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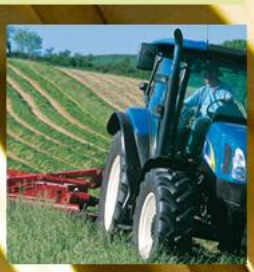
AGRICULTURE 2050 STARTS HERE AND NOW







IAD
INSTITUT
DE L'AGRICULTURE
DURABLE

AGRICULTURE 2050 STARTS HERE AND NOW

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EXECUTIVE SUMMARY

This document written by IAD (Institute for Sustainable Agriculture) forms a working and discussion basis on the potential of agriculture to produce ecological services and provide its goods for society. The innovations, models and results presented are taken from the indicator scorecard developed by IAD and tested on over 160 farms with a wide variety of productions.

Last-gasp agriculture which must move on

In a particularly difficult context for agriculture and faced with growing sustainability issues, agronomy is at the heart of a fundamental objective - combining production and preservation of resources by developing pioneering farming systems. **How, therefore, can the agricultural policy be a profitable development lever for environmental protection and spatial planning through the work of farmers?** The history of agriculture is punctuated by innovations based on five tools[1] essential to agriculture and united within IAD since 2008.

Innovation: nature as a working model

If agriculture improves its tools, it can produce in another way, more, better and using few fossil resources. Agriculture copies nature, which has been sequestering carbon and producing ecological services for millions of years, to develop techniques to resolve the challenges raised: help nourish nine billion human beings whilst preserving the natural resources and adapting to climate change.

Measurable results for sustainable agriculture

The IAD indicators measure the results from a series of 26 indicators divided into seven basic themes (economic, social, input efficiency, soil quality, water quality, GHG emissions and biodiversity), thereby showing that agriculture[2] can sequester carbon in the soils and produce a number of ecological services: creating fertile soils, purifying the water, increasing the biodiversity, producing quality food, biomaterials (wood, flax, hemp, etc.), energy (biogas, wood, ethanol, etc.), landscapes and tourism and growing areas.

A Common Agricultural Policy in preparation

Of the 26 IAD operational indicators, nineteen measure the results of ecological services and ten the agricultural carbon sink. A concrete scenario produced from tests is presented to understand how easy it is to remunerate ecological services produced by the farmer. The good results obtained can be encouraged whilst keeping two CAP pillars.

An "Agriculture and Environment" Policy may emerge. Pioneering production systems developed in conjunction with measuring ecological services provided by farmers will, without question, enable agriculture to meet the forthcoming food, climate and energy challenges head on. Collecting results used to remunerate ecological services and the agricultural carbon sink could be achieved easily by incorporating indicators into farmers' everyday routine, under cooperation between public services and private registrations.

This is a proposal around an ambitious Agriculture and Environment focus in preparing a Common Agricultural Policy which encourages food and energy independence by improving agricultural revenues in the long term.

[1] Five essential agricultural tools: a genuine living soil carbon sink hosting the vital functions of water recycling and purification, agricultural machinery maintaining this living soil, all the variability of genetics, suitable fertilisation and all plant protection techniques.

[2] This agriculture, admittedly still imperfect, is emerging the world over (Australia, South and North America, Indonesia, Europe, China, India, etc.)

SUMMARY

Why change? Agriculture has become essential more than ever in 2010, both in terms of coping with food safety, competitiveness and economic constraint, creating direct and indirect jobs and protecting the environment and in helping to resolve the energy crisis. Major fact: 97% of the civil society will depend on the agricultural policy. This will involve about 3% of the population - the farmers, who will shoulder all the demands and constraints. You have to over-produce in agriculture to have enough! If we have grasped "*Why change?*", these few pages will shed light on "*Change to what?*" and the necessary adjustments which must be a feature of the next forty years: "Agriculture 2050 starts here and now!"

Change to what? Although environmental issues appear to be a priority for the survival of society, farmers are facing the same challenge as they strive to re-establish soil fertility, among other things. The planned reform of the CAP in 2013 includes these environmental objectives through the notion of "ecological services" which could remunerate the farmers and round out an increasingly tricky economic equation.

The environmental issue is being developed around an elementary model - the ecosystem! Nature has sequestered the atmospheric CO_2 sustainably through plant photosynthesis and also produces ecological services. Farmers should therefore inspire the operation of this "natural carbon sink" to produce fertile soils, clean water, strong biodiversity, quality food, biomaterials (wood, cotton, flax, hemp, etc.), energy (biogas, wood, ethanol, etc.), landscapes and tourism and growing areas. All these services provided by nature rely on maximum plant production within the ecosystem.

Since 2008, using international scientific resources, IAD has been working on identifying and using indicators capable of measuring the efficiency of agricultural systems in developing carbon sinks and in providing ecological services. Trials on 160 farms of varying types (livestock, arable crops, vegetables) in 2009 and 2010 showed that the production of ecological services can be measured and that it is the fruit of "sustainable" practices inspired by the major operating principles of nature itself!

With this document, IAD is offering food for thought put together from the work carried out. A presentation of concrete results from the trial phase demonstrates that agriculture also produces ecological services at the same time as it produces food. The remuneration simulation highlights tremendous potential for improving practices given that the payment gaps for ecological services vary form 42% to 63% of the maximum possible between the conventional and the pioneering managed using the natural model. Farmers could easily collect indicator results in their everyday routine as part of cooperation between public services and private records.

One thing is certain, a suitable public policy will be required to develop the ecological services, focusing on a long-term "agricultural carbon sink". This policy could be fed by "carbon credits" and by Payment for Ecological Services (PES) under the new CAP from 2013 onwards. This new agriculture will not be achieved without a strong structural policy, encouraging farmers to alter their practices and reconcile **production** and **protection**.

If you like, **Agriculture 2050 starts here and now!**

FOREWORD

Agriculture structures the rural environment, the development of societies and the management of natural resources. Nowadays it is faced with sizeable challenges: produce more and better, using less land, less water and less fossil energy. This foreword puts European agriculture into context between coping with a socio-economic crisis, loss of competitiveness and environmental pressure. These few pages hope to shed light on the changes which must feature in adapting agriculture in terms of productivity and environmental protection over the next forty years: the 27 countries of Europe need a genuine long-term structural agricultural policy. "Agriculture 2050 starts here and now!"

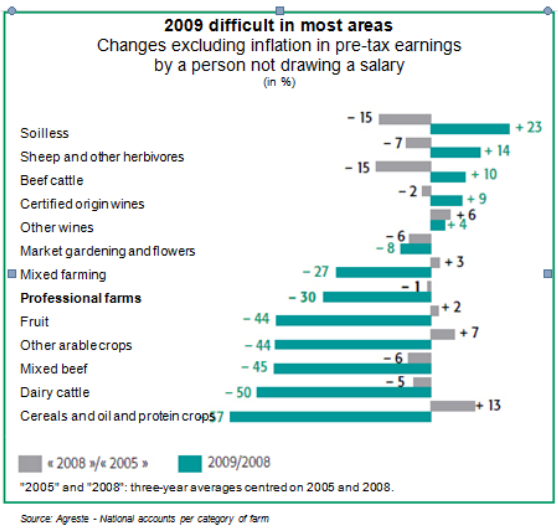
FRANCE: INVENTORIES

The agricultural crisis made newspaper headlines in the review of 2009, mainly with economic data published early in 2010[3].

Agriculture has been weakened for years by major structural changes such as the erosion of the active population (farming and food-processing), dropping from 12%[2] in 1980 to just 6.2%[2] of the total workforce as at 1 January 2010. Following the same trend, the number of farms dropped from 1.6 million in 1970 to 507,000 today on utilised agricultural area (UAA) representing 29.3 million hectares. This represents 1.8% less than in 2000 and 15% less than in 1950. Growing urbanisation is the main reason for the loss of UAA. Agricultural statistics note a loss of 93,000 ha between 2006 and 2009.

Added to these structural changes are the difficulties faced by agriculture from a particularly difficult economic context in 2009, when revenues plummeted in the majority of productions (-16.3%[4], Figure 1 below).

Figure 1: Changes in French farming revenues per production sector compared with 2008 and 2005 data. Source: Graph published in Agreste Primer 243 - June 2010.



The variation in revenues is even more disturbing given that prices for agricultural products had soared in 2007-2008 as a result of the collapse of world food stocks. Conversely, prices fell drastically in 2008-2009 faced with production surpluses (+2.8%[3] of volumes in France) in international markets. The price of inputs increased at the same time, causing production costs to rise. Agricultural products were sold at a loss (milk, wine, etc.). Price volatility has weakened the entire farming and food-processing sector, which now only accounts for 3.5% of Gross Domestic Product (GDP), i.e. a share halved since 1980. The sector requires a political response capable of guaranteeing economic viability and stability for producers.

[3] Source: all figures are taken from Agreste, unless stated otherwise in a footnote.

[4] Source: "Agricultural production and added value" INSEE, provisional agricultural account end May 2009 - base 2000.

France held onto its title of leading agricultural region in Europe in 2008, with an 18% share[5] of agricultural and food-processing production despite a drop of 2% in twelve years (20% in 1998[4]). This situation is all the more worrying as it goes hand in hand with a loss of competitiveness compared with our European neighbours. French food-processing exports fell behind Germany, the Netherlands and the United States in 2009. Even products with high added value have not escaped the crisis. As a rough guide, a typical turnover for a farm in Germany included 20% for the sale of renewable energy in 2008[6]. What about France?

EUROPEAN SITUATION

Internationally, Europe accounts for 17% of world exports of agricultural products with 127 billion dollars, just behind the United States which exports 134 billion dollars. However, despite a fairly favourable pedoclimate, the loss of market shares over the past ten years is substantial (accounting for 19% approximately of world trade in 2000). Europe turns out to be the leading world importer in agricultural value (173 billion dollars in 2008), outstripping even the USA (116 billion $) and China (87 billion $). The main imports are maize, soybean, vegetable oils, animal feed, fruit, vegetables and sugar. This situation is combined with serious environmental deterioration, identified by the work under the Soil Protection Framework Directive[7].

AGRICULTURE AND ENVIRONMENT: A NEED FOR EUROPE

Farmers must resolve the environmental problems to protect the resources whilst continuing to produce to satisfy the markets.
The situation is complex given the committed European public requirements (framework directives on water, biodiversity, pesticides, Kyoto, etc.) and regulatory translations of specific national policies (Nitrate Directives, ECOPHYTO 2018 Plan, Second Grenelle Act, etc. for example for France). The results noted are limited: there are still just as many nitrates, or almost, in the water and green algae on Brittany coasts and other problems are emerging such as accelerated soil loss (organic matter, erosion and fertility) and degraded biodiversity, illustrated mainly by the debate over Colony Collapse Disorder about bees.

Reconciling agricultural production and environment protection is proving complex, as a number of factors are brought into play. It will therefore be impossible to redefine agriculture without discussions at European scale, to propose a uniform policy across the Union. The European Parliament has used its prerogatives to open the way.

In the society, 97% of peoples depend on a rural territory maintained by barely 3% of the workforce - the farmers. This situation prompts the desire to construct a new "Agriculture and Environment" policy which, by 2050, should respond to the need for i) adaptation to climate change, ii) protection of resources, iii) economic business competitiveness, iv) production in quantity and quality, v) reliable provisioning at affordable prices, vi) production of energy and biodegradable materials, etc.

[5] Source: Eurostat - Accounts for agriculture "economic results for agriculture" - 2009
[6] Source: Le télégramme de Brest – 11 July 2010
[7] Proposed European Parliament and Council directive of 22 September 2006, defining a framework for soil protection and amending Directive 2004/35/EC

INTRODUCTION

The first CAP was adopted in the 1960s and restated the general objectives of the 1957 Treaty of Rome. The post-war social and economic conditions called for radical transformation of production methods to meet the new needs of society: this meant increasing agricultural productivity, ensuring a fair standard of living for the population, stabilising markets, guaranteeing food safety and providing farmers with remunerative prices, yet affordable for the consumer. *Intensive agriculture* was the result, fulfilling all the fundamental goals of the time.

WHY CHANGE?

The social and economic context, society and its needs have now all moved on. Europe, far from being self-sufficient (proteins, energy, oils, sugar, maize, etc.), is facing the pollution and degradation of natural resources (water, soil, air and biodiversity). Given the potential risk from these degradations for nature and society[8], the environment is playing an increasing role in the debates surrounding the agricultural sector and was an integral part of the 1992 reform of the CAP.

Although commonly accepted that agriculture is partly responsible for problems linked to the degradation of nature, it is also the first to suffer the consequences. Conversely, recent studies by the United Nations (FAO, 2007) and France (INSEE, 2007) and the European Parliament proposal for the 2013 reform of the CAP (G. Lyon, S. Le Foll, 2010) demonstrate that the agricultural sector also offers solutions to resolve the problems: certain practices protect the environment, help combat climate change (reduced greenhouse gas emissions (GHG)), improve productivity, boost competitiveness, foster the production of renewable energies, etc.

The CAP reform planned for 2013 (G. Lyon report, §59) suggests incentivising the orientation of agricultural practices by remunerating "ecological services".

CHANGE TO WHAT?

A new development cycle for European agriculture must get under way. IAD has assembled agronomic innovation based on constructing and implementing "five tools" essential to agricultural production: a genuine living soil acting as a true carbon sink hosting the vital functions of recycling, machines preserving this living soil, the variability of animal and plant genetics, suitable fertilisation and all the plant protection techniques. Implementing these "tools" helps protect the environment whilst producing more, better and in another way.

Farmers who copy the natural ecosystem restore the fertile soils which store the carbon and produce ecological services.

But which basic mechanisms lead to this type of agriculture? How can we measure and remunerate this carbon sink? Why is the agricultural *carbon sink* capable of producing ecological services? How can they be measured and remunerated to urge farmers to use favourable practices? …

This report identifies the methods whereby agriculture can sequester the carbon and provide ecological services. Given the constraints, agriculture should manage to introduce suitable techniques by 2050!

[8] See the extensive research at the IPCC, FAO, INRA, CIRAD, AEE, etc.

I – For a productive farming which produice also environnement

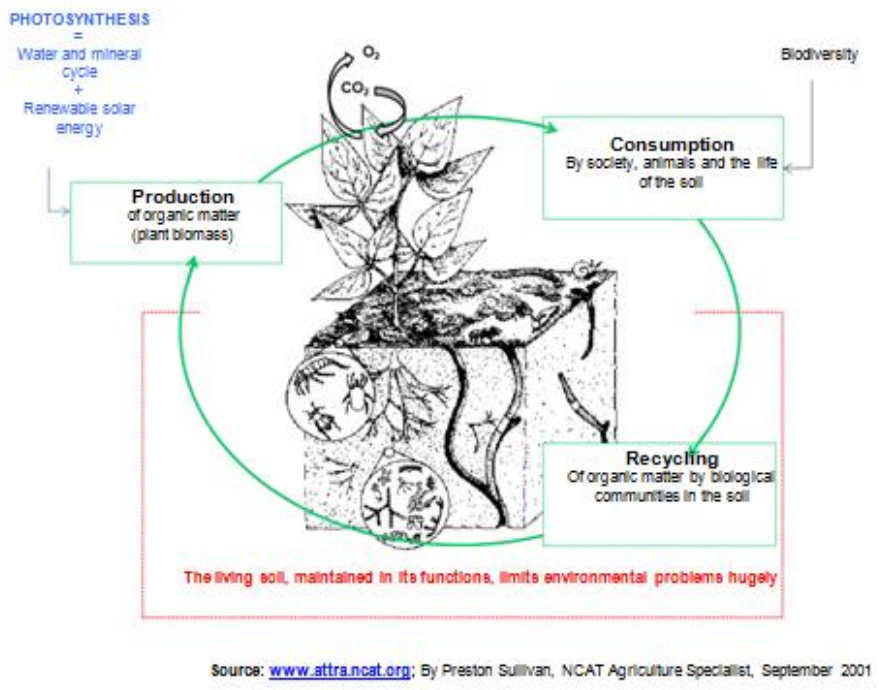
(a) A few forgotten obvious facts: the functioning of ecosystems

First obvious fact: carbon is a major element which structures the living systems. On Earth, the ecosystems and associated biodiversity depend on the sun which provides inexhaustible, free energy.

Second obvious fact: in nature, a few keys govern the functioning of elements. The main one is summarised in the celebrated formula by Lavoisier (1789), stating that **"NOTHING IS LOST, NOTHING IS CREATED, EVERYTHING IS TRANSFORMED!"**

Third obvious fact: the ecosystem functions in a cycle built on a perfect balance between three additional functions: Produce, Consume and Recycle.

Figure 2: The three fundamental functions of the ecosystem.
Source: NCAT Agriculture Specialist, September 2001.



Material is routed in nature via a cycle, alone capable of generating sustainable development of ecosystems and achieving a balance between **production** of the plant biomass, its **consumption** by the fauna and its **recycling** by communities living from the soil into digestible mineral nutrients (Figure 2). The soil is home to an intense biodiversity which forms a true recycling unit. Another key to nature's operation is the permanent soil cover which maximises plant production and CO_2 sequestration by photosynthesis.

A third key is essential to the maximum biomass production noted in the ecosystems. The soil must never be bare, nor cultivated, if the natural cycle is to work at its optimum level. It is **THE** home for the biodiversity assigned to the degradation of the biomass and organic waste, which provides temporary storage for a huge quantity of carbon.

By incorporating these three essential operating principles[9], the ecosystem can thus sequester the carbon sustainably in the natural cycle: produce - consume - recycle!

IPCC[10] experts working on climate change have revealed a certain number of mechanisms contributing to carbon sequestration. If we go back 500 million years BC, it is clear that there was far greater concentration of carbon dioxide (CO_2) in the atmosphere (at least 22 times) than is true today[11].

An analysis of data presented in Figure 3 shows clearly that plants are champion of the atmospheric carbon sequestration and at the root of recycling. The development of this cyclic operating process has taken place in three successive stages over elapsed geological eras.

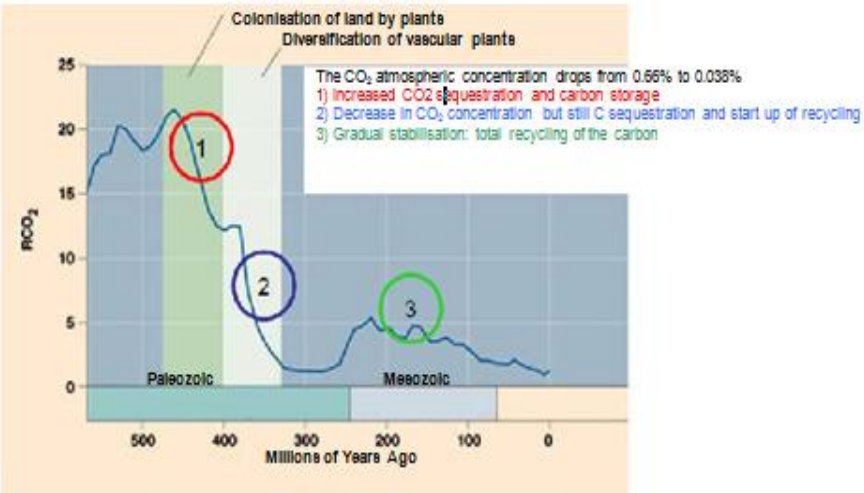
The third carbon sequestration stage relates to perfecting the ecosystem cycle before introducing 100% carbon recycling.

Clearly the atmospheric CO_2 level equivalent to the current percentage (0.038%) had already been achieved on Earth over 300 million years ago.

This constant in the ecosystem cycle validates the functioning model of nature as efficient and sustainable. Does not relying on this model and its major functioning principles represent the best method for adapting agriculture to its forthcoming challenges?

Figure 3: Carbon sequestration by plants

Sources: Brener, Science, 1997 - IPCC work



[9] a) Maximising photosynthesis and CO_2 capture by permanent soil cover for maximum biomass production; b) never cultivating the soil or bare soils, as the soil is the recycling matrix; c) cyclic operation.

[10] IPCC: Intergovernmental Panel on Climate Change, responsible for assessing scientific information on climate disruption caused by humans.

11 Source: Brener, Science, 1997

(b) The ecosystem as a model for an agricultural carbon sink

As a producer of plant biomass, the farmer interacts constantly with nature. It is therefore up to him to produce as much biomass as possible, to manage it for the best in the consumption phase, ensure optimum recycling and store a maximum amount of carbon in order to construct a sustainable agriculture. Introducing ecosystem principles and cycles into agriculture will carry on the ecological functions related to an expanding biodiversity.

The enrichment and storage of organic matter in the soil relies largely on the incoming and outgoing carbon amounts and the retention time in the soil in organic format (INRA 2002).

One fact is therefore obvious when constructing a sustainable agriculture based on the natural ecosystem model: creating an agricultural carbon sink today will make it possible to produce more and better, with fewer inputs, whilst expanding the biodiversity, tomorrow. This carbon sink agriculture can resolve all the problems of economic competitiveness and environmental protection.

The Common Agricultural Policy (CAP) must be structured for the creation and financing of these agricultural carbons sinks which will produce ecological services thanks to the immense biodiversity generated throughout the sustainability cycle.

Figure 4: Biological, chemical and physical properties influenced by the provision and storage of organic matter in the soil. According to INRA and FAO data.

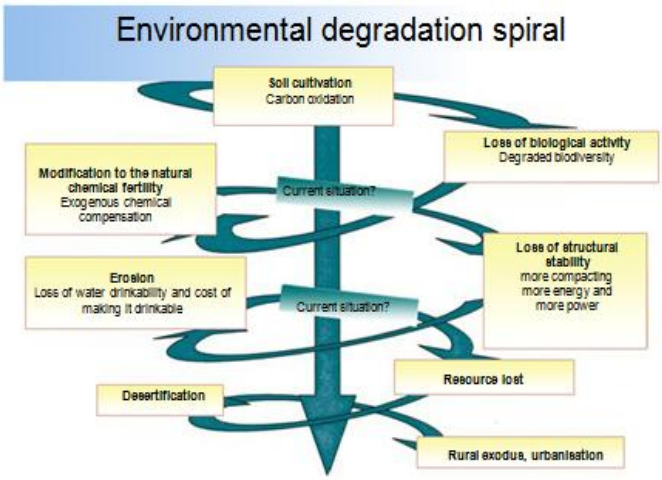
Properties	Actions	Benefits
Physical	Structure, porosity	-Improving the soil resistance -Water circulation, gaseous exchange -Water storage -Reducing hydromorphy -Limiting runoff -Limiting erosion -Reducing soil compaction -Atmospheric carbon storage
	Water retention	-improved water input
Biological	Stimulation of the biological activity (earthworms, micro-organisms, bacteria and fungi in the soil)	-degradation, mineralisation, reorganisation, humification of the organic matter -soil aeration (burrows) -biodiversity
Chemical	Break down, mineralisation	-Supply of mineral nutrients (N, P, K, trace elements, etc.) -Improved overall fertility -Plant nutrition
	CEC (see glossary)	-Mineral storage and availability
	MTE retention (see glossary)	-Limited toxicities (copper, lead, etc.) - Water purification
	Retention of organic micropollutants and pesticide residues	-Water purification and filtration -Water quality

(c) Agricultural techniques encouraging the production of carbon sinks!

Certain techniques adopted in agricultural are perfectly capable of improving the "ecological" situation of lands. It has now been proven that non-cultivation (no till) of the soil increases carbon sequestration in soils (Reicosky, 1995; Rattan Lal, 2001), on the one condition that the production and recycling of harvest residues are maximised for permanent soil cover.

The soil is not just a support for plant production. The techniques using soil tillage are incapable of copying the functioning of the ecosystem (see Figure 2) as they partly destroy the habitats and associated biodiversity (*the inhabitants*). Soil cultivation is without doubt principally responsible for the environmental degradation spiral (Figure 5).

Figure 5: The environmental degradation spiral through cultivation.
Source: K. Schreiber, 2005, Mesure des résultats du Champ de comparaison de Maure de Bretagne (35),



This has been highlighted by measuring results comparing soil tillage with techniques copying the ecosystem (no till, or very minimum tillage: sowing only or direct drilling). The degradation process is always identical, resulting in economic loss and environmental degradation.

Soil tillage should therefore gradually be eradicated from our farming practices as the processes induced by this technique reduce the fertility and ultimately the ability to produce (Figure below).

The United Nations (FAO, 2002) confirm this hypothesis. The organic matter is the main indicator of soil quality, both for agricultural (fertility, yields) and environmental functions, despite only representing 0.5% to 10% of the soil under the different climates. There is a close link between the loss of fertility from a drop in organic matter levels and the loss of numerous services rendered by nature. Are not degradation in water quality, erosion, loss of biodiversity, transfer of pollutants, GHG emissions, desertification, etc. the result of the conventional agriculture practised currently?

INRA found in 2002 that **the carbon storage in the soils** is that much higher the greater the crop yields and residue recycling in the soils, that the provision of organic matter can offset the outgoings and, finally, that **organic matter** from the activity of soil organisms must be **recycled** slowly.

This view of the "natural ecosystem" model and the carbon storage routes evoked above show that three principles act in the stock of organic matter (of carbon) and, by extension, in the services rendered and the "*health*" of the soil: **permanent cover** to nourish the life of the soil, the **lack of mechanical tillage** to preserve the habitats and the **maximisation and diversity of biomass inputs** all help in adapting to the constraints of exporting harvests.

Applying these principles using the techniques identified in research into agro-ecology (minimum tillage, no till or direct drilling under plant cover, covers crops, etc.) **produces an agricultural carbon sink and, by extension, as in nature itself, all the ecological services linked to the development of the biodiversity.**

II - The key for the environment: financing carbon sink agriculture

The failure of Copenhagen and abandoning the carbon tax both seem to thwart the goals of combating global warming.

The suggestion of a European agricultural policy encouraging the creation of agricultural carbon sinks makes it clear that carbon sequestration in the soils (and in the plants and biodiversity) would be one easy method of combating the greenhouse effect. How can farmers be urged to change their agricultural practices permanently? The question of remunerating this service rendered to society is henceforth raised!

(a) The potential for agricultural techniques to sequester carbon!

Since its creation in 2008, IAD has been hosting the tools and partners committed to technical innovations around agricultural carbon sinks. These really do exist and can be measured. Measuring carbon sequestration in the soils is a major step, ideal for introducing innovations in total transparency and with full knowledge of the facts.

Since 2009, IAD has been testing the indicators required to measure and monitor carbon sequestration in the soils, the biomass and the biodiversity. To achieve this, it has identified indicators capable of measuring results.

The following two figures (6 and 7) present the farm results from surveys of soil analysis histories.

Figure 6: The increase in organic matter in the soil. Source: IAD 2010, history of farms which have changed agronomic practices: Direct drilling with soil cover

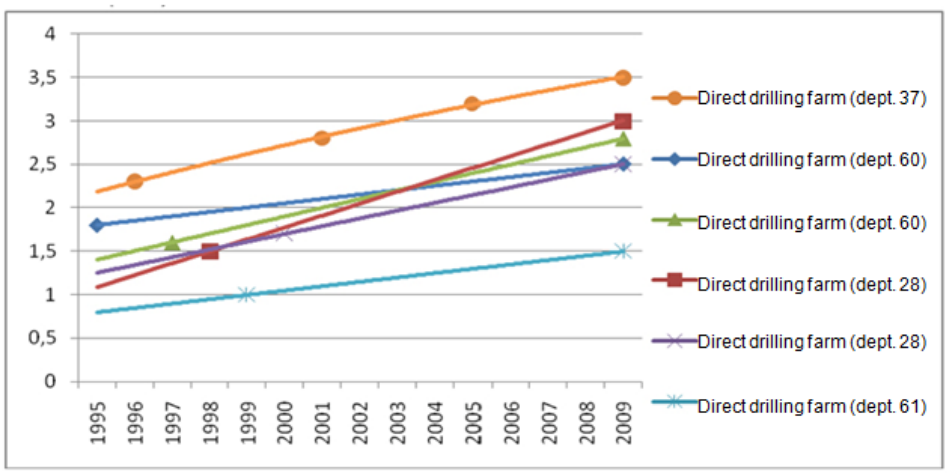
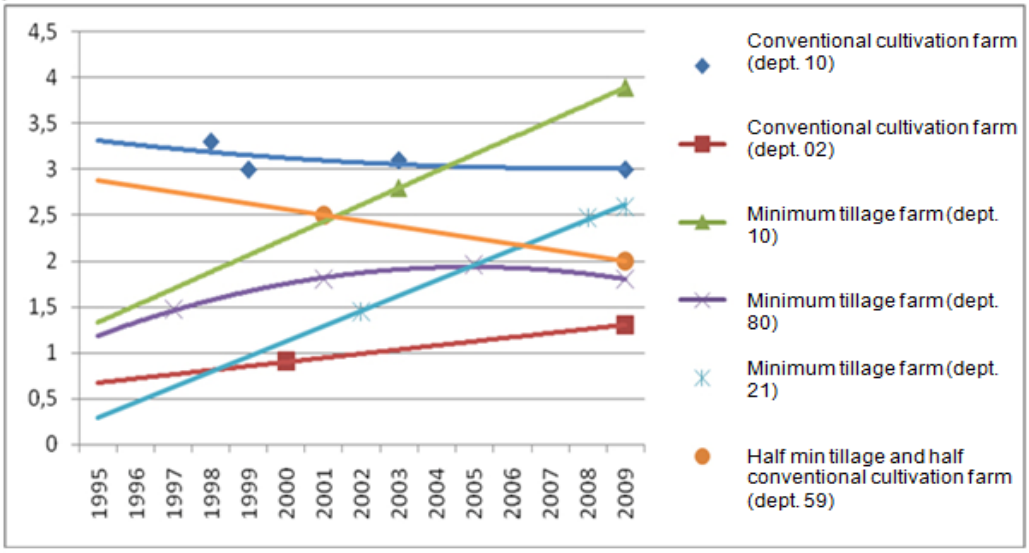


Figure 7: variation in levels of organic matter in the soil. Source: IAD 2010, history of farms which have changed agronomic practices: Minimum tillage and soil cultivation with more or less soil cover



The survey data show clearly that a variation in the level of organic matter in the soils can be recorded. This depends directly on the intensity of soil tillage and the annual cover rate with a major recycling of biomass. All results with increasing organic matter levels therefore come from techniques copying the functioning of the ecosystem as far as possible: no till or little soil tillage, permanent cover and optimised biomass recycling. Figure 7 represents an increase in organic matter on a farm with conventional soil tillage. This increase is correlated with good soil cover, but the organic matter level remains low for the department: 1.3%.

These results are interesting for more than one reason. Not only do they confirm that the soil is a carbon sink, but the sequestration flows and pace can now be measured. IAD will produce results relating to this work in 2011.

Although the organic matter level is a good indicator, it does not lend itself to the annual measurement. This impedes using soil analyses to measure agricultural carbon sinks. An annual humus rate would improve the "organic matter level" indicator.

The humus rate simplifies measuring carbon sequestration in the soil. A positive rate shows carbon storage, a negative one a CO_2 emission. The farmer would have two indicators of changes in the soil: the humus rate in the short term and the organic matter level in the long term as a supplement.

The best sequestration figures measured during the IAD test and survey phases are about <u>2 metrics tonnes of carbon per ha and per year (i.e. 7.4 t CO_2) and very low GHG emissions on livestock farms.</u>

By extrapolating an average of 1 metric tonne of carbon per hectare by arable crops[12] in France, for example, 13.5 million metrics tonnes of carbon can be sequestered annually (50 million tonnes of CO_2), i.e. 50% of French agricultural emissions[13]. This example illustrates **the potential for agriculture to contribute to the Climate Plan**, i.e. dividing CO_2 emissions by four as planned by France by 2050.

With a CO_2 tariff fixed at €20 per metric tonne for CDC domestic projects[14], a "carbon credit" can be allocated to remunerate a carbon sink.

[12] Cereals and oil & protein crops, source Agreste

[13] Source: CITEPA 2007

[14] *Caisse des Dépôts*: calls for domestic projects 10/2007

(b) Competitiveness of agriculture through carbon credits

An economy has a duty to be competitive to provide the "consumer citizen" with products and services at the best quality-price ratios.

Any strategy constructed exclusively on taxing polluting activities, for example CO_2 emissions, downgrades the competitiveness of businesses by increasing production costs and accelerating the loss of market shares to world or intraEuropean competition paying no or less tax.

But the inefficiency of a carbon tax is perhaps only alleged. If this tax strategy is to have a positive impact on controlling CO_2 emissions, it must be accompanied systematically by a compensatory payment strategy through financing "carbon credits".

The example of "green certificates" around renewable energy in Belgium could be applied on a wide scale throughout European agriculture. The advantage of a carbon credit lies in the increased economic competitiveness given to an act of production capable of sequestering the carbon or emitting less and less. A policy remunerating agricultural carbon sinks with a carbon credit or "*carbon certificate*" would thus encourage the competitiveness of the economy developing good agri-environmental practices.

It then becomes easy to steer the practices by managing pollution thresholds. The tax applies above a certain threshold - the "polluter-payer" principle. Remuneration is applied below the threshold, the principle of competitiveness aided by environmentally-friendly virtuous practices, in this case carbon emission control and climate change adaptation.

Other financing sources can be included in this discussion over carbon. Another way towards limiting the environmental impact of agriculture could be **recourse to carbon compensation.** A compensation mechanism at the very heart of production sectors could be envisaged.

Today, a study of the carbon level of a major consumer food product shows that 70%[15] of the carbon is linked to its production and 30% to its processing and marketing. The entire sector has to be mobilised to improve this level. Lowering GHG emissions will involve modifying commodity production methods.

Introducing carbon compensation mechanisms is a must to remain within the Sustainable Development principles (here ethics and fairness). The beneficiaries of the labelling and virtuous practices by farmers (traders and processors) would in return finance investments encouraging a drop in CO_2 emissions. These compensations would raise the productivity and competitiveness of farming systems, especially investment in renewable energy production.

A dozen indicators identified by IAD can measure the efficiency of the agricultural carbon sink.

Just like in nature, only soils which sequester the carbon through plant photosynthesis and biological activity are capable of protecting the environment and producing ecological services for society.

[15] IAD in-house source

III - The agricultural carbon sink as an ecological services producer!

(a) What is an ecological service?

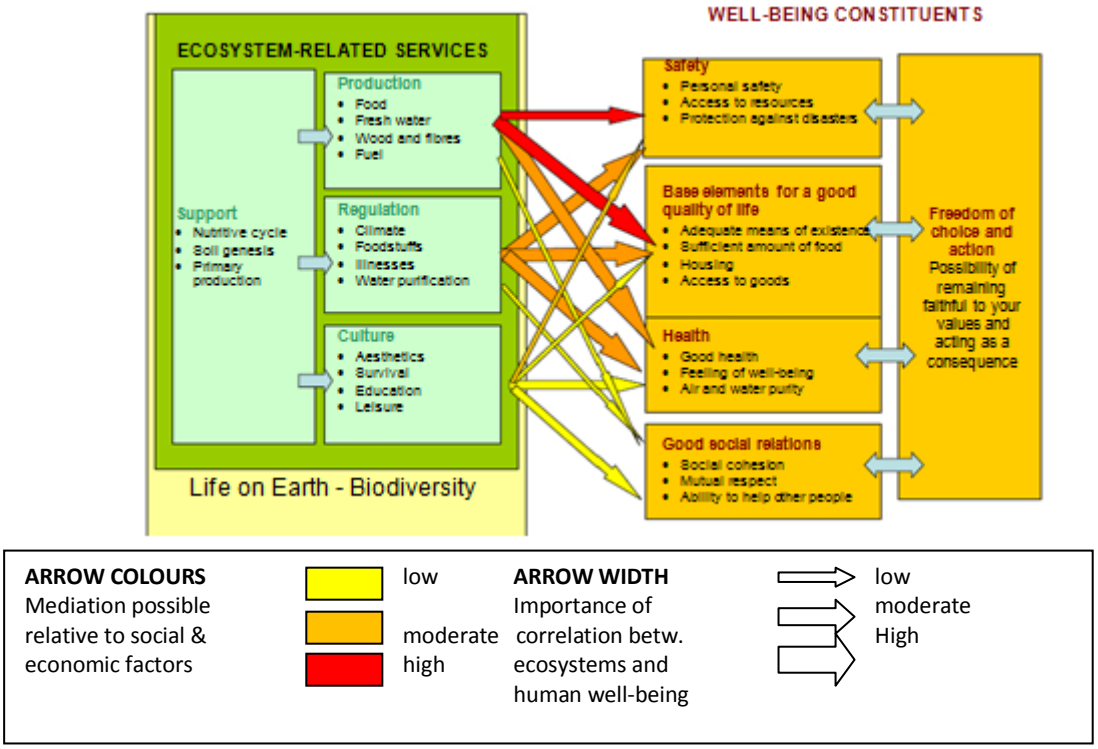
Agriculture has used certain of nature's services, especially plant-related (food, fibres, etc.), to create products and markets thereby ignoring the services without apparent value such as air and water quality, soil fertility or the biodiversity. In nature, however, all the links in the ecosystem chain are closely interconnected. In 2010, a majority of scientists have qualified these natural functions as ecosystem **SERVICES**, which are **ALL** essential to the survival of human communities.

In line with the impetus for CAP reform in 2013, IAD is suggesting a discussion on the potential of agriculture to provide ecological services to respond to the challenges and demands of society.

WHAT IS AN ECOLOGICAL SERVICE?

Natural ecosystems produce a wide range of goods and services for the populations. The *Millennium Ecosystems Assessment* (a major world study spearheaded by the UN at the beginning of the century) has highlighted the major contribution by ecosystems to Man's well-being.

Figure 8: Links between the services rendered by the ecosystems and the constituent parts of the well-being of society. Source: FAO 2007.



The ecosystem functions of benefit to society are called "ecosystem", "ecological" or "environmental" services. We are using the term "ecological service" here as the ecological processes within nature and plant production are clearly behind all services produced.

By "ecological services" are understood the advantages that population derives from ecosystems: food, clothes, water quality, wood, energy, climate regulation, protection against natural risks, erosion control, medicines, leisure activities, etc.

The farming policy initiated in the 1960s with its focus on food production triggered huge environmental problems: greenhouse gas emissions, soil erosion and loss of fertility, water polluted by nitrates, phosphorous and pesticides, etc. The policies turned the farmers into major disrupters of ecosystems as well as the first to have solutions to protect nature. There are many farming techniques suited to supplying all the services linked to good ecosystem operation and useful to society.

This notion of "services" is important. All that is needed to get out of the environmental degradation spiral is for the Common Agricultural Policy to remunerate the services of nature listed above and until now "forgotten". Agriculture will take a stance as a "source of public goods", essential to human well-being. The post-2013 CAP should become an Agriculture and Environment Policy.

DIFFERENT TYPES OF SERVICE

Agriculture-related ecological services can be classified in a variety of ways, but the most common approach is that of the Millennium Ecosystem Assessment (Figure 9 below), which classifies the services into four distinct categories:

- **Supply** services
- **Regulating** services
- **Socio-cultural** services
- **Supporting** services

All these services rely on the biodiversity of the living systems associated with the primary production of biomass (partly due to pollination which ensures the reproduction of about 30% of cultivated species). The biodiversity, guarantor of the conservation of genetic resources, dictates the aesthetic value of rural landscapes. It is also linked intimately to producing ecological services and agriculture, found in over half of lands, must become a producer.

A compromise between use and restoration of resources must be found urgently so that agricultural production can move towards sustainable practices. Tomorrow, a productive and competitive agriculture will also be an improver of resources.

Ecological services are supplied from maximum biomass production and the preservation of habitats. We have seen that producing an agricultural carbon sink is reliant on "preserving the habitats and feeding the inhabitants". This approach identifies suitable technical itineraries for maximum biomass production and in managing the organic matter as a driving force for agriculture to produce ecological services.

But which techniques ensure efficient agricultural production and the supply of ecological services to society? How can a farmer alter his practices and techniques to produce a maximum of services and public goods?

Figure 9: The various categories of ecological services (Source: FAO 2007)

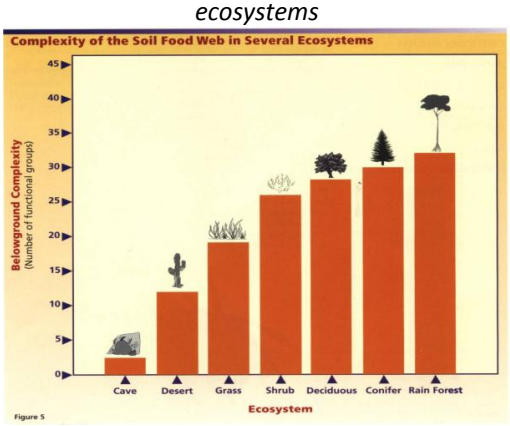
PROVISIONING SERVICES	REGULATION SERVICES	CULTURAL SERVICES
Products from ecosystems	*Advantages of regulating ecosystem processes*	*Non-material advantages from ecosystems*
▪ Food	▪ Climate regulation	▪ Spiritual and religious
▪ Drinking water	▪ Disease regulation	▪ Recreation and ecotourism
▪ Woodfuel	▪ Water regulation	▪ Aesthetic
▪ Fibre	▪ Water purification	▪ Inspirational
▪ Biochemicals	▪ Pollination	▪ Educational
▪ Genetic resources	…	▪ Sense of place
…		▪ Cultural heritage
		…
SUPPORT SERVICES		
Services required to produce all other ecosystem services		
▪ Soil formation	▪ Nutrient cycle	▪ Primary production
LIFE ON EARTH - BIODIVERSITY		

Source: FAO Report 2007, itself adapted from "Ecosystems and human well-being: a framework for assessment" by the Millennium Ecosystem Assessment. Copyright © 2003 World Resources Institute. Authorised for reproduction by Island Press Washington.

(b) Maximum biomass production increases the production of ecological services and benefits to the whole of society!

An analysis of ecosystem functioning shows that every pedoclimatic environment encourages maximum production of plant biomass until a balance entitled"climax"[16] is reached.

Complexity of the soil food chain in different ecosystems



[16] - Rose, S., Elliott, E.T., 1999 – *The Soil Food Web* - Soil Biology Primer, pp 1, Natural Resources Conservation Service, Soil Quality Institute - http://www.statlab.iastate.edu/survey/SQI/sqihome.shtml

The diversity of functional groups of main European climates varies from 25 to 35 according to Rose and Elliott (1999). They relate systematically to optimum soil cover.

Some agronomic techniques, especially the practice of minimum tillage, no tillage, and direct drilling under plant cover, are capable of protecting the habitats. This is a first step towards providing ecological services.

The second one involves producing the biomass. The ecological services all rely on "support services" (Figure 9). These services directly facing the farmer involve soil formation, nutrient cycles and the production of plant biomass. It is the farmer who manages, for better or for worse, the formation and preservation of soils, the nutrient cycle and the total production of plants by the yields. The objective is good management and extensive production!

Simple common sense, away from any technical, scientific or political considerations,

indicates that the maximum number of plants must be produced. The farmer must obtain the possible yields, never degrading the soil, more encouraging its formation, nor losing the fertilisers by optimising the recycling. The maximum yield must be obtained with the minimum inputs possible to remain economically profitable.

The benefit for society from a high yield is potentially huge. The more agricultural yields increase, the more it becomes possible to organise the promotion of these productions for a local economy. Numerous outlets are available to the biomass which has to be produced. The farmer becomes the arbiter of good yield management and society must help him. A natural order exists in biomass management and it is important to understand how it is established:

1. Soil cover ;
2. Carbon storage in the soil ;
3. Human food and animal feed ;
4. Renewable energy ;
5. Biomaterials.

1. Soil cover

Soil formation depends directly on the biological activity hosted by the soil. The living beings, be they microscopic or giant, all have the same needs: they must eat, protect themselves and live somewhere. Soil cover fulfils these functions. Not only do the plants nourish, but they also protect and serve to build habitats. The soil must be covered all year round for this cover to protect and nourish the biological activity. The farmer must recycle a significant part of crop residues into the soil to build and preserve it. The minimum residue threshold is 5 metrics tonnes of straw equivalent a year.

However, leaving part of harvests in the fields is a net loss for the farmer as exporting straw (for example) has a financial value. Society must help leave part of the residues in the fields. It must participate financially in this ecological service.

2. Carbon storage in the soil

This is a huge service rendered to societies by nature. The biological activity, by feeding off plant residues, also uses an organic fraction to develop its habitat. A well-known example is the earthworm burrow. This is an underground tunnel in the earth with walls coated with organic matter to facilitate its functions: flexibility, solidity, ambience and viability. And it remains operational for more than thirty years after death.
By incorporating organic matter in the soil through biological activity, nature stores the carbon on the one condition that these habitats are not destroyed! Thus, the higher the yields are, the greater the amount of plant residues are that can remain on the ground, the greater the biological activity and the greater carbon storage.

Society must here also help the farmer to encourage this carbon storage in the soils. Creating carbon sinks is a way of controlling climate change. It is a fundamental ecological service. It encourages the development of a very powerful biodiversity producing ecological services. When a farmer creates a carbon sink by protecting soils, he is giving future generations a chance to benefit from fertile soils. But this is not enough, he must still produce food for society!

3. Food

If it is essential for a part of yields to remain in the soil, it is equally essential that another part can be used for society. Nutrition is the urgent thing. Although food safety seems secure in Europe, what will it really be like if the farmers are forced to leave 50% of biomasses and plant yields on the ground to accommodate carbon sinks and biodiversity? Will an agriculture not producing high yields be capable of provisioning society without risking shortages? Would the agriculture without yield be capable of rendering ecological services?

Another factor is arguing for the highest possible yields. This is the solidarity that Europe must show for peoples less well-off in

terms of land and climate. Asia and also Africa are affected directly by climate change and food shortage, given the increasing population, is already tricky.

Europe must give itself a Common Agricultural Policy capable of securing strategic reserves. Given its history, it would be inconceivable in the eyes of the World for a continent enjoying such a favourable climate to fail to make the effort for the solidarity required to face up to climate change and demographic growth.

4. Renewable energy

An increase in the cost of energy is inevitable as easily-accessible fossil energy resources become depleted. The question raised today is to understand how and at what price agriculture could produce high yields. A fact often forgotten is the high energy dependence of agriculture on fossil energies. It seems unlikely that our food provisioning (transport, production, harvest, etc.) is one day based on nuclear energy. Food sovereignty relies on secure energy.

By allowing the production of bioenergies, the CAP secures food for society regardless of the energy crisis context. Biogas and biofuel production must supply the autonomy of agricultural foodstuff production and distribution systems in priority - just in case. Agriculture has a high energy production potential. Biofuel can easily be produced with a second annual oilseed harvest; the cake produced from the seed-crushing operation feeds the livestock.
This will not just produce meat and dairy products but also biogas from manure - and the plant straws cover and nourish the living soil.

By developing agricultural autonomy, the production of energy can be used to manage strategic and solidarity stocks. It then becomes possible to dispense with "overproduction", to adapt easily to the market and respect the food sovereignty of peoples. But this is impossible without high yields.

Agricultural independence in a context of producing a carbon sink and ecological services calls for significant yields.

5. Biomaterials

At this stage in development, a certain number of new energy and scientific solutions are likely to appear. Green chemistry and algae technologies are already in the starting blocks of innovation. Agriculture will tomorrow be expected to feed this enormous reservoir of economic activity. This challenge can also only be met by producing the highest possible yield per hectare. The eco-design of materials will tomorrow contribute to the sustainability cycle of society!

Achieving high yields and permanent recycling is the cornerstone of sustainability. Soils can be protected by permanent cover, agricultural carbon sinks can be created, food can be produced including the amount required for the solidarity of peoples, provisioning and agriculture production prices can be made secure by renewable energy and green chemistry innovations can be fuelled. With good agronomic management techniques, **achieving high yields is fundamental, to render all possible ecological services to society!**

(c) Indicators to measure ecological services

The use of result-measuring tools is essential to understand the impacts of all farming practices producing a beneficial supply of ecological services.

The Institute for Sustainable Agriculture (IAD) is working on identifying and using indicators capable of measurin the result of farming practices on the ecological services and sustainability criteria.
Agricultural sustainability is defined by its ability to maintain over time an economically viable and competitive, socially equitable and environmentally-friendly agricultural production. Under the "environment" label, sustainable agriculture incorporates very broadly the biodiversity, soil and water quality, the potential to adapt to climate change, controlling the greenhouse effect and producing renewable energy.

The indicators were identified and selected in 2008, both internationally and locally, based on criteria of relevance, neutrality, occurrence and result measurement.

Ultimately, after two years of trials on 160 farms, the approach gave birth to a genuine scorecard and dashboard (Appendix II) made up of 26 indicators grouped into seven relevant themes, some of which need to be improved by science (Appendix III):

- **Theme 1: economic viability**
  - *EBITDA per ha and/or per livestock unit*
  - *EBITDA/labour unit*
  - *Production costs per ha or livestock unit*
- **Theme 2: social viability**
  - *Full-time equivalent working hours (1,800 hours/year)*
  - *SI - Satisfaction Index*
- **Theme 3: efficiency of input use**
  - *IFT - Pesticide treatment frequency index*
  - *NPK balance (nitrogen - phosphorous - potassium)*
  - *Energy balance*
  - *Energy independence rate*
  - *Water consumption (irrigation)*
  - *Food autonomy rate*
  - *Yield ha, livestock farm*
- **Topic 4: Greenhouse gas**
  - *GHG level*
- **Theme 5: soil quality**
  - *Yield/ha UAA*
  - *Yield/ha main fodder area*
  - *Soil tillage index*
  - *Annual soil cover rate*
  - *Organic matter level*
  - *Soil biological activity*
- **Theme 6: water quality**
  - *NO3 level - boreholes and wells*
  - *NO3 level – rivers*
- **Theme 7: biodiversity**
  - *Soil utilisation*
  - *Biodiversity surface area*
  - *Crop diversity*
  - *STOC "birds" (common bird mapping)*
  - *STERC "insects" (common insect mapping)*

Nineteen of these indicators are identified as capable (in blue) of measuring directly or indirectly the ecological services in accordance with the scientific references available in the Millennium Ecosystem Assessment (Figure 7).

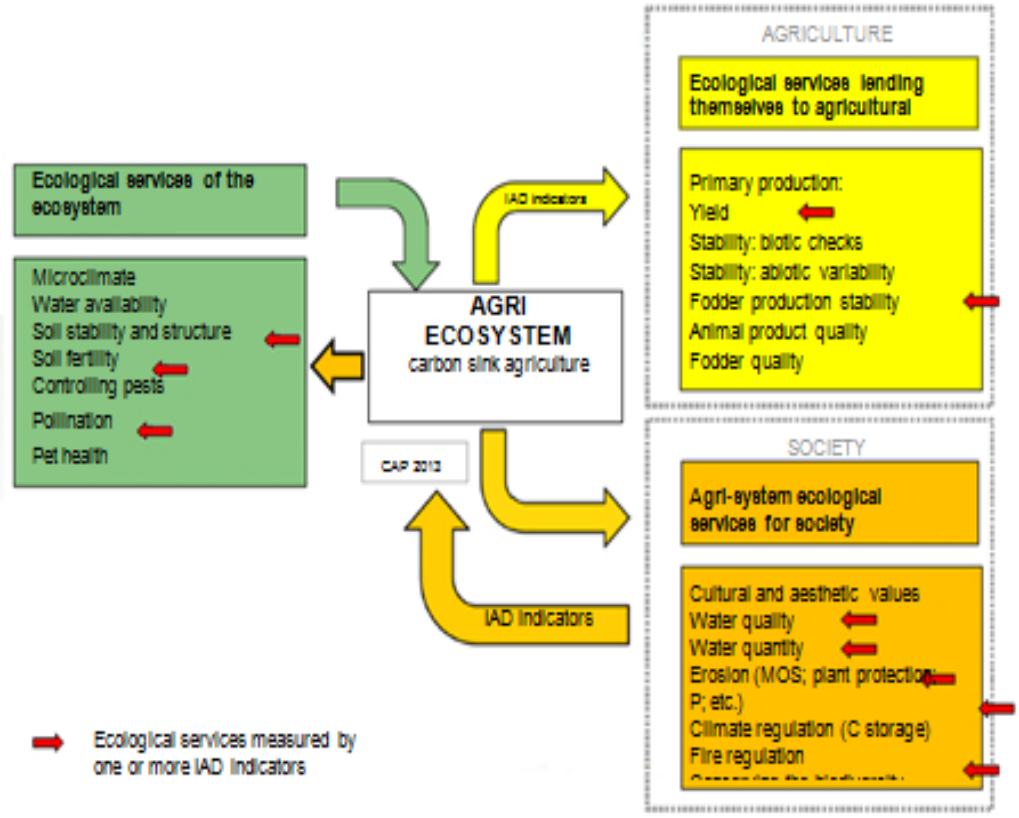
The use of the indicators aims at measuring farming practices and at detecting the strengths and weaknesses, thereby revitalising farmers' thinking and encouraging them to produce

ecological services. It involves ASSESSING to EVOLVE and committing to MOVING FORWARD. This constant move to improve develops a lasting, competitive agriculture, part of an Agriculture and Environment project propitious to the development of society.

The first results from testing these indicators during 2009 and 2010 show how easy it is to measure the results of farming practices.

Urging farmers to commit to supplying ecological services could take the form of remunerating results acquired independently from resources used. Economic rationality forces control of resources at the best quality-price ratio which remains the business' province.

Figure 10: the IAD indicators can measure part of the ecological services identified by the Millennium Ecosystem Assessment
(Source: IAD presentation 2010 based on MEA data)



IV - Value the major farmers' contribution to the supply of ecological services

Agriculture has a huge role to play in creating ecological services. But this role is linked closely to the political and economic incentives in place. Remuneration in return for services rendered to society would be one way of changing the agricultural model, reconciling Agriculture and Environment and ensuring long-term agricultural production. A new agricultural policy must provide focus once more and support the rural world in moving towards a serene future.

The latest opinion surveys reveal increasing public interest in protecting the environment.

Most people consulted consider themselves to be "*very concerned*" by environmental problems and 84% of French people believe that "*ecology cannot be viewed as a luxury"* and that "*we don't do enough to protect our environment"* (according to an Obea/Infra Forces survey for France Info).

To make it up with society and achieve recognition of its status as major manager of ecosystems, agriculture must develop solutions for its fundamental problems. A new agricultural policy, remunerating ecological services, must urge farmers to alter their practices and **reconcile production and protection.**

(a) Support for ecological services is not new

Various methods of support for environmental functions linked to agricultural production have already been introduced.

The reform of the Common Agricultural Policy (CAP) in 1992 introduced agri-environmental measures. For the first time, farmers had a chance to commit voluntarily, over at least five years, to adopting environmentally-friendly techniques. These measures include the *Agri-environmental Grassland Premium (PHAE)*, the *Territorial Management Contract (CTE)*, *Sustainable Agriculture Contracts (CAD)* and the MAE (Agri-Environmental Measures). Many other measures cover converting to organic farming, preserving endangered breeds, crop diversification in rotation, etc.

All these measures aims at financing the loss of revenue from changing a practice, or the investment cost generated, but they exclude the necessary incentive to adopting agri-environmental measures.

Yet the issue is crucial. European indicators suggest under-provisioning of public agriculture-related goods[17]. These indicators reveal among other things a drop in common bird populations in agricultural environments, high soil erosion levels, poor ecological state of numerous water points, etc. According to the rare studies on the topic, the loss of an ecological service such as pollination by bees could cost society 154 billion euros[18] every year, i.e. a tenth of the total value of world agricultural food production. The degradation in these natural services thus equates to the loss of essential heritage and will require costly alternatives.

Faced with such prospects, public intervention is needed for a large proportion of farmland;

[17] According to the study "Provision of public goods through agriculture in the European Union", December 2009, IEEP (Institute for European Environmental Policy).

[18] According to Gallai, N *et al*. (2008) "Economic valuation of the vulnerability of world agriculture confronted with pollinator decline".

this should encourage farmers towards practices which maintain soil functions, reduce GHG and conserve the biodiversity. Investing today in our natural capital therefore comes down to making savings and maintaining the potential of future generations to satisfy their own needs.

Under current negotiations around the draft reform of the Common Agricultural Policy by end 2013, it is not inconceivable that the future CAP proposes a range of instruments capable of encouraging the supply of ecological services and public goods required to meet society's demand.

Remunerating ecological services meets the need to reduce the impact of human activities on the environment. Remunerating farmers for their ecosystem-friendly actions makes it obligatory to consider the impacts on the environment, the economy of the sector and the social well-being of its players all at the same time. It involves taking into account all the criteria making up sustainability.

How can farmers be persuaded to change their practices to produce ecological services? Which mechanism(s) should be used to remunerate farmers via the "Payments for Environmental Services (PES)"?

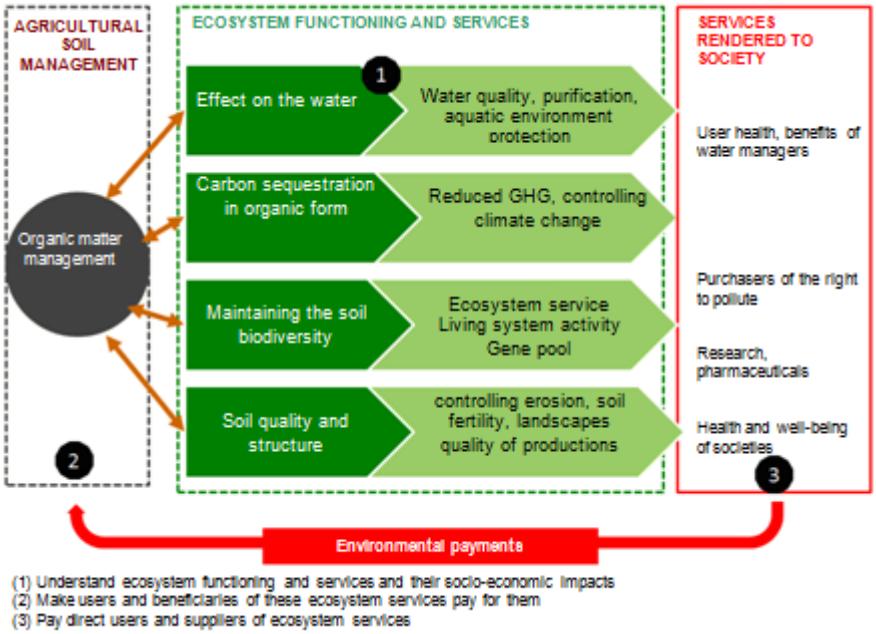
(b) Farmers benefiting from Payments for Ecological Services (PES)

Agricultural policies have imposed the environmental issue as a constraint until now, a penalty on the production and economy of sectors. The political applications and media take-up have fuelled the conflict between agriculture and the environment.

Socially, remuneration or payments for ecological services are a mini-revolution as they are based on a voluntary initiative by the farmer and reward his environmentally-friendly action. The decision-making process between the desire to act to protect nature and the action to be undertaken depends on numerous factors.

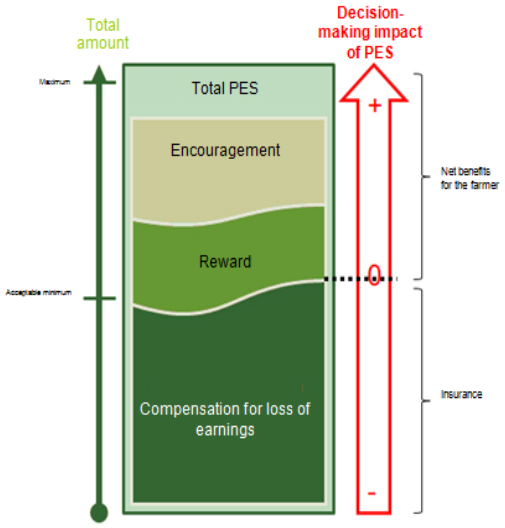
The 2007 report by the Food and Agriculture Organisation of the United Nations (FAO) underlines the fact that the farmer acts to protect the environment when the objectives and measures implemented have a positive influence on his well-being and that of his family. In addition, decisions made on the management of natural (soil, water, plant species, animals, etc.) and economic (capital) resources are highly dependent on the yield and benefits of his activity. Ultimately, the decision is dictated by available technologies, markets and political constraints.

Figure 11: From theory to practice in setting up environmental payments for ecological services.
Adaptation of the Pagiola and Platais (2006) scheme for agriculture.



Any remuneration introduced for farmers in return for ecological services must therefore incorporate these factors to transform the environment-related political constraints into opportunities. To achieve this, the payments must include three components as shown in Figure 12 below.

Figure 12: Breakdown of the acceptable amount for Payments for Ecological Services (PES) and its impact on the farmer's decision.
According to FAO data, 2007



(1) **Compensation** for loss of earnings and production vagaries from adopting new practices likely to provide ecological services. This component relates to the minimum acceptable amount and forms a safety net whilst the system gets going. It **provides essential financial insurance** that the farmer can remain economically viable.

(2) **An additional share** over the minimum amount **rewards** the use of good practices producing ecological services as much for society as for the farmer himself.

(3) The last share of PES relates to an **encouragement "bonus".** This additional amount is an incentive and gives the decision making a bit of a boost. The financial encouragement is therefore an incentive to develop good practices producing ecological services for society, private and public enterprises and consumers.

The incentive "power" of "PES" payments is only effective when the compensation between the cost borne by the farmer to change practices and the remuneration he receives is advantageous both economically and socially. Once more according to FAO, and assuming adequate financial incentive, it seems that the farmers are ready to change their practices to meet the demand for ecological services, all the more so that the techniques exist and produce results.

REMUNERATION SYSTEM PRINCIPLE AND TERMS

Farmer remuneration based on ecological services rendered to society is an effective way of protecting resources and uniting farmers in environmentally-friendly production initiatives.

It involves creating a remuneration system which encourages farmers to move towards the practices the most protective of the environment and to produce ecological services.

These payments can be established at several significant points in farms where the results can be measured. For example, out of nineteen indicators identified by IAD to measure ecological services, thirteen can be used directly:

- plant protection rate (IFT)
- nitrogen level
- energy balance
- renewable energy production
- irrigation water consumption
- GHG rate
- yield per hectare
- soil cultivation intensity
- soil cover
- organic matter level
- soil utilisation
- biodiversity surface area
- crop diversity

A minimum threshold is defined for each of these points, giving rise to the minimum amount of the bonus, i.e. the "**insurance**" which could represent 30% of the total

payment. The maximum threshold sought and measured, when achieved, gives rise to a payment equal to the full bonus, i.e. the "**encouragement**". The intermediate "**reward level**" lies between these two extremes. This could be 65% of the maximum bonus, for example. The amount of the bonus of course covers the *result* and not the *resources* used to achieve it.

All farmers must be covered by the remuneration package to incite them to subscribe to a productive and environmentally-friendly initiative. A farmer producing few results under the system for ecological services will received the smallest bonus amount, i.e. **the insurance level.** The aim is not to exclude anyone. A financial **reward** is granted for the efforts made so that everyone feels involved and can plan the necessary changes to move forward in a spirit of progress.

Monitoring the efficiency of farming practices to promote ecological services can be measured annually. The IAD has identified indicators capable of this. Measuring results could easily be included in accounting records making them operational for regular monitoring of enterprises. The link between the accounts and the ecological service indicators would be an excellent statistical basis for the agricultural policy, thereby avoiding double or triple entry problems and establishing an excellent results control tool for the Civil Service. A PES strategy like this can easily be included in the future CAP (2013) with the best cost-service-registration-control ratio via a simple declaration based on a copy of results measured.

(c) Sample payment mechanisms

The presentation of payment mechanisms has been simplified deliberately. We believe that this point is essential for ease of understanding. It is not up to IAD to set the bonus amount, however. With no economic study defining the laws and value of transactions for each service, it is difficult to give a fair assessment of the actual cost of a service or even how much it will cost to set up on the farms. IAD has therefore chosen to establish a fictitious value to avoid discrediting the process by setting an arbitrary amount. This value is "y", the maximum amount of the environmental payment. The PES percentage resulting from the measured results will therefore be allocated to this value:

- "y" x 30% for the insurance level;
- "y" x 65% for the reward level;
- "y" x 100% for the encouragement level.

The performance level of agricultural ecological services is based on measuring results using indicators identified by the Institute for Sustainable Agriculture's tests. Every indicator linked to an environmental impact is a measuring tool which can be used to calculate the amount of the bonus.

Twelve IAD indicators have been adopted for the moment in this simulation as potentially serving as a basis for remuneration mechanisms. They are presented in the table below:

Indicators / Value	Soil cultivation intensity: index	Annual soil cover rate as %	Humus rate Positive or negative	Nitrogen level Kg/ha	IFT Approved doses/ha	Soil utilisation Ha/TOE produced	GHG level TeqC/ha	Energy balance TOEproduced/TOEconsumed	Energy independence as %	Biodiversity surface area as %	Hedge distance In km	Crop diversity in qty. ≥ 10%
Variability of results from IAD indicator tests (2010 and 2009)	0 to 1.4	40 to 100%	+ or -	≤ 10 to ≥ 40	≤ 3.5 to ≥ 7	≤ 0.2 to ≥ 1	≤ 0.6 to ≥ 1	≤ 1.2 to ≥ 7	+60% to +10% and less	+10% to less than 3%	5 km and more to 1km and less	5 and more to less than 2
PES insurance Y = 30%	> 0.7	<60%	/	> 40	> 7	> 1	More than 1	< 5	< 10%	< 3%	< 1 km	< 2
PES reward Y = 65%	0.1 to 0.6	60% to 90%	/	10 to 40	3.6 to 7	0.2 to 1	60 to 1	5 to 8	between 10% and 60%	3% to 9%	1km to 4 km	3 to 4
PES encouragement Y = 100 %	< 0,1	more than 90%	+	< 10	< or = to 3.5	< 0,2	≤ 0.60	> 8	= to 60%	10%	5 km and more	5 and more

(d) Ecological service payment scenarios (PES)

To keep the exercise simple, a single typical scenario is studied in the practice remuneration scenarios. IAD also suggests open discussions on various usable mechanisms.

Two different farming practices are presented following the various trials carried out in the IAD farming networks.

Firstly, a farmer using so-called "conventional" practices where the soil is still ploughed and secondly, an innovative farmer in the no-till cover crop systems.

The aim is to test whether remuneration for ecological services can be achieved. The example compares granting remunerations according to the result of practices and distinguishes between the actual amounts of payments granted to the agricultural enterprise.

The humus rate which could supplement the "organic matter level" indicator, the hedge distance and the presence of trees are not yet included in the calculation as this information is not provided by the farmers for the moment. In addition, the humus rate is being re-assessed by INRA.

Ecological Service Payment (PES) scenarios Hypothesis 1: 100% of the CAP mobilised (1st and 2nd pillar) Source: IAD, indicator test phase, 2009 and 2010				
	Conventional agriculture 2009		**No-till cropping system innovative farming 2010**	
indicators	Result	% of PES	Results	% of PES
Soil tillage intensity	0.88	30 % €Y/ha	0	100 % €Y/ha
% annual soil cover	48%	30 % €Y/ha	100 %	100 % €Y/ha
Nitrogen level	21 kg N/ha	65% €Y/ha	45 kg N/ha	€0/ha
IFT	1.73	100 % €Y/ha	1.70	100 % €Y/ha
Soil utilisation	0.21 ha/TOE p	65% €Y/ha	0.9 ha/TOE p	65% €Y/ha
GGH	0.94 TeqC/TOE p	65% €Y/ha	0.6 TeqC/TOE p	100 % €Y/ha
Energy balance	4.80 TOE p/TOE c	30 % €Y/ha	5.60 TOE p/TOE c	65% €Y/ha
Energy independence	0 %	30 % €Y/ha	62 %	100 % €Y/ha
Biodiversity surface area	1.45 %	30 % €Y/ha	5.30 %	65% €Y/ha
Crop diversity	3	65% €Y/ha	4	65% €Y/ha
Hedge kilometrage	No information	/	No information	/
Humus rate	Not tested	/	In progress.	/
Cumulative Y = €30/ha		5.1 €Y/ha €153/ha		7.6 €Y/ha €228/ha
Actual surface area	163 ha	€24,939	233 ha	€53,124
100% potential of PES 12 indicators at €30 Max. PES of farms		12 €Y/ha €360/ha €56,680		12 €Y/ha €360/ha €83,880/ha
Difference between actual and optimum system in €/farms PES remuneration in %		-€33,741 42 %		-€30,756 63 %

The hypothesis of this example envisages a contribution from the entire CAP budget to remunerate Payments for Ecological Services (PES). Starting with a budget of 54 billion[19] euros and a European UAA of 172.5 million hectares (Europe-27), the fair distribution of sums represents about €320/ha. This sum is to be divided by the number of indicators being used to allocate payments (twelve in our example): 320/12 = €27/ha, rounded up to €30/ha to make it simpler. This sum makes up the "y" of our PES, i.e. 100% of the PES at the "encouragement" level for each ecological service measured.

The indicator test phase is continuing in 2010. This sample scenario shows that:

- results can be measured;
- the results vary from one farm to the next;
- some practices are more favourable than others;
- payment for ecological services can be envisaged;
- certain practices lend themselves to overall improvement of ecological services;
- it would be relatively simple to collect the results with an improvement to existing indicators and the development of cooperation between public services and private recordings.

[19] Source: www.europa.eu

This stimulation teaches us a great deal. Incorporating the 1st and 2nd CAP pillars in their entirety into the PES produces incentive financing levels for farming practices. The PES remuneration differences vary from 42% to 63% of the maximum possible for our example. There is still a great deal of work to be done to produce all ecological services.

This PES example provides other information.

- The first is the identification of a fair remuneration regardless of the surface area and European country involved: something that functions in France will also function throughout Europe. The distribution of the total CAP budget over each hectare of UAA can promote both grassland systems and cropping or mixed systems.

- There is tremendous room for manoeuvre. The difference in PES remuneration is €75 per hectare between a "conventional" practice and an "innovative no-till cropping system". In addition, the results and remunerations can be perfected to at least 60% for conventional agriculture and 40% for "innovative no-till cropping systems".

- The scenario tested does not mobilise all the available CAP budget. Pending sums can therefore be made available to States to produce additional measures encouraging investment in agronomic systems which produce PES. This situation therefore validates a 1st and 2nd pillar for the post-2013 CAP. For example, it would be sound to finance the training, the replacement in the event of training, the seed drills and tyres adapted to carbon sink living soils, aids for plant cover seeding, and irrigation infrastructures, etc.

- Two CAP pillars would remain after 2013, becoming variable and free flowing between each other.

- The minimum level of "insurance" is achieved in conventional agriculture. The farmers are all the more encouraged to alter their farming practices when a substantial PES remuneration is on offer. Thus, what they will gain as time goes on in the PES will be deduced from ancillary incentive systems developed with unallocated budget surpluses (2nd pillar = % of Ecological Services not financed by the 1st pillar).

- CAP budgetary monitoring is an excellent tool for measuring the results of European policy. The PES level granted in the 1st pillar is a barometer of services rendered to society by the farmers. The availability of the 2nd pillar budget means that credits can be directed towards environmental dossiers at any time.

- The farmers will be able to choose and adapt their production techniques based on economic results and remunerated PES. Thus, theoretically, no agricultural system is in difficulties. But, such a policy will direct the production techniques towards better virtuous systems capable of producing and protecting the environment - which is the goal sought.

This sample remuneration scenario is constructed from work carried out at IAD with neutral and factual indicators. This work is just one example.
This scenario can be improved or modified at will. Vigilance is however key: too little remuneration for ecological services will lead to failure of the post-2013 CAP if it goes this way. The sums allocated to the ecological services must provide an incentive!

CONCLUSION AND PROSPECTS
Change to what?

Agriculture 2050 starts here and now! We are at the start of a new era, focusing on ecology and the sustainability of agricultural systems. Studies on the sustainability of farming practices show that following the natural cycle is a systematic feature of high system productivity and environmental protection. The investigation into the functioning of nature indicates that creating a carbon sink is a prerequisite to re-establishing all the ecological functions. This involves optimising the soil management and understanding mechanisms governing the recycling by the biological communities.

Thus, the agricultural policy must act at two levels if the farmers are to provide 97% sustainable provisioning in consumer goods and ecological services to their fellow citizens:

- The first level involves creating a carbon sink. The political tools, via carbon credits, must allow farmers to put together carbon sequestration strategies in the soil and the plant biomass.
- The second level follows on from the agricultural carbon sink. The good biological and structural state of soils encourages the development of a powerful biodiversity capable of producing ecological services for society.

The polluter-payer principle can be used to remunerate carbon credits. This involves establishing thresholds beyond which a tax on CO_2 emissions is levied. This same threshold serves to remunerate virtuous practices of carbon sequestration to improve the competitiveness of the new act of production. Compensation mechanisms can be set up right inside the production sectors. It seems logical and fair that the carbon sink beneficiaries (processors, retailers and citizens) help the farmers to create carbon sinks to control the effects of climate change.

Surveys on carbon sequestration in the soils show that the proportions of organic matter increase as and when the farmers alter their production techniques. Direct drilling into a cover crop seems more efficient than other, more conventional agronomic practices. However, the on-going measurement of the "organic matter level" indicator is far from easy. The investigation surrounding this indicator suggests that the simplified humus rate calculation could be more relevant and easier to use.

A true logic has been identified in this work. The agriculture which sequesters the carbon is without question also the agriculture which produces the most ecological services for society. The two dossiers go hand in hand. The innovations available around "soil fertility conservation" which copy the ecosystem functioning to agriculture produce sustainable agriculture. This result constitutes a new research hypothesis for agronomic science.

Since its creation in 2008, IAD has worked on identifying indicators to help measure strong and weak points in all farming practices. The indicators identify the carbon sinks and ecological services. Measuring results on farms is used to present a remuneration example called "Payment for Ecological Services or PES".

The one and only remuneration mechanism proposed in our example is based on the results of measured practices. The innovation of the no-till cropping system (called SCV in French by CIRAD) produces good results (63% of PES - Payment for Ecological Services) and is established at the "reward" level in our example. All farmers still have extensive development work to do.

The topic of ecological services has little by little become a serious development focus to be monitored since 2007 and the FAO report. Starting from yesterday's ideal, agriculture can now develop ecological services and this is becoming a major objective of public policies under the 2013 CAP reform. Any action to meet the agreed objectives (Ecophyto 2018 in France, Fertilisation, Biodiversity, etc.) involves using agronomic techniques on the fundamental causes leading to the desired consequences.

Ecological services form a solid basis for developing interdisciplinary projects on economic (agricultural productions), environmental (water and soil quality, climate change, biodiversity) and societal (well-being, product quality, landscapes, biodiversity, etc.) issues.

The European Parliament proposal for the 2013 CAP reform encourages widely the adoption of cropping techniques combining "*minimum tillage techniques that provide cover crops and allowing catch crops and crop rotation*" with a view to maximising photosynthesis and enriching the soil with organic matter. Other practices such as reducing greenhouse gas emissions by integrating renewable energies are also highlighted. Under the 2013 CAP reform, the European Parliament proposes to encourage farmers to commit to these techniques by incorporating special payment conditions financed by the European Union budget.

The spatial and temporal dimension of agriculture is well known, as the benefits of changing practices are not immediate and can have an impact at a more or less "wide" scale (local, national or international). A policy which takes Agriculture and Environment into account by creating and remunerating carbon sinks and ecological services in all territories would encourage the protection of resources. It will be possible for an ecological services policy to evolve in the long term provided it is addressed to everybody, targets all surfaces and banks on a financial incentive.

Introducing remunerations responds to strong societal demand in a world context around millennium goals, involvement by FAO, OECD, the European Commission and MAAP and MEEDDM at local level. This solution **would also be compatible with the WTO green box**.

Developing farming practices providing ecological services by constructing carbon sinks must become one of our priority actions given the results they render to society. We hold all the cards to enable agriculture to meet the huge food, energy and climate challenges of tomorrow. The techniques are available, indicators can measure results and identify the best practices, pooling existing tools helps monitoring and development - all that remains is to act.

Agriculture 2050 really starts here and now. By creating IAD in 2008, the farmers and their partners have offered citizens responsible for managing public goods a strategic discussion document. The aim is to create a genuine move forward benefiting the development of wealth and the "reconciliation" between farmers and the civil society.

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GLOSSARY

Conservation agriculture: Conservation agriculture (CA) targets sustainable, profitable agricultural systems and strives to improve the living conditions of farmers through simultaneous application of three principles at field level: minimum soil cultivation, crop combinations and rotations and permanent soil cover. It is a way of reconciling agricultural production, improving living conditions and protecting the environment. (FAO, BASE definition)

CEC: Cation Exchange Capacity: chemical measurement to determine the capacity of the soil to fix the exchangeable cations (Ca++, Mg++, K+, etc.) reversibly.

Humus compounds (humus substances, humus): these are macromolecules with high molecular weight, made up of an assembly of different hydrocarbon chains with no repetition of a defined sequence (unlike biological molecules). These compounds together form the stable organic matter. They come from slow biochemical changes in various organic matter in soils (humification).

(Economic) competitiveness: Competitiveness is the aptitude for an enterprise, sector or set of enterprises in an economy to face up to actual or potential competition. (Source: TRADER-FINANCE.fr)

Ecotoxicology: Ecotoxicology is the study of the impacts of polluting agents on the structure and functioning of ecosystems. In the knowledge that a polluting agent is a natural or synthetic substance introduced by humans into the environment or where the distribution in the different compartments of the biosphere is altered by humans. Many factors govern the effects of a polluting agent, including changes in the pollutant in the environment or how the pollutant is administered. Ecotoxicology characterises the risk of a substance which depends on the danger of the substance and the likelihood of exposure to this substance. (Source: SDAGE RMC)

MTE: Metallic Trace Element or micronutrient Example: copper, aluminium, lead, etc.

Ploughing (farming technique): Ploughing is a method of cultivating the soil using a plough which opens up the arable layer of the soil before turning it over prior to sowing a crop.

Ecosystem link and chain: An ecosystem chain is a set of living beings interacting with each other as well as with the environment for access to resources, food, water, habitats, competition between two species, the services they provide, etc. Each level in the chain is an ecosystem link.

Metabolites: molecules from the microbial metabolism.

Micro-organism: tiny living organism. These are basically bacteria and fungi.

Mineralisation: the debris are initially depolymerised by enzymes. The small molecules (sugars, amino acids) are used by the microflora in the soil (fungi, bacteria). This attacks the largest molecules and degrades them more or less rapidly, releasing mineral nutrients amongst other things. This is mineralisation.

CAP or Common Agricultural Policy is a policy set up atEuropean Union scale, based principally on price control and subsidisation measures, aimed at modernising and developing agriculture. Created in 1957 and set up from 1962 onwards, the CAP has two pillars: the first deals with market regulation

and the second with rural development and the environment. The CAP has been reformed several times, especially in 1992 with the incorporation of the environmental section. The next reform is scheduled for 2013.

Plant protection products: Falling under the family of pesticides, **plant protection products** are used to treat or prevent diseases of plant organisms. Plant protection products are composed of an active substance or a combination of several chemicals or micro-organisms, a binder and if appropriate a solvent possibly accompanied by adjuvants or a surfactant.

Food quality or wholesomeness: food quality or wholesomeness is a food health component defined by AFNOR (NF VO1-002:2003). Food quality covers the intrinsic characteristics in terms of organoleptic quality (taste, smell, texture, colour, presence of degradations, etc.) and is defined as "*the guarantee that the foods, when consumed in accordance with their intended use, are acceptable for human consumption*". Added to this is product harmlessness (guarantee that the foods will not harm the consumer).

Natural resources: Resources drawn from nature which serve to produce goods and services; land, water, wood, fishing, oil and minerals, soil fertility, climatic conditions required by agriculture, etc.

Direct drilling (farming technique): Direct drilling describes a farming technique based on not cultivating the soil and direct sowing of the seed in the surface soil horizon without prior ploughing.

Food safety; according to FAO, food safety is defined by four components: and socially-acceptable **food** of appropriate quality **available** in sufficient quantity, **accessibility** to the food by right and adequate (economic) resources to access it, utilisation to respond to all the physiological needs (drinking water, nutrition, etc.) and **stability** (of productions and suppliers), providing access to the food at all times.

Minimum tillage: Minimum tillage groups all soil cultivation methods which limit mechanical interventions.

Treaty of Rome: was ratified in 1957 and gave birth to the European Economic Community (EEC). With the establishment of a common market and gradual link-up of member State economic policies, the EEC has the task of promoting harmonious development of economic activities throughout the Community, on-going and balanced expansion, increased stability, accelerated upturn in living standards and closer relations between the States it unites.

LIST OF FIGURES

LIST OF ABBREVIATIONS

EEA, European Environment Agency

CIRAD, Centre for the Development of International Cooperation in Agronomic Research

FAO, Food and Agriculture Organisation of the United Nations

GHG, Greenhouse gas

IPCC, Intergovernmental Panel on Climate Change

IAD, Institute for Sustainable Agriculture

IFT, Treatment frequency index

INRA, National Institute for Agronomic Research

INSEE, National Institute of Statistics and Economic Studies

MAE, Agri-Environmental Measure

MAAP, Ministry of Food, Agriculture and Fisheries;

MEA, Millennium Ecosystem Assessment

MEDDEM, Ministry of Ecology, Energy, Sustainable Development and the Sea

OECD, Organisation of Economic Cooperation and Development

WTO, World Trade Organisation

UN, United Nations

CAP, Common Agricultural Policy

PES, Payment for Ecological Service

UAA, Utilised Agricultural Area

SCV (French acronym), drilling into a cover crop system

SD (French acronym), direct drilling

TCS (French acronym), Minimum tillage

TOE, Ton Oil Equivalent

LIST OF APPENDICES

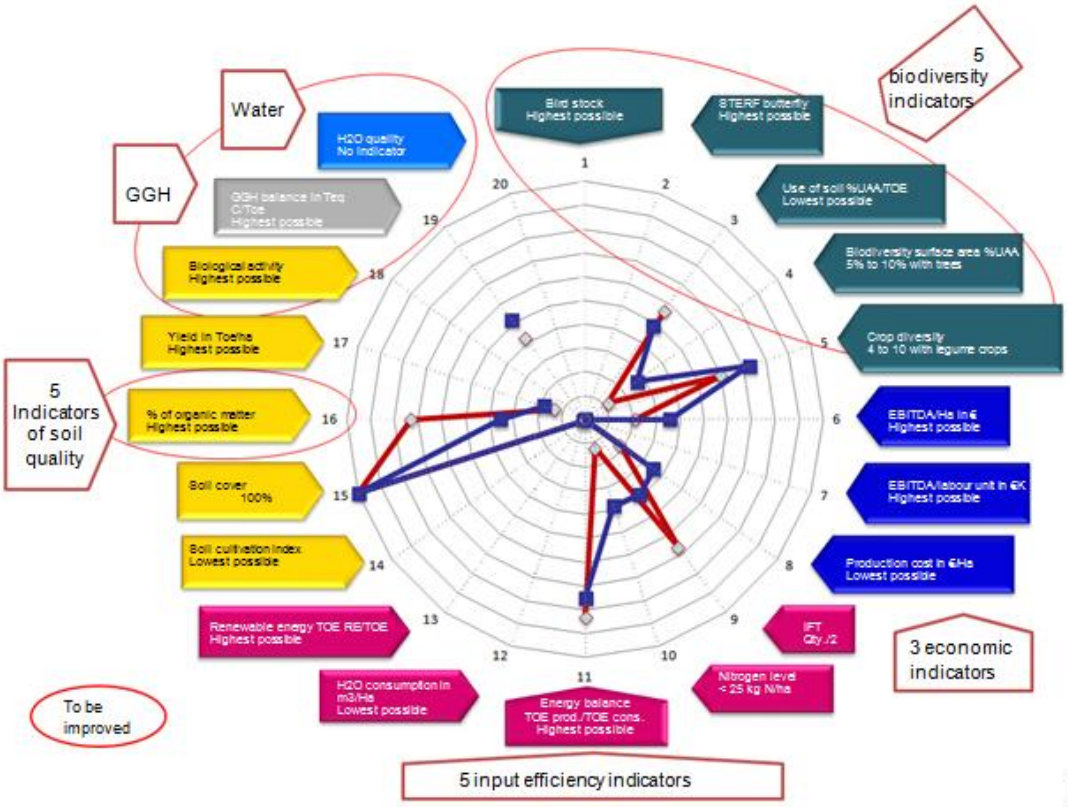
APPENDIX I: Ecological services and their functions

The various services produced by the agri-systems and their properties. The link is also made with the farming revenue and the impact the farmer could have by supplying these services. Source: FAO 2007

	SERVICES	ECOSYSTEM FUNCTIONS/PROPERTIES
Input services	Structural soil stability (erosion control, resistance to soil compaction)	Soil structuring: porosity, aggregation Stabilisation via the roots Soil organic matter
	Water availability for the primary production	Water cycle
	Soil fertility	Organic matter dynamics: mineralisation, decomposition Nutrient dynamics: elementary transformations, solubilisation
	Microclimate regulation	Daily and seasonal temperature variations, Hygrometry; windbreak
	Pollination	Pollen transfer and dispersion
	Controlling pests	Habitats and resources for beneficials Predation, parasitism, pathogenicity
	Control of biological invasions	Resistance to invasions
	Pet health	Animal resistance to diseases and pests Limiting food toxicity Limiting allergies
Services produced which contribute to the direct agricultural revenue	Plant production (food, fibres, energy, etc.)	Primary production: yield Primary production: yield stability (climate, plant-eating organisms, pathogens, etc.)
	Animal production	Fodder quality (nitrogen, fibres, special molecules) Food motivation Secondary production (dairy and meat products) Organoleptic product qualities
Services produced outside direct agricultural revenue	Water availability (drinking, irrigation, hydroelectricity, industry, etc.)	Evapotranspiration Intercepting rainfall Lateral water flows Water retention capacity of the soil
	Water purification	N and P cycles: trapping/leaching/transformation (e.g. denitrification) Biodegradation of xenobiotics Sequestration of xenobiotics Retention of pathogens
	Global and regional climate regulation	Carbon sequestration (soil and vegetation) Greenhouse gas emissions Surface properties: albedo, roughness, etc.
	Fire mitigation	Flammability Spatial connectivity
	Conservation of ordinary and heritage diversity	Habitats and resources Migration, allogamy, biotic interactions Habitats Spatio-temporal heterogeneity
	Aesthetic, tourist, spiritual value	Spatial patterns Quantitative or qualitative biodiversity

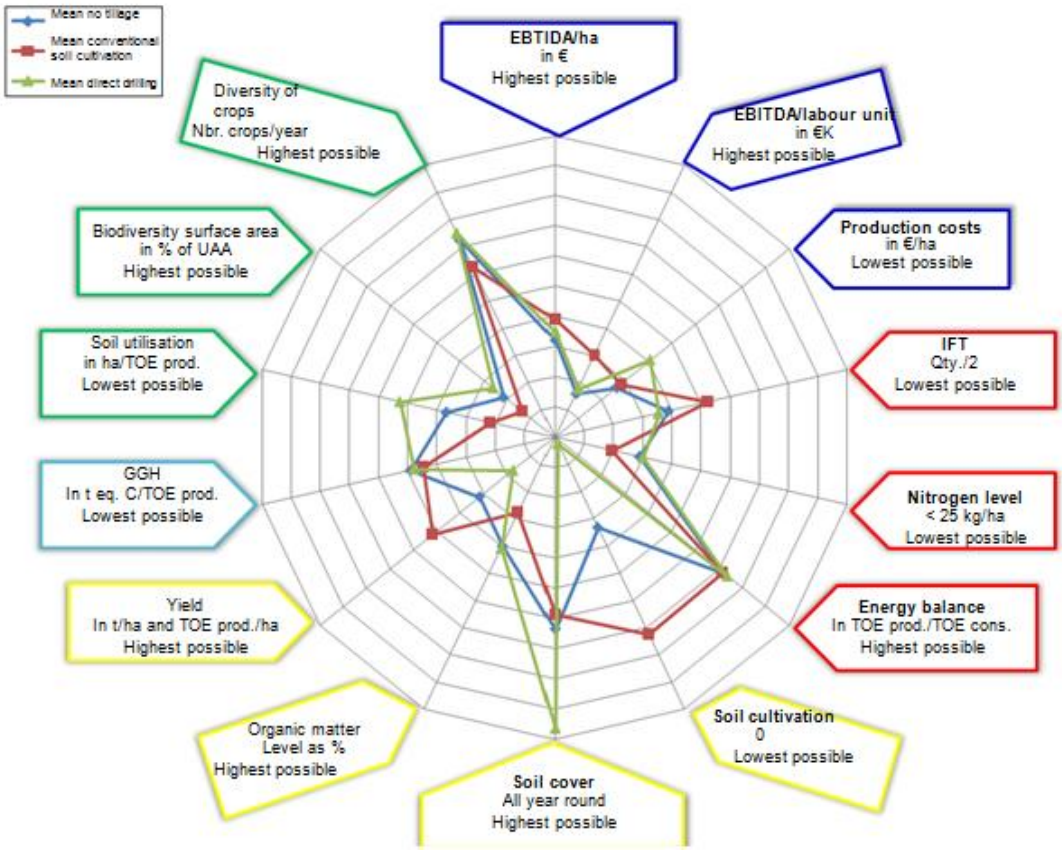
APPENDIX II: Scorecards for sustainable agriculture indicators

(a) Scorecard of twenty indicators developed in 2008-2009 for farms concentrating on cereal and industrial arable crops In 2010, seven additional indicators supplemented the scorecard for livestock farms. Source: Presentation of indicators; Konrad Schreiber, 2009



Only sixteen of the original twenty indicators measure results of interest in managing farms. The indicators circled in red require improvement. In particular, the water quality, biological soil activity and specific biodiversity (STOC birds and STERF butterflies) indicators are lacking information. No result indicator currently exists which can measure accurately the water pollution or maintaining of biodiversity relating to farming practices. Agronomic research should help answer certain questions, mainly those relating to existing links (or otherwise) between soil quality and water quality, agronomic practices and the biodiversity of fields, to propose result indicators correlated with agronomic practices.

(b) Example of results during the survey phase from farms concentrating on cereal and industrial arable crops The figure presents the comparison between the averages of miscellaneous cultivation practices (conventional "soil cultivation", minimum tillage and direct drilling) obtained from the results of 2009 surveys of the 2007-2008 financial years. Source: IAD 2010.



The field trial phases have demonstrated the efficiency of indicators in measuring a convincing result and in shedding light on the differences between cultivation practices and production management methods. Here, we have identified clearly the significant differences in soil cultivation, soil cover, yields and even IFT.

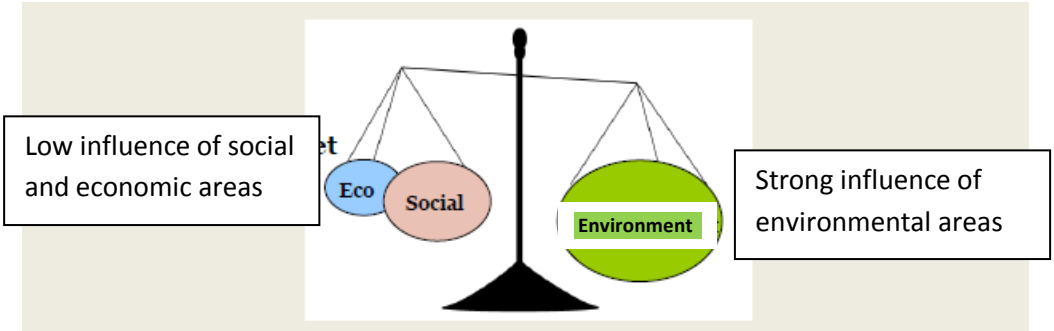
APPENDIX III: Technical indicator sheets

Genesis of sustainable agriculture indicators

Observations around agriculture:

Since sustainable development indicators have been harmonised, countries carry out self-assessment and compare themselves with each other to match each one's performances.

What about sustainable development in agriculture? The harmonisation dynamics are far slower to set up and the resulting indicator systems are lacking balance.



The Institute for Sustainable Agriculture believes that sustainable agriculture must be guided by farming practices, concerned for economic, environmental and social issues and above all capable of meeting the challenge of "providing sustainably for the food requirements of nine billion individuals by 2050". French agriculture should clearly take part in this effort given its highly-favourable pedoclimatic situation.

The only solution to avert a world hunger crisis would be to produce more, i.e. by increasing yields or by increasing agricultural surface areas or by a combination of the two.

Sustainable agriculture is now facing huge challenges. It has to produce MORE to participate in the nutrition effort and BETTER to preserve the planet's resources - water, soil, air and climate. But also produce more to meet the energy challenges, to remain competitive and profitable, in order to adapt to local and world markets and ensure the survival of agricultural enterprises.

IAD is suggesting a pioneering approach to farmers to achieve all this: **self-assessment to progress in a process of improvement.** This process is based on indicators measuring results easily available in the farms and accessible to the farmers.

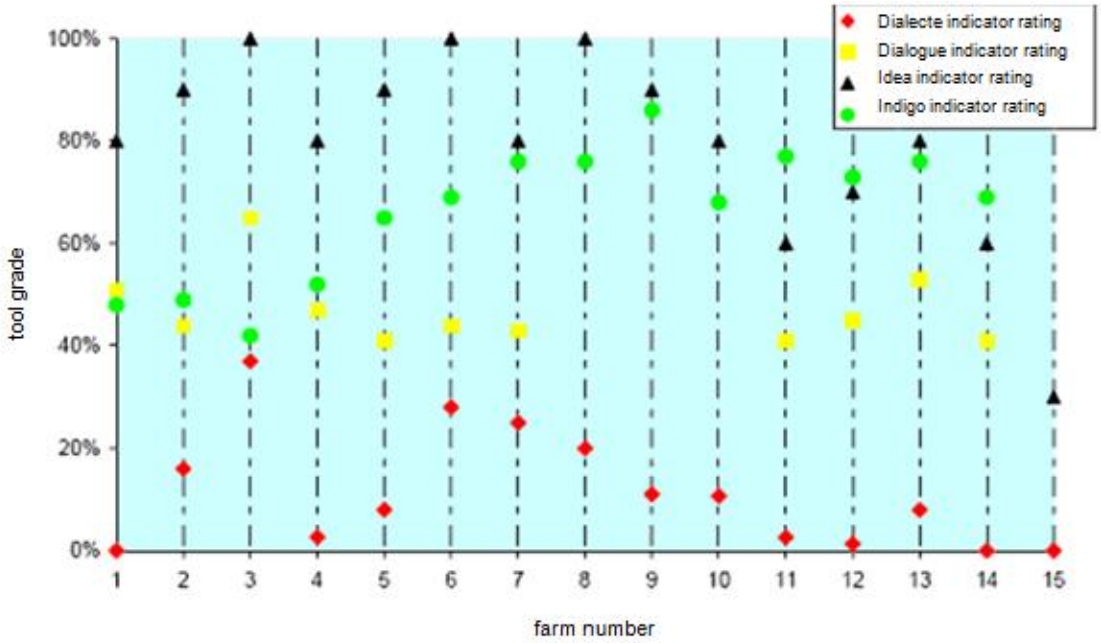
Inventories around French agricultural indicators:

Numerous national and international indicators and input tools exist to try and assess the sustainability of farms. The best-known in France are IDEA, DIAGE, DIALECTE, DIALOGUE and INDIGO. The aim of all these tools is to assess the sustainability of farmer practices.

One major problem: rather unreliable tools

They show major design and result disparities for a common goal. OECD tested various methods on the plant protection indicator (OECD, 2004).

OECD document 2004: IDEA, DIALECTE, DIALOGUE and INDIGO results on the impact of water pollution on plant protection products in fifteen farms in Picardy



Source: **OECD,** 2004, D. Peschard, M.B. Galan, H. Boizard: "*Tools for evaluating the environmental impact of agricultural practices at the farm level: analysis of 5 agri-environmental methods*";

Major differences have been noted between the tools in terms of how they are calibrated and the scores obtained. The calibration applied by each tool therefore induces tremendous variability in the final score. The score between IDEA and DIALECTE varies from 80% to just 10% satisfaction in the plant protection indicator! Staying with the same indicator, a comparison of the IDEA and INDIGO results suggests that the scores obtained by the farm follow no logic between the two tools.
This test highlights the huge variability of results obtained according to the diagnostic tools. Most systems use a scoring system which causes subjectivity, as demonstrated by the OECD study.

IAD proposal

The farmers apparently find it difficult to improve their practices using non-homogeneous and barely operational tools based on subjective scoring systems. A poor result with DIALECTE could come good with IDEA. The IAD members have decided to introduce a synthesis identifying relevant indicators. This involves meeting farmer expectations for a reliable, simple and objective evaluation system. **Objectivity is easy to identify, you simply have to measure a result.**

IAD approach:

The process of advancing towards sustainable agriculture must measure the results of the agricultural system and be easy to understand. Farmers can apply simple-to-use indicators for self-assessment purposes if necessary, with a reasonable collection and processing time (two to three hours at most).

The indicators are chosen from assessment systems validated at national, European or international level for their relevance, balance, objectivity and ease of use. The sources used as a reference are as follows:

- Institutions: UN, FAO, FDA, WTO, European Union, Eurostat, ADEME, ARVALIS, IFEN, MAFF
- Professional agricultural bodies: FNSEA, APCA (Permanent Assembly of Chambers of Agriculture), Ukraine, Poland, Benelux, China, Australia, USA
- Intergovernmental organisations (IGO): UNDP, OECD, WHO, World Bank
- Non-governmental organisations (NGO): WWF, Greenpeace, Solagro
- Mass-market retailing: Casino, Carrefour, Leclerc, Unilever, Kraft, Tesco, Nestlé

Subsequently, the data input for the analysis follows the methodology for the most consistent French indicator and the most suitable for measuring results. Ultimately, the tool has 26 indicators grouped in seven relevant themes: economic viability, social impact, efficient use of inputs, soil quality, greenhouse gases, water quality and biodiversity.

The IAD indicators:

- form part of a results measuring logic as soon as possible. The pressure indicators can have very different environmental consequences depending on the situations (e.g. two applications of plant protection product at the same dose can cause very different runoff leaks depending on the pedoclimatic context of interventions and the soil management techniques).
- can be re-used over time to measure any advancement dynamics.
- are legitimate as they come from existing, recognised assessment systems.
- are easy to compare and can be exchanged and communicated. The scales chosen and units used are fully comprehensible, including by the general public.

The measuring scale adopted is the agricultural enterprise. But the indicators also function for a plot if the technical and economic recordings are allocated to this scale. Similarly, they measure the results at sub-national or national scale by aggregation. It is possible ultimately to have results for all territorial scales, from micro-local to global and for all types of production.

Development of IAD indicators:

Registration will be proposed online. The farmer can self-assess and have a result available with a simple click. This tool is being finalised and will be operational in 2011.

In terms of registration, the items required are accounting results, the fertilisation log, the health log and the pesticide registration log for a same management year (for example, 2009) along with the CAP declaration.

Produced by

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