It seems obvious that a policy of soil protection will be effective if farmers commit massively to it. The farmers also expressed a will to work in a way that would preserve both their economy and the environment.

The question is whether it is better to establish a voluntary or a mandatory base. The answer is surely to keep both choices open and to find a good balance. It is clear today that the three main factors that influence the farmers' decision are market prices and (mandatory) policies, and the payment levels of voluntary measures

Before performing the analysis, the main strengths and weaknesses of existing policies were identified. The proposals were also established on the basis of existing texts, to strengthen their consideration of soil. These proposals concern mandatory measures in the first place and tend towards a better protection of grasslands, the preservation of a minimum of agronomic fallow, of a minimum of landscape elements, a more ambitious re-definition of national GAEC, clearly oriented toward soil protection. In a second time, these proposals are in line for better addressing the problems of soil degradation, at least in areas at high risk of erosion. The AEM scheme could fund the development of practices to improve soil quality among volunteer farmers. This would require flexible measures and a low administrative burden. Table 7.1 below sums up the strengths, weaknesses and proposals for the studied policies.

Publicity, training and awareness on soil erosion issues must also be developed. But soil issues have to compete with other environmental issues better considered and targeted by farmers as the question of nitrogen, pesticides, Natura 2000 but also energy and GHG emissions.

**Table 7.1: Conclusions and proposals on main policies**

Policy	Strengths	Weaknesses	Proposals
Set aside	Has protected at least 10 % of arable land in intensive crop areas with soil covers during the period 1993-2007. Depend on their implementation in the water catchments	Part of the set-aside has been used for industrial and energy producing crops managed as traditional crops. The set aside was removed in 2008.	Maintain a minimum agronomic set-aside through GAEC as the French GAEC 'Grass strip'
The Nitrates Directive	Main drive for cover crop implementation. Vulnerable zones cover a large part of areas under erosion risk. Also used to protect grasslands and landscape elements. Objective of 100 % soil cover in 2012. Nitrate directive is part of the SMR.	Limited to vulnerable zones. Depending on the departments, some measures are only proposed and are not compulsory. The cover crop should be maintained in autumn and not during the spring period when erosion risk is also important	As from the next fourth Action Programme, extend the requirement of cover crops for all spring crops. Adapt AEM to cover the spring period (between February and May)
The Water Framework Directive	Should reinforce the Nitrate directive.	Focused only on water quality. Limited budget.	
GAEC Grassland protection	Permanent grasslands is the best protection against soil erosion	This compliance is not working even if grassland surfaces are decreasing.	Achieve a better protection of permanent and temporary grasslands in erosion risk areas. Develop a ratio per department (at NUTS3) or per small agricultural region. Support grazing systems in low lands.



GAEC 'grass strip'	Achieve a permanent cover (3 % of arable land surface) in intensive crop areas.	Mainly located along riverbanks. Their impact in preventing soil, erosion depends on their implementation in the talwegs of the water catchments.	Make mandatory to locate part of this grass strip in the talwegs and where erosion risk is important. Increase the ratio to 5 % of the UAA included hedgerows. Fund the implementation of landscape planning.
Other GAECs		No or little impact concerning soil protection. No protection of landscape elements which can improve soil protection	Better define the minimum rotation. Include a minimum surface of cover crops for spring crops. Add a mandatory soil degradation diagnose at the farm level
LFA	Support permanent grasslands.	Payments are low compared to direct payments and cereal prices.	Increase the payments in low lands affected by erosion
National policies	National Decree (n°2007-882 of 14 May 2007) concerning 'zones under environmental constraints'	Not implemented yet	
SPS/IACS		No clear information concerning the integration of landscape elements in the surface allowing direct payment	Allow a minimum percentage (7 %) of landscape elements in the arable surface.
Grasslands and grazing systems		Decrease of mixed farms. Decrease of total livestock units. Decrease of grasslands	Maintain or increase aids to grassland and grazing systems (LFA, AEM). Reinforce the GAEC concerning grassland preservation.



Agri-environment measures	Specific measures concerning reduced or no-tillage (2000-2006), implementation of cover crops, crop diversification and hedgerow plantation. Good targeting of the measures in some regions (as Nord-Pas-de-Calais) and for some measures (no-tillage)	Some measures are not well targeted on high erosion risk areas (as cover crops). In the new rural development plan Priority to Natura 2000 and WFD, and not to erosion issues. Important transaction costs. Soil covers are funded only beyond mandatory requirements	Give also a priority to areas at very high and high level of erosion risk. Propose a global and flexible contract on erosion Maintain and increase the measures concerning crop diversification.
National envelope	Allows each Member State to use up to 10 % of the component of the national fund targeted in Article 41 of the First Pillar Could be used for environmentally friendly agriculture	Not currently applied in France.	Use part of these funds to develop the most advanced form of conservation agriculture
Farmer training	Sufficient funding.	Soil is little or not taken into account in agricultural development (e.g. there isn't always a soil scientist in the Chambers of Agriculture) Conservation agriculture is not (or little) taken into account	Establish networks of demonstration farms at the level of the agricultural district (NUTS 4-5) Accumulate knowledge and expertise Involve agricultural research
National policy: Decree 'areas under environmental constraints'	A combination between voluntary and mandatory measures A regulation consistent with the project of Soil Framework Directive	An implementation based on local programmes on soil conservation is sometimes insufficient and requires specific erosion monitoring tools (not available everywhere in France, or in high erosion risk) An optional phase, based on AEM scheme (important transaction costs). Not implemented yet	Develop a monitoring tool Develop knowledge and local animation on soil erosion Allow local authorities and Water Agencies to give direct payments for erosion programmes



7.2 Policy design and implementation

Today, two factors prevent the achievement of these goals. The first is the lack of knowledge, extended to all stakeholders, on the functioning of agricultural soils. The low awareness of soil conditions (from the national to the local level) is linked to this factor as well. The second is that in a context of high prices, where the current state of the soils does not give place to excessive loss of yield, farmers do not subscribe voluntary measures on soil protection (expect 1,5 % of farmers involved in no-tillage). That is why actors (including farmers) think that in addressing the problem of soil degradation mandatory measures are unavoidable (in association with a better knowledge of soils and good technical training). Moreover, if these measures are included in cross compliance, their effectiveness will be high.

It is clear that the ideal would be farmers' massive optional compliance to soil protection measures. To achieve this goal, there first has to be a national determination (through the Ministry of Agriculture) to define and implement a policy focused on soil protection. This supposes that the people in charge of policy design concerning soil degradation are aware of the urgency. Therefore, farmers' massive optional compliance supposes that actors in charge of the implementation of these policies are technically capable of training farmers and locally providing technical advice.

The lack of knowledge on soil is a crucial point. On one hand, among the surveyed actors (involved in agricultural development), there are few (or no) soil specialists able to identify a soil degradation problem (or anticipate it) and propose corrective measures. On the other hand, farmers would be more willing to adopt new measures if they see other farmers use them and they are able to talk issues over with these 'pioneer' farmers), or if they get locally adapted advice.

This is particularly true for complex measures that have no positive economic impact in the short term (e.g. no-tillage, crop rotation). The farmers generally base their assessment of the different methods of soil conservation on comparisons between productivity and the cost of implementing the technique. The methods have to be economically viable in the system.

Today only one environmental target is proposed for each territory. But CA limits the risk of erosion and is also an answer to reduce GHG emission or reduce the risk of surface water pollution. The rules concerning the cover crops implementation proposed in vulnerable zones do not covered totally erosion issues and should be adapted (by increasing the time period until spring). It is necessary to propose a global approach of the different environmental issues in the same territory.

To implement a policy against erosion, actors must be able to identify sensitive areas at plot scale. This implies a very good knowledge of the local landscape and mapping tools adapted.

The remuneration of optional measures is also a determining factor. At present, associated payments are the main reason given for entering a AEM scheme (some farmers mentioned the need to recoup money lost through modulation). Therefore, in a context of high cereal prices, measures poorly paid (and associated with a high administrative burden) will not be subscribed by the majority of farmers.

Under the French AEM scheme, the five years obligation and the administrative burden were considered constraining for farmers who wished to be free to be able to respond to changing markets. In this same context of rapid price change, optional measures should be flexible in order to be interesting for farmers. This is true for those who want few constraints (compatible with existing farming practices) and also for those involved in conservation agriculture. These farmers change their techniques from one year to the other (date of sowing, soil cover management, and date of cover crop destruction) and do not want to be forced to do so.

Most farmers (and local actors of agricultural development) encountered feel they have little or no influence on policy design. They feel that this is only a top-down approach with a clear



problem of ownership. At the local level, many consider that policy design should be more focused on local actor consultation (bottom-up approaches). Most actors encountered considered that this bottom-up participatory approach is key to effective policy design and implementation.

A summary table containing information on the above policies, as well as additional details on their actual implementation, can be found in Appendix C.

7.3 Soil related actors

7.3.1 Actors in the farming practices arena

Broadly speaking, farmers' (and advisors') perception (and knowledge) for of soil conditions (fertility) is too weak to influence their decisions (with the notable exception of farmers involved in conservation agriculture). Farmers will feel concerned with soil degradation processes when they lead to loss of productivity (this is not yet actually the case in the studied areas). All actors (mainly farmers and advisors) must realise that the soil is not only a surface for crops (currently the point of view of the majority) but that its fertility will ensure sustainable yields. Farmers are still prepared to take environmental risks in order to achieve a greater return. They would also be more willing to try out new techniques if they were financially rewarded for it (insurance against loss of productivity).

In Midi-Pyrénées, 14 representative farms were selected according to different phases and techniques, include in simplified tillage techniques (reduced tillage, no-tillage before and after the transition phase). The farms have different types of soils and farmers have different motivations as well. Three main reasons have prompted farmers to change their systems (based initially on conventional tillage, bare soil and short rotation): economic (profits and labour time), agronomic (preserve fertile soil as the base of agriculture), and environmental (fight against erosion).

The environmental motivation is not the main reason driving farmers to adopt new techniques. Only those who have suffered significant losses (land or yields) and have steep slopes (between 20 to 30 %) with soil types conducive to erosion have put forward this motivation. Six farmers mentioned economic motivations, based on the reduction of fuel oil consumption, mechanisation, and working time. Those farmers moved from conventional tillage (plough based) to reduced tillage; and they keep up a system based on a short rotation (the choice of crop is mainly related to the market price). They represent the majority (more than 95 %) of farmers using simplified tillage techniques; and the pursuit of less expensive, faster production, without relevant impacts on yield, is one of the strongest arguments in the adoption of reduced tillage techniques.

Six farmers (using no-tillage techniques and permanent soil cover) consider fertile soil as the basis of their production. Restoration of the soil structure, promotion of soil biological life (earthworms) are their main motivation (two of them have highlighted the crop rotation effects). For these farmers, the transition period (between the implementation of no-tillage and achieving a new stable balance in the functioning of the soil) remains the weak point. This transition phase may be longer (more than 5 years) or shorter, depending on the farm conditions (soil and climate) and on the farmer's skills. It is possible during this time to see any positive effects on the economy. The seeding material is still very expensive and remains an important investment for farmers (especially for small farms). These farmers also consider reducing their economic risks (after the transition phase) by:

- restoring their soil to buffer the inter-annual climate variability and thereby ensure consistent high yields; and
- reducing the share of each crop (by diversifying crop rotation) and thus reducing the economic sensitivity of the farm to rapid market price changes.



This situation in conservation agriculture is not comparable to organic farming where farmers get better prices after the 2 years transition periods.

The level of awareness, technicality and expertise has a heavy impact on how to conduct the system and the transition period: system change is a relevant risk for farmers. Whatever the motivation, it is important that farmers be able to exchange, share experiences and find local references. Most surveyed farmers are self-trained and have changed their system after seeing (in France or abroad) successful experiences. The training offered by agricultural development organisations, do not address issues of soil degradation, or do so minimally.

All farmers pointed out their low level of participation in policy design and the need for soil conservation policies to adapt to local soil and climate conditions. The lack of flexibility, the administrative burden and the low level of remuneration are the main weaknesses of the current policies related to soil conservation (optional measures of the AEM scheme).

7.3.2 Actors in the policy design and implementation arena

Public administrations, including water agencies, have generally other environmental goals than soil issues. The context of a decreasing public budget and people working in the administration will not offer a favourable situation to include this 'new' environmental objective which is pointed out by a directive.

The awareness of soil degradation problems is very low in France. Within the Ministry of Agriculture and Fisheries, the issue of soil protection is managed by the 'Office of soil and water'. French policy is clearly oriented toward water quality, and in this Office only one person handles the issue of soil. This person is responsible for the acquisition and publicizing of knowledge on soil. In the regional and departmental levels of the Ministry of Agriculture, soil degradation is scarcely taken into account.

To acquire knowledge on soil, a Scientific Interest Group on Soil (GIS SOL) was established in 2001. It brings together the Ministry of Agriculture and Fisheries, the Ministry of the Environment and Sustainable Development, the National Institute of Agronomic Research (INRA), the French Institute of the Environment (IFEN) and the Agency for Environment and Energy Management (ADEME). In 2004, the *Institut de Recherche pour le Développement* (IRD) joined the GIS. The objective of the GIS Sol is to build and monitor an information system of soils in France: their spatial distribution, their properties and the development of their qualities. The GIS SOL co-funds up to 25 % of the data purchase programmes. The regions and departments are co-funders. Two main tools were implemented within this framework: the Data Base on Soil Analysis and the Network Measures of Soil Quality. France is among Europe's most advanced countries regarding research on the functioning of soils (expert opinions). However, the obtention of references and spatial data (mapping) is insufficient. Today the only complete and available data are at a scale of 1/1,000,000. Work is underway to encourage regions (at NUTS 2) to produce soil maps at a scale of 1/250,000 (minimum requirement to work on soil erosion). By way of comparison, a large part of Belgium is mapped at the scale 1/25, 000. This lack of information restricts the adaptation of local programmes related to soil, such as the fight against erosion, advice on cultivation practices and general agronomy advice.

Broadly speaking, information and knowledge on soil is scarce, and not all is taken into account in agricultural development, (e.g. a soil specialist is not always a member of the team in the chambers of agriculture). There is no network of standardised measures on soil quality (whatever the topics being monitored) at a European level. It is difficult to obtain consistent approaches.

In the studied areas (heavily affected by erosion) the level of awareness is related to the costs of damage from erosion.

Midi-Pyrénées is a region where the damage related to erosion is not encrypted and rarely affects urban areas; taking into account of soil degradation by local authorities is low. Only a



part of the actors concerned with agricultural development (mainly technical advisors) take soil erosion issues into account. The Regional Chamber of Agriculture has been leading for over 20 years work groups (that include farmer associations, technical and research institutes) focused on the theme of erosion control, and since 2000, conservation agriculture (and especially its most advanced forms) has become the central working point. For the period 2007-2012 a regional work group concerning the most advanced forms of conservation agriculture, was established. It is based on a partnership with the Chambers of Agriculture, technical institutes and farmers' associations; a network of show-case farms and a research program. The objectives are:

- The development of simplified tillage techniques (no-tillage) in the soil and climate conditions of south-western France;
- Impact assessment: agronomic, economic and environmental benefits of these techniques;
- The definition of the necessary conditions, for their publicizing among farmers and development agents.

This work on the most advanced forms will allow the development of local references and will be the base of the farmers' future training.

New actors are now promoting simplified tillage techniques (reduced or no-tillage) in Midi-Pyrénées region. These are private companies that give technical advice based on their own experimental sites and references. They meet the needs of farmers to increase their margins and for a part, to better take into account the problem of soil degradation. Farmers pay a fee (90 €/ha) for such locally adapted advice

All these actors (mainly technicians) feel particularly involved in the implementation of policies and little involved in their design. They argue for policies set from the constraints and environmental issues of a territory. This means that the flexibility of national (or European) measures is a crucial point. For local authorities (at the local, department or regional level) soil erosion is not a priority (except when severe damages occur on private and public goods).

In Seine-Maritime, the violent storm of December 1999 and 2000 (over 100 mm/hour) caused severe damage and deaths in urban areas, due to soil erosion. In 2000, under the leadership of the Prefect, a catchment management structure (*syndicat de bassin versant*) was put in place. Its single objective was to fight runoff and erosion (performing diagnoses, identifying 'hot spots', identifying and carrying out the necessary measures). The catchment management structures are the relevant bodies to address erosion problems due to agriculture. They are headed by a president (most often a mayor of one of the municipalities in the community of municipalities affected by the problems of runoff) and are composed of 3 to 4 employees with an agricultural expert. They are funded by the General Council (1 employee) and the Water Agency (1 to 2 employees). Between 2000 and 2003, the 'catchment area association' has made many studies and maps. Actions since 2003 have focused on putting in place elements to limit run-off (hedges, grass strips, etc.) and holding basins. The 'catchment area association' centralises and manages all public payments to aid farmers carry out these actions (AEM scheme, Departmental aid, water agencies aid, etc.). At present, the 22 catchment management structures cover the entire department of Seine-Maritime. They are very useful in a sector where the fight against erosion is related to the establishment of collective measures upstream and downstream catchment.

The catchment management structures are a valuable help to define or refine policies related to soil protection. They combine knowledge of the local soil and climate constraints, of agriculture and farmers, of applicable technical solutions. To aid the activities of these structures, a non-governmental organisation (acting as research department) was established. At present, in Seine-Maritime, soil erosion is a priority for all actors in policy design and implementation. All noted that the environmental policy of France, focused mainly on (i) water quality issues and (ii) biodiversity issues makes it difficult to use funds (from the AEM scheme) for programmes to fight erosion. For these actors, it seems important that aid



in the fight against erosion come from water agencies or local authorities, without coercion from Europe (notification, cap).

The national Decree (n°2007-882 of 14 May 2007) concerning 'zones under environmental constraints', including 'agricultural erosion areas', is being tested in 2008 in Seine-Maritime. All actors agree that it could be a relevant policy (but its establishment will require very detailed monitoring tools not currently available, same remark for the proposal of the Soil Framework Directive).

7.4 Conclusions

Success in designing a policy on soil protection is based primarily on the approach at the national level. This requires a good knowledge of soil conditions in France. Therefore, this requires that all regional and departmental offices of the ministries of agriculture and the environment, ownership of this issue. The aim would be to have a contact point for erosion in each department (see the USA model: a soil conservation office with a representative in each county) to accumulate and transfer knowledge, establish actions, facilitate operations, participate in designing, implementing and monitoring policies. This 'contact point' could also improve the issue's visibility among administration, agricultural development structures and water agencies.

Awareness of the importance of soil degradation must be raised at the national level. A comprehensive study of the costs incurred in by erosion events (related to agriculture) would show the importance of addressing the problem upstream and then calculate the gains for society. This study has to take into account drinking water quality (turbidity), muddy-flow damages, and actions by the equipment board to rehabilitate roads, losses of soil fertility, loss of inputs (nutrients) and eutrophication. The agreement on a Soil Framework Directive would raise awareness on the importance of soil degradation as well. However, at least 10 years are needed between the adoption by EU 27 of the Soil Framework Directive and the implementation of the first actions by farmers. It is therefore important that Member States adopt this new policy as soon as possible.

In a second step, this policy, promoted at the departmental level, must be translated into concrete actions at the level of the farmer (information and training). This requires both the global vision of an agricultural district (at NUTS 4) and a parcel approach (the advisors/technicians must work hand in hand with the farmers). At this step, it is crucial to have a programme at a coherent level, for example the catchment management structures in Seine-Maritime department), a production of local data, such as work groups and networks of show-case farms implemented in Midi-Pyrénées to fund simplified cultivation techniques and conservation agriculture, and a definition of sensitive areas at plot scale (mapping tools adapted).

Due to the complexity of soil erosion process, the specifications of funded measures (in the existing policies) should be sufficiently flexible to adapt to the different situations found among the various plots and even between two different years (farmers have to apply technical measures, based on a detailed knowledge of the field). In this option, the simplification of the current administrative procedures is one of the main requirements. The fight against erosion must be carried out by means of a series of small steps, requiring an almost yearly adjustment to be effective and not give place to other problems. The idea is therefore to give farmers an overall 'erosion' contract (concerning all the farm and not only specific plots), allowing them flexibility to act and making some items mandatory (non destruction of hedgerows, preservation of a minimum percentage of grassland, protection of the talwegs, minimum soil cover, etc.). The farmers' contract would be a full-fledged AEM. It will be less complicated (less transaction costs) than the current complex selection process of AEM.



For an overall point of view, it is also necessary to propose a global approach of the different environmental issues in the same territory (soil degradation, water quality, GHG emission, biodiversity, landscape).

8 General conclusions

The main soil degradation in France is caused by erosion: 12 % of the UAA (5.6 million of hectare) is at high or very high risk of erosion (MESALES model, GIS SOL) and 17,000 muddy flows events were recorded during 1985-2001.

The main land use with high erosion risk relates to spring crops (potatoes, sugar beet, maize, sunflower) and to vineyards. The areas at risk are either located in the northwest France (*Nord Pas de Calais, Picardie, Seine Maritime* with loamy soils) or in the southwest of France and Mediterranean areas (steep slopes with intense spring rainfall).

There is no specific national policy on soil erosion and conservation agriculture. These themes are addressed indirectly by measures (mainly soil cover and buffer zones) within agricultural and environmental policies, or developed by farmers as reduced tillage practices out of policies mainly for economical reasons.

The French agri-environment policy focuses mainly (i) on water quality issues (Nitrate and Water Framework Directives), and (ii) on biodiversity issues, with the Habitat and Bird Directives. There is no specific regulation on soil conservation. The current French rural development plan targets these 2 objectives. This is also consistent with requirements linked to cross compliance (Statutory Management Requirements and French Good Agricultural and Environmental Conditions mostly target water quality).

The context of a decreasing public budget and people working in the administration will not offer a favourable situation to include this 'new' environmental objective which is pointed out by a directive.

Considering that 65 % of the high and very high risk of erosion areas is located in vulnerable zones, the Nitrate Directive can also be used to (partially) address erosion issues through the implementation of cover crops, a better protection of permanent grasslands and unfarmed landscape features. These objectives have been reinforced during the successive Action Programmes and it is proposed that they become compulsory in the Fourth Programme 2009-2012. These measures were also put forth under the agri-environment measures inside vulnerable zones (at a time when they were not compulsory).

Water quality and the protection of the drinking water catchments are currently priorities in France (Decree n°2007-882 of 14 May 2007, Water regulation). This decree identifies 'zones under environmental constraints' where specific compulsory measures must be implemented. The decree also targets also zones at risk of erosion and wetlands, but only the priority 500 drinking water catchments defined in the 'Grenelle de l'environnement' are concerned at the present time.

A first step for better policy design must be raise awareness at the national level on the importance of soil degradation. A comprehensive study of the costs incurred in by erosion events (related to agriculture) would show the importance of addressing the problem upstream and then calculate the gains for society. The agreement on a Soil Framework Directive would raise awareness as well.

In a second step, this policy, promoted at the departmental level, must be translated into concrete action at the farmers' level (information and training). This requires both the global vision of an agricultural district (at NUTS 4) and a parcel approach (the advisors/technicians must work hand in hand with the farmers). At this step, it is crucial to have a programme at a coherent scale (e.g. the catchment management structures in Seine-Maritime department), an acquisition of local data, such as working groups and networks of show-case farms



implemented in Midi-Pyrénées to fund simplified cultivation techniques and conservation agriculture) and a definition of sensitive areas at plot scale (mapping tools adapted).

All stakeholders encountered agreed that it must act at the source to be effective, by increasing the infiltration capacity of soils. Moreover, some technical solutions to solve erosion problems are already known, and they even are simple to implement (decrease of parcel size, inclusion of grass strips, etc.). Other measures can simply rely on a better communication/coordination between farmers within the same watershed (e.g. rotation: farmers can agree among themselves that the same culture is not replanted the same year in order to reduce runoff). But whatever the solutions, their establishment requires a good knowledge of the local soil and climate conditions (solutions for clay-rich soil and steep slopes, which in Midi-Pyrénées are subject to spring storms, are not necessarily transferable to the loamy soils and gentle slopes of northern France).

CA techniques are a way of reducing land degradation (erosion, organic matter decline, and desertification) through the improvement of the stability of soil surface structure, restoration of vertical and connected soil porosity and improvement of soil biodiversity. The soil can then keep its capacity of rainfall infiltration and therefore erosion problems are reduced at the origin. There are many possible forms of simplified cultivation techniques (and of farming practices), depending on the type of soil tillage used (from reduced tillage to direct-seeding), crop rotation implemented and the percentage of soil coverage (30 % to 100 %). All these forms have a positive effect on soil protection. The main disadvantage is the increase in the use of herbicides (+10 %) to control weeds.

Mastering Conservation Agriculture (CA) techniques (cover crop implementation, reduced tillage, direct sowing, longer rotation) requires several years of field trials and experiments for the farmer. The publicizing of these techniques requires their adaptation to local conditions (type of soil, climate, social conditions), The lack of local references is, at the present time, the main weak point (without training implementation of conservation agriculture can severely disrupt the economy of farms). Therefore there is a need to establish networks of show-case farms at the agricultural district level (NUTS 4-5) and acquire and build knowledge and expertise (with the participation of agricultural research and technical institutes).

The most advanced forms of CA techniques (direct-seeding + long and diversified rotations + soil coverage) allows for a rapid restoration and preservation of soil fertility. In addition, these more advanced forms can also address other agro-ecological issues (water quality, GHG emission, biodiversity) and develop solutions for weed control, without a systematic use of herbicides (crop rotation, mechanical control). Theoretically, these techniques can be adapted to all soil and climate conditions.

Today only one environmental target is proposed for each territory. But CA techniques limit the risk of erosion but are also an answer to reduce GHG emission or reduce the risk of surface water pollution. The rules concerning the cover crops implementation proposed in vulnerable zones do not covered totally erosion issues and should be adapted (by increasing the time period until spring). It is necessary to propose a global approach of the different environmental issues in the same territory.



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Abstract

This Technical Note 'Case Study – France' is part of a series of case studies within the 'Sustainable Agriculture and Soil Conservation' (SoCo) project. Ten case studies were carried out in Belgium, Bulgaria, the Czech Republic, Denmark, France, Germany, Greece, Italy, Spain and the United Kingdom between spring and summer 2008. The selection of case study areas was designed to capture differences in soil degradation processes, soil types, climatic conditions, farm structures and farming practices, institutional settings and policy priorities. A harmonised methodological approach was pursued in order to gather insights from a range of contrasting conditions over a geographically diverse area. The case studies were carried out by local experts to reflect the specificities of the selected case studies.

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