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System for Environmental and Agricultural Modelling; Linking European Science and Society

The major characteristics of environmental policies and agro-ecological technologies to be studied in Test case 2

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SEAMLESS integrated project aims at developing an integrated framework that allows ex-ante assessment of agricultural and environmental policies and technological innovations. The framework will have multi-scale capabilities ranging from field and farm to the EU25 and globe; it will be generic, modular and open and using state-of-the art software. The project is carried out by a consortium of 30 partners, led by Wageningen University (NL).

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General information

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Executive summary

The main objective of the integrated modelling framework (SEAMLESS-IF) is to support analysis of agricultural systems and assessment of impacts related to sustainability and sustainable development. To reach this objective, two test cases, driven by economic (test case 1) or environmental policies (test case 2), are considered to test and improve SEAMLESS-IF. The focus of this deliverable is to describe the major characteristics of environmental policies and agro-ecological technologies to be studied in test case 2. This deliverable will provide the background of knowledge, policies and technologies on which policy scenarios will be defined in Test case 2 (PD 6.2.4, SEAMLESS DOW, 2005).

The report is divided into three parts. The first part describes the stakes and the current situation of water use, water pollution and biodiversity in EU and in each of the agricultural regions (as defined in Perez et al., 2005) selected for detailled implementation of the test case in France (The Neste and the Massif Central) and in Poland (Pyrzyce). It further reviews the main difference on water use, pollution and biodiversity, between the north and the south of Europe and between accession and western European countries.

The second part of the report details the main European regulations and directives aimed to reduce the use of the water, the water pollution by nitrate and pesticide and to preserve biodiversity. This part of the deliverable is divided in three paragraphs:

1. The overview of directives and regulations to control water use and pollution by describing nitrate directives and pesticide legislation.
2. Birds and habitats directives to preserve biodiversity.
3. Implementation of directives to preserve water quality, water use and biodiversity, in each agricultural region of the test case in France and Poland.

The first two points include a discussion on the effect of crop rotation and management, via experiments through the world and in Europe, to reduce water use and pollution by nitrate and pesticide. This part describes also the role of grassland to preserve biodiversity.

The last part describes main agro-ecological innovations to preserve water and biodiversity. It is focussed on agro-ecological innovations such as conservation agriculture, agroforestry, organic farming which are known to preserve water and biodiversity.

Specific part

1. Introduction

The objectives of WP6 are to test the SEAMLESS integrated framework (SEAMLESS-IF) and its tools at macro-level (EU with a NUTS2 grid) and at meso-level in more details in four typical agricultural regions, in France, Poland and Mali (Perez et al., 2005). Two test cases will be implemented at these levels: *test case 1* focusing mainly on policy changes at EU level and world-wide, and *test case 2* focusing on changes driven by environmental policies at the meso-scale.
Test case 2 will mainly answer the following questions:

(i) what will be the impact of the implementation of water directives in the EU on the sustainability and multifunctionnality of agriculture and on the socio-economic and environmental sustainability of rural areas?
(ii) will agro-ecological technologies be favoured by these environmental policies or will it be necessary to implement specific incentives for these technologies ? How will they affect sustainability and multifunctionnality ?

To answer these question, several “policy scenarios” involving water directives, technological innovations and their combinations will be compared to a “baseline scenario” (the same as in Test case 1 ; Perez et al., 2005).

The aim of this document is to present the environmental and agricultural backgrounds of the components of these policy scenarios, in order to give informations to other WP on the external constraints and agricultural system’s behaviour to be represented in models and indicators. Final scenarios to be implemented in Test case 2 will be defined in interaction with prime users, using participatory approaches developed by WP7.

2. Agricultural water use, water pollution and biodiversity: stakes and inventory of fixture.

2.1 Agricultural water use

Agriculture is the largest water-consuming sector, in particular via irrigation. The role of irrigation differs between countries and regions because of climatic conditions and farming systems. In southern Europe, it is an essential element of agricultural production, both for crop locations and for crop productivity, whereas in central and northern Europe, irrigation is generally used to ensure high yields of summer crops in dry years and shallow soils.

A major influence on the amount of irrigated land in the EU has been the common agricultural policy with its higher subsidies on irrigated crops such as maize and peas and lower subsidies on drought adapted crops such as barley, chickpea and lentils.

The area of irrigated land in southern accession countries increased steadily between 1993 and 1999, whereas in Western Europe it remained relatively constant (Figure 1). In central accession countries it steadily decreased. Southern European countries (western and accession) account for 74 % of the total irrigated area in Europe. In countries such as Turkey, it is expected to further increase in the near future following new irrigation developments. Changes in the economic structure and land ownership, and the consequent collapse of large-scale irrigation/ drainage systems and agricultural production have been the main drivers for the changes in irrigation in the past 10 years in the central accession countries.

The mean water allocation for agriculture for the irrigated area increased from around 4 700 to 5 600 m3/ha/year between 1993 and 1999 (Fihgure 1). There were, however, large differences between regions and countries. In southern countries it is three to four times higher than anywhere else and the average water applied on irrigated lands increased from 6 100 to 7 200 m3/ha/year over this period, largely due to the increase in Cyprus, Spain and Turkey. Portugal had the largest consumption on m^3 per hectare in these countries in 1999. France showed a 50 % reduction over this period even though the irrigated area increased, thus implying some increase in irrigation water efficiency and/or changes in the crops being irrigated.

In most western (central and Nordic) countries, the mean water allocation has decreased, with the exception of Denmark and the UK, where water used per irrigated area has increased steadily from 1993 to 1999. The average water consumption in central accession countries decreased steadily from 1 250 in 1993 to 500 m3/ha/year in 1999. This is because, even though large areas may be equipped for irrigation, they are not necessarily irrigated, because, the major part of the existing irrigation systems is in a bad state, or even abandoned (EEA, 2003). In those countries socio-economic and legal aspects of this economic transition are linked to this critical situation, creating a significant potential of unexploited agricultural production capacity. Opening up of this capacity will reduce, or prevent the requirement of food imports, create the potential for export of agricultural products. It will also significantly contribute to rural development. If developed on a sustainable basis, irrigation can play a significant role in such a process (ICID, 2002).

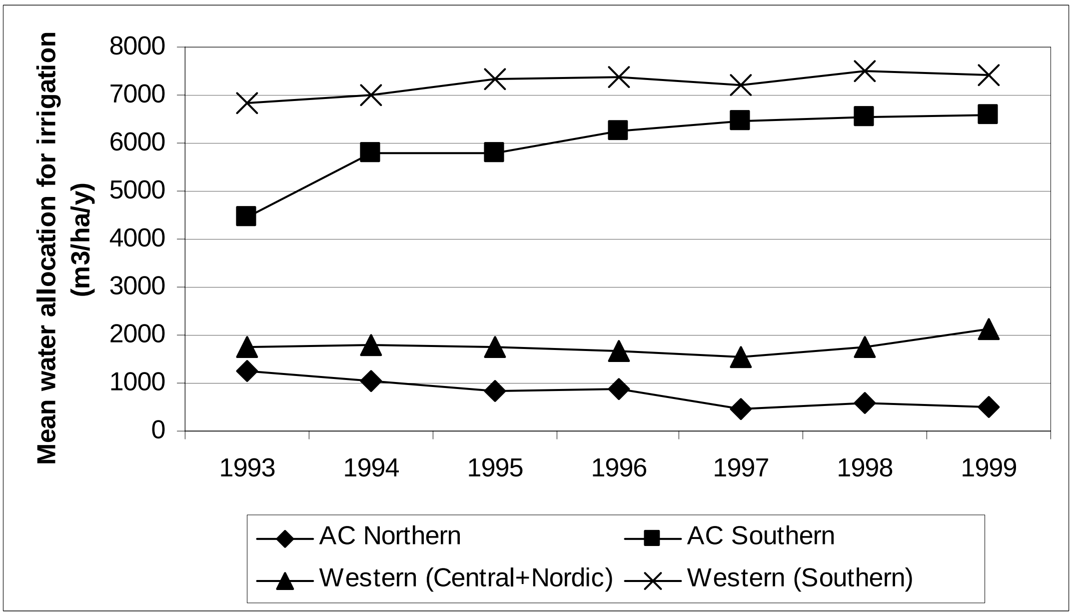

Figure 1: Water use for irrigation in EU and accession countries (EEA, 2003).
It has been assumed that the main use of water for agriculture is for irrigation.
Central accession countries: Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic, Slovenia.
Western (central and Nordic) Austria, Belgium, Denmark, Finland, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Sweden, UK.
Western Southern: France, Greece, Italy, Portugal, Spain. Southern accession: Cyprus, Malta, Turkey.

2.2 Water pollution

2.2.1 Water pollution by nitrate

Concentrations higher than 50 mg NO3/l, i.e. the drinking water directive standard (OECD, 1997), were detected frequently or very frequently in 39 groundwater bodies (14 %) in EU (EEA, 2003). According to the latest European Commission report (EC, 2002), 20 % of EU stations had concentrations in excess of the maximum allowable concentration and 40 % were in excess of the guide value in the drinking water directive (25 mg NO3/l)[1] in 1996–98 (figure 2). Countries showing an overall increase in nitrate concentrations in groundwater are France and Sweden.

This situation is more accentuated in rural zone where water quality is not necessarily reported or well monitored since they often only serve small populations. For example, in Belgium 29 % of 5 000 wells examined had nitrate concentrations in excess of 50 mg/l nitrate. In France, Germany and Spain, over 3 % of drinking water samples exceeded nitrate standards. The significance of these excedances has, however, not been quantified, as there is no complementary information on the duration and level of this depacement, and on the number of people exposed. Shallow private wells fed by percolation from

[1] The EC Nitrates directive (1991) set a maximum admissible concentration (MAC) of 50mg of nitrate per mitre of water and a recommended limit of 25 mg/l.

intensively farmed agricultural land are particularly vulnerable to nitrate pollution. The vulnerability of private supplies is illustrated by the situation in Lithuania in the mid-1990s where less than 1.5 % of samples taken from public water supplies exceeded the nitrate standard, whereas nearly 50 % of samples from private supplies exceeded the standard. In other accession countries, the shallow wells in central and southern Poland and Hungary are known to be contaminated, and in Bulgaria it is estimated that, in the early 1990s, up to 80 % of the population was exposed to nitrate concentrations greater than 50 mg/l (OECD, 1995).

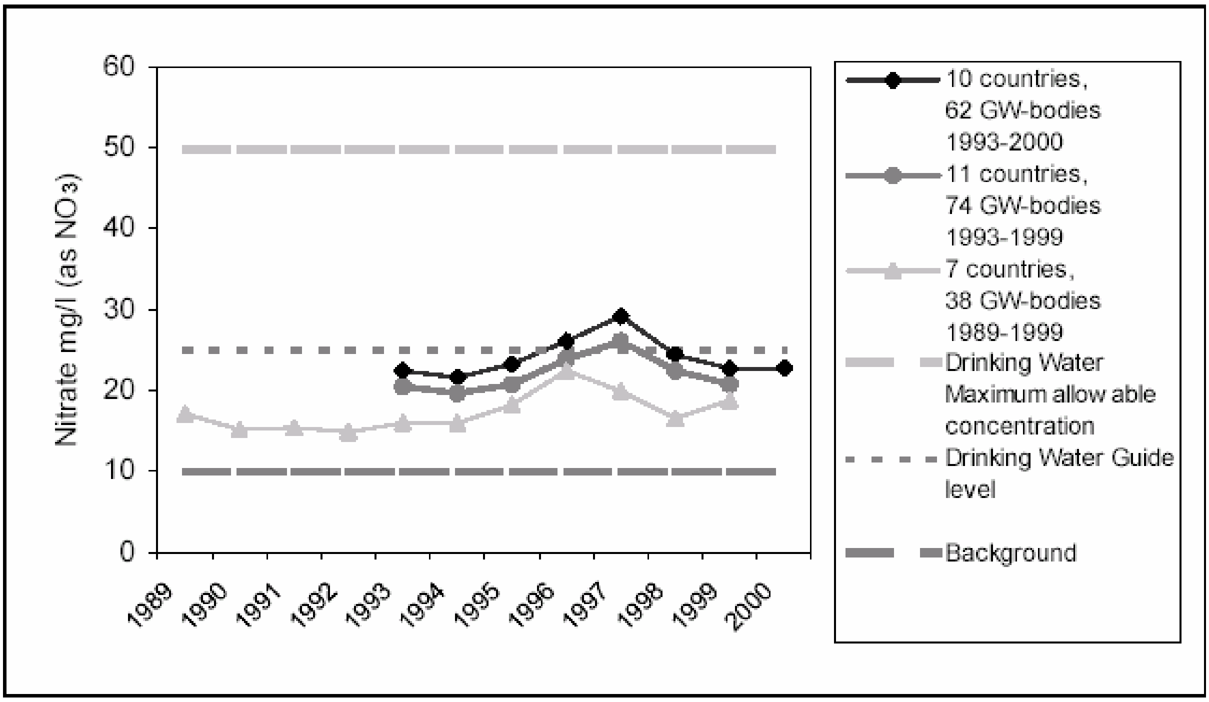

Figure 2: Nitrate concentration in drinking waters in EU and accession countries.
The figure shows three time series containing different numbers of groundwater bodies, depending on the countries. Values are compared with the drinking water directive's maximum allowable concentration, guide level, and the typical background concentration **(EEA, 2003).**
1993–99 time series: Austria, Belgium, Bulgaria, Denmark, Estonia, Hungary, Latvia, Lithuania, Netherlands, Slovak Republic, Slovenia, Spain. 1993–2000 time series: Austria, Belgium, Bulgaria, Denmark, Estonia, Latvia, Lithuania, Netherlands, Slovak Republic, Slovenia.
1989–99 time series: Bulgaria, Denmark, Estonia, Hungary, Lithuania, Netherlands, Slovak Republic.

2.2.2 Water pollution by pesticide

Pesticide pollution of drinking water has been identified as a problem in Belgium, Denmark, France, Germany, the Netherlands and the UK (Eureau, 2001) where it is estimated that between 5 and 10 % of resources are regularly contaminated with pesticides in excess of 0.1 µg/l. For example, in Germany in 1995, 10 % groundwater monitoring stations exceeded 0.1 µg/l particularly for atrazine, despite its ban in 1991. Similarly accession countries have recently seen a slight rise in the use of pesticides, but levels are still much lower than before the pre-economic transition (Figure 3). For example, in the

Czech Republic, 4 302 t of pesticide active ingredients were used in 2000, compared to 8 920 t of active ingredient in 1990 (EEA, 2003).

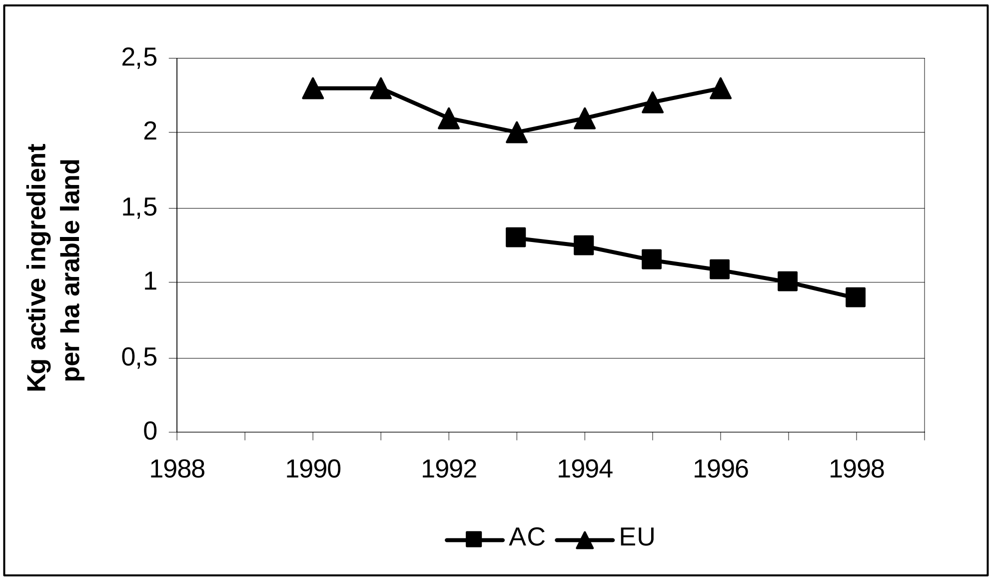

Figure 3: Evolution of pesticides use in EU and accession (AC) countries between 1990 and 1998. Data are pesticides sales in the country. For many countries actual pesticide consumption correlates closely with fluctuations in crop production. In agriculture, different types of pesticides are used for different crops. For example, greater volumes of fungicides tend to be applied for viticulture and greater volumes of herbicides for cereal crops **(EEA, 2003).**
EU countries: Austria, Denmark, Finland, Germany, Netherlands, Portugal, Spain, Sweden, United Kingdom.
Accession countries: Czech Republic, Estonia, Latvia, Poland, Romania, Slovenia, Slovak Republic.

2.3 Biodiversity

2.3.1 EU current situation

Biodiversity is the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (Convention on Biological Diversity, 1992). Biodiversity in its widest sense encompasses all aquatic species and habitats as well as the species and habitats of cultivated and managed fields, forests, parks and gardens and all the less intensively used and cultivated (semi-natural) and natural areas (Eldredge, 1998). The approach to biodiversity is complex: it relates not only to numbers of species and habitats, but also to variability, continuity, processes and patterns (Williams et al, 1996). Maintaining thriving natural systems is essential not only for economic or ethical reasons, but also for ecological, social, recreational, educational and aesthetic reasons (Miller, 2005). Recognition of this is the background for the growing awareness and development towards sustainable use and management of natural resources in most countries and sectors. But the rate and scale at which the environment is being altered have accelerated in recent decades to levels which, in many areas, may be close to the thresholds for securing a sustainable biological future despite the many counter measures (Redford et al, 1999; Ammann, 2005). Loss of biodiversity, considered at three scales: genes, species/populations, habitats/ecosystems, has been recognised as an issue of urgent concern both in the EU Fifth Environmental Action Programme and through the adoption of the Convention of Biological Diversity by most governments in the world. This problem ranks alongside global impacts such as climate change, ozone depletion and desertification (EEA, 1999a).

Biodiversity (species, habitats, gene pools…) is mostly affected not only by one single pressure, but by a combination of pressures derived from: agriculture, forestry, fisheries, as well as from urbanisation, industry, transport, tourism and recreation, energy use, chemicals and minerals. The biodiversity loss due to agriculture activity is likely to increase, while other environmental problems such as air and water pollution are likely to remain more stable or decrease slightly (table 1) (EEA, 1999a).

Table 1. Importance and trends of environmental issues by continent or large region (EEA, 1999a). Importance: *** Critically important; ** important; * lower priority; 0 negligible. Regional **Environmental trends:** ↑ increasing; → remaining relatively stable; ↓ decreasing; - Not applicable.

Environment problem	Africa	Asia-Pacific	Europe and former USSR	Latin America and Caribbean	North America	West Asia	Polar region
Land degradation	***↑	***↑	**→	***↑	**↓	***↑	*→
Forest: loss	***↑	***↑	**→	***↑	*→	*↑	0 -
Biodiversity: loss	**↑	***↑	***↑	**↑	**→	**↑	**→
Fresh water: access, pollution	***↑	***↑	***→	**→	***→	***↑	*→

2.3.1.1 Species in Europe

Some native species in Europe are spreading or their populations are increasing, due to protection laws, restoration programmes (Moller, 1995) and reintroductions: these include most raptors, geese, butterflies locally, and in certain areas large carnivores (wolf, bear). Some species benefit from new environmental conditions (newly created habitats as in urban areas, more availability of food), and some even have dramatic increases in their populations, such as in the case of several opportunistic or generalist species. However, many more native species are declining (Tucker and Heath, 1994; Sotherton, 1998; Robinson and Sutherland, 2002), although so far the rate of total species disappearance (extinction) has been low in Europe, except for endemic species. This phenomenon is partly the result of the intensification of agricultural production (Ortowski, 2005) due to the changes in farming methods, simplification of landscape structure, massive use of pesticides and crop specialization (Gillings and Fuller, 1998; Brickle et al., 2000; Robinson and Sutherland, 2002).

Species under pressure include (Halahan, 2000):

- 64 endemic plants of Europe (including the Macaronesian islands) have become extinct in nature (8 in the 1980s and 9 in the 1990s), among which only 27 have been saved in cultivated form (conservation ex-situ) (Halahan, 2000);
- More than one in every five bird species on Earth is now considered to be in trouble and 179 are now categorized as Critically Endangered (OCA, 2005);
- 45% of European butterflies are threatened, with vulnerable or endangered populations (Van Swaay *et al.,* 1997);
- of the 3 200 species of land and freshwater molluscs present in Europe, 145 species are considered as threatened at global level (Bouchet *et al.*, 1999);
- of the 1687 species and subspecies of Bryophytes occurring in Europe, at least 24% are threatened (European Committee for the Conservation of Bryophytes, 1995).

2.3.1.2 Habitats in Europe

In large areas of Europe, semi-natural and natural habitats are heavily affected by intensification or abandonment of agriculture, pollution, drainage and introduction of species. Field abandonment can have both positive and negative impact on biodiversity and meanly on bird fauna (EEA, 1999a). In the farming regions of northern Italy the set-aside practice was proved to exert negative influence both on abundance as well as on species composition (Farina, 1997). On the other hand, in central Spain, a series of rare and endangered species were found on the fallow land area (Suarez- Seoane et al., 2002). Also in Western Europe much higher densities of many species were recorded on set-aside fields compared to those where normal agricultural activities continued (Berg and Part, 1994; Henderson et al., 2000; Firbank et al., 2003).

In Poland, at the outset of the 1990's a political and economic transformation began, accompanied by the restructuring of agriculture. One of the side effects of these changes has been a steady increase of the uncultivated land area. In this country, results of recent studies showed an increase of abundance of some bird species on set-aside or abandoned fields (Ortowski, 2005).

Distribution per country and per biogeographic zones of species and habitats listed under the Birds and Habitats Directives region is shown in figure 4b. The full Mediterranean area – covering European, Asiatic and African coasts – is one of the most important centres of species richness in the world. More than 25 000 species, i.e. more than 10% of the world's flowering plants (phanerogams), occur in an area amounting to only 1.5 % of the earth's surface. About half of the species are endemic to the Mediterranean area. Around 200 phanerogams are in danger of extinction in the northern Mediterranean, and around 350 in the sourthern part. Animal diversity shows similar trends, though the species are less well known. The Mediterranean area is also one of the world's eight most important centres of origin for today's cultivated plants. The main pressures come mainly from agriculture, such as severe overgrazing and intensification of cultivated area and from fast growing urbanisation and tourism (EEA, 1999a).

In terms of number of habitats and species, three EU countries have a special responsibility (figure 4a): France and Spain, for four biogeographic regions, and Italy. Portugal shares with Spain an important responsibility for endemic species. The other biogeographic regions in the EU have other characteristic features of responsibility such as large areas for migrating and breeding birds, importance of forest or wetland habitats (EEA, 1999a).

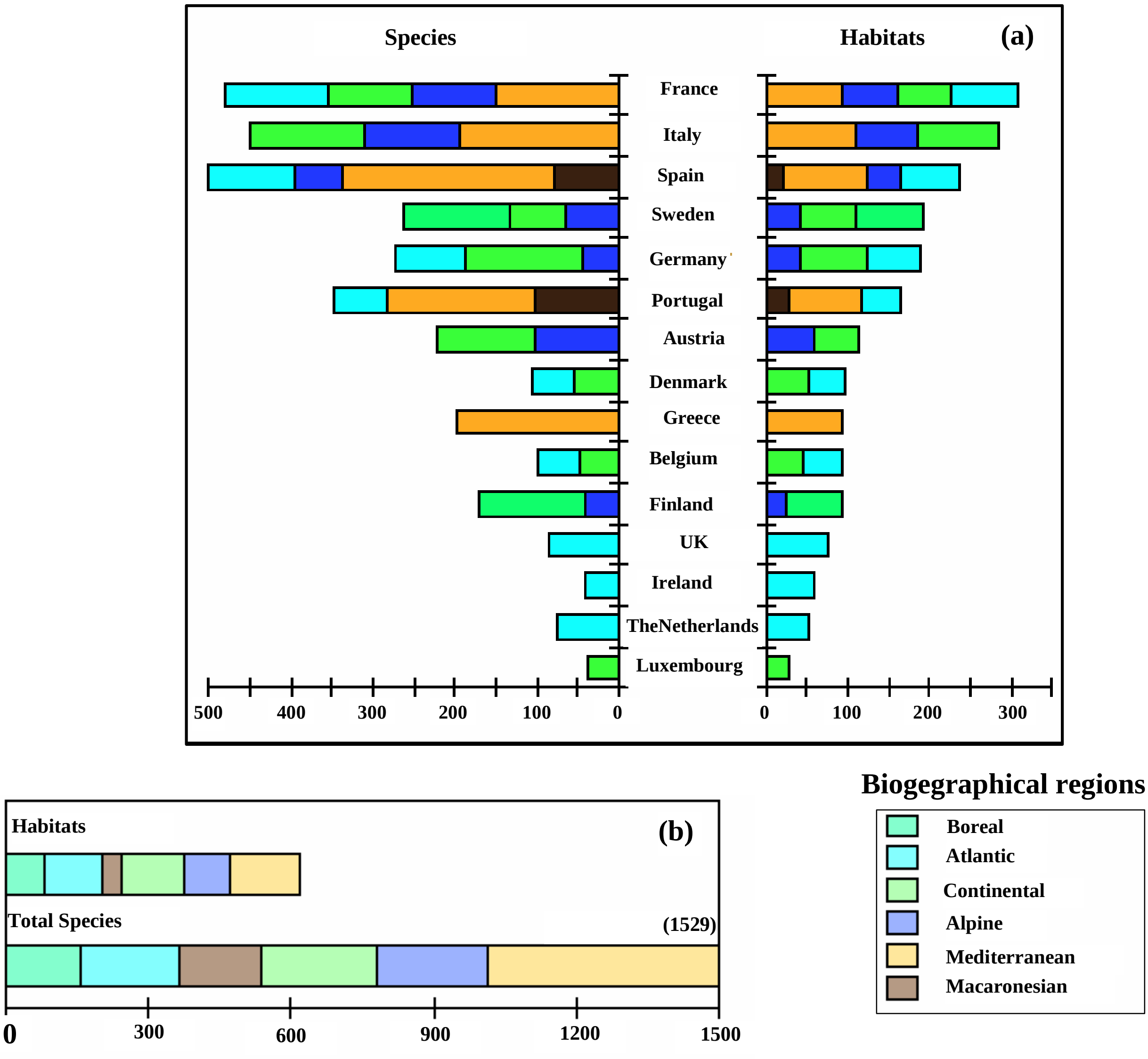

Figure 4. (a) Distribution per country and per biogeographic region of species and habitats listed under the Birds and Habitats Directives; (b) their distribution by biogeographic region (EEA, 1999a).

2.3.2 The grassland habitats of Europe

Beyond the supply of food for herbivores, grasslands provide many services for the ecosystems and society. Their role in maintaining water provision and quality, air quality (carbon sequestration) and preserving pollinating and symbiotic organisms and other processes which assure the resilience and the stability of ecosystems are now well determined. They also have an important function in the maintenance of landscape amenity and cultural heritage. Lastly, they participate to the conservation of biodiversity of animals and plants needed to nutrient, water and energy flows and the function of ecosystems (Kempt 2005, Hector 2005, Eder 2005, Gibon, 2005).

These services are resumed by the EEA (1999) in his definition of functional qualities grasslands: i) high biological diversity of species; ii) presence of traditional, even historic (grazing) agricultural landscapes; and iii) high aesthetic/recreational value.

2.3.2.1 The importance of grassland in Europe

Livestock's grassland is one of the major land uses in Used Agricultural Area (UAA) in Europe. Many countries have more than half of their UAA covered by meadows and more than 90 % of these are permanent grassland (Table 2). Permanent grassland, *i.e.* land used continuously for 5 years or more for livestock grazing, represented 35 % of the UAA, i.e. 15 % of the EU's territory. There are some 67.7 million hectares of permanent pasture, over 30 per cent of which occur in just France, Spain and the former Yugoslavia (EC, 1999, EEA, 1999b).

Very little accurate information is available on the current distribution of temporary grassland at European level. However, the database of Eurostat and the results of PASK study (see http://agrifish.jrc.it/marsstat/Pasture_monitoring/PASK) provide global information on the distribution of the major types of grasslands in UAA- (table 2).

Table 2. The part of grassland in utilized agricultural area in Europe in 2004 (EUROSTAT website database).

	Perennial green fodder*(a)	***Temporary grasses and grazings ** (b)***	***Permanent grassland**(c)***	***Total of grassland(a+b +c)***
UK(2000)	8%	8%	62%	78%
Estonia (2002)	38%	30%	10%	78%
Sweden	29%	29%	17%	75%
Luxembourg	11%	11%	51%	73%
Ireland			72%	72%
Slovenia	6%	5%	58%	69%
Austria (2003)	4%	2%	57%	63%
Netherlands	12%	12%	40%	63%
Latvia	18%	5%	38%	61%
France	10%	9%	34%	53%
Finland	26%	25%	1%	52%
Tcheq Rep. (2002)	7%	22%	23%	52%
Lituania	9%	4%	37%	50%
Belgium	6%	6%	38%	49%
Romania (2003)	5%		33%	39%
Portugal		1%	37%	38%
Italy (2003)	8%		29%	37%
Bulgaria (2003)	2%	0%	34%	35%
Slovaquia	6%	1%	27%	34%
Germany	3%	1%	29%	33%
Spain	2%	1%	29%	32%
Poland	3%	2%	21%	25%
Hungary	3%	0%	18%	22%
Denmark	8%	8%	7%	22%
Greece				
Average	**10%**	**9%**	**33%**	**50%**

** They occupy the soil in a temporary way (more than one year) and are defined especially by the predominance of the legumes at the level of 80%.*

*** They occupy the soil from one to five years and are made up of graminaceous plants or of grasses mixed with legumes and other species but graminaceous are the majority.*
**** Areas always covered by grass, sown or natural, in place for at least 5 years.*

In spite of their importance, the overall extent of permanent grasslands in Europe has been falling gradually for several decades due to many factors: afforestation, increased mechanisation, the ploughing up, agricultural intensification, urbanization, etc (EEA, 1999b and 2003). There was a 12% decrease in permanent grassland in the first nine member countrys of EU between 1975 and 1995. . Four million hectares of permanent grassland were lost in Europe of which 2.4 million hectares in France. The greatest impact was on land used for rearing herbivores (cattle and sheep) in the plains. In mountainous regions, or regions where stock-rearing was the only way of utilising land, changes in permanent grassland over the same period were minimal (Poiret, 1999a).

Pressures on grassland habitats were steadily increasing in the last decades: 60% of the newly-afforested areas in the EU were previously permanent grassland (Caradec *et al.*1999; Poiret, 1999b). Between 1975 and 1995, arable land has taken over from permanent grassland. This growth is particularly noticeable in farm type "field crops" and in farm type "grazing livestock", where feeding from arable land has risen from 15 to 20 %, replacing permanent grassland (Poiret, 1999b).

2.3.2.2 Grassland and biodiversity

Out of a total of 576 European butterfly species 71 are threatened. Of these around 50% occur in grasslands (EEA, 2001). More generally, the open ground habitats are further underlined relying their high number of vagetal, animals and insects species (Bignal, 2000).

Within the meadows, the permanent grasslands are the most important for the conservation of biodiversity and to provide ecosystem services (Nösberger 2002, Gibon, 2005, EEA, 1999b). They are key habitats for many species of herbs, animals, butterflies, reptiles and many birds and they play also a major, environmental, agricultural, tourist and social role (EEA, 2001 and 2003).
“High nature value farmland” (HNVF) which are “hot spots of biodiversity in rural areas usually characterised by extensive farming practices” are in majority habitats such as semi-natural grassland in plains or in mountainous regions (EEA, 2003 and 2004).

As presented by Clergue (2005) the concept of biodiversity in agricultural areas can be defined as the some of three functions which can be applied directly to permanent grassland. The patrimonial function is defined as biological and cultural patrimony. The ecological function traduce that biodiversity generate typical habitats with particular species and is related to ecosystem functioning. The agronomical function allows to pest and disease control and to have benefits for soil properties, microclimate, pollinisation and crop and animal production.

Many experiential manipulation of diversity in grasslands have showed that biodiversity is often positively related to primary production and could be related to stability and resilience of ecosystems (Isselstein, 2005; Hector, 2005).
Furthermore, the biological biodiversity could improve the quality of animals’ products and can be attached to a “terroir” in Protected Designation of Origin approach (Clergue et al., 2005; Coulon et al., 2002).

Two major changes in agriculture have upset the equilibrium between agriculture and biodiversity: the intensification of production and the under-utilisation of land (EEA, 1999b; EEA 2003; EEA 2004, Clergue et al. 2005). Loss of semi-natural grassland is a consequence of these two agricultural trends. The best data available to traduce this are for birds (no European’s data are really available for plants communities and habitats). As birds depend of plants and animals for eating, feeding, nesting and shelter they are good indicators of farmland biodiversity (EEA 2003 and 2004; Clergue et al. 2005;

Parris, 2002). For example, loss of extensive grassland habitat is reflected by the decline of 50% of the corncrake (*Crex crex*) in 10 countries.

Actually, the links between intensification of grasslands and loss of biodiversity is clearly established (Bignal, 2000; Gibon, 2005; Poiret, 1999a). But, in some EU Member States, land abandonment and the withdrawal of traditional management may also become a threat to biodiversity on farmland. Indeed, the big majority of the permanent grassland is maintained through grazing and cutting and the herbivores are a natural component of these ecosystems. The conservation of the intensity of these practices is crucial for the protection of these grasslands and their species. Traditional farming, extensive methods of production and sound agricultural practices taking biodiversity into account contributes to safeguarding existing natural or semi-natural grassland (Bignal, 2000; EEA, 2001). Therefore, preventing these processes is a key action for reaching the 2010 target of European Union of halting the loss of biodiversity (EC, 2004; Mariott, 2004).

The Pan-European Biological and landscape Diversity strategy (PEBLDS) recognises the importance of specific actions of grassland for the conservation of the biodiversity. At the European level, the Bern convention stress the importance of extensive farming systems and semi-natural grasslands which are respectively taken into account by EU in habitats directive and in the agri-environmental measures implemented in Europe.

2.4 Situation in each agricultural region selected for Test case 2

2.4.1 In the NESTE Region (France)

The so-called Neste system covers 4/5 of the French Department of Gers (South-West of France) and supplies 70 % of the drinking water of this department. It extends over the hillsides of Gascony, an agricultural zone of plains and dry hillsides, divided by “the Gascony rivers" (for more details see Perez et al, 2005 for region description and Belhouchette et al, 2005 for farming systems typology)”.

These rivers, marked by severe water shortage, have been artificially recharged since the XIXth century by the canal of Neste. The Compagnie d’Aménagement des Coteaux de Gascogne (CACG), a water management organisation created in 1960, is the main administrator of this recharged rivers network called the “Neste system”. However, in this report we will designate under the term of “Neste system” not only this network, but also the whole area of the watershed of the Gascony Rivers. In this area, recharged rivers as well as small private hill reservoirs are used to irrigate crops (Leenhardt, 2004a).

2.4.1.1 Water use

“Water resources of the Gers Department and the Neste zone are weak and insufficient” and subterranean waters offer few possibilities of withdrawals (Comité de Bassin Adour-Garonne, 2004b). To recharge the Gascony rivers, between 1960-61 and 2003-04 the annual transferred average volume by the Neste canal was 217 millions of m^3 (Mm^3) from which 36 Mm^3 came from high-mountain stored reserves. Nevertheless, during each summer of this 37 years period, the Gers river has reached a water flow lower than the limit[2] fixed within the framework of the Management Plan of Low-waters[3] of the Neste system (Conseil Régional Midi-Pyrénées, 2004).

[2] This limit is called Objective Flow (“Débit Objectif d’Etiage”, DOE, in French).
[3] « Plan de Gestion des Etiages », PGE, in French.

The part of the water taken annually for irrigation represented in 2001 more than 88 % of total withdrawal while, for the whole Midi-Pyrénées Region, this level of 88% was reached only for the summer period and its annual average being only 35 % (Conseil Régional Midi-Pyrénées, 2004).

From1988 to 2000, irrigated surfaces increased by 31 % in the zone. But during this period, because water reserves increased more than irrigated areas (56% versus 31%), available water per hectare increased (Conseil Régional Midi-Pyrénées, 2004). To reduce water deficit in periods of low-water, numerous compensating reservoirs, individual or collective, dedicated to irrigation were created (they represented 46 % of the water resources in 2000). As a result, the Gers Department is far away the most equipped Department of Midi-Pyrenees, in term of storage capacity by hill reservoirs with 63,9 Mm^3 on a regional total of 143.8 Mm3 *i.e.* 44% of this supply (Conseil Régional Midi-Pyrénées, 2004).

Despite the artificial recharge of rivers and the creation of numerous hill reservoirs, the Management Plan of Low-water (PGE) of the Neste system, approved in 2002, identifies a quinquennial global deficit of 7 Mm^3 for this zone.

This PGE proposes a strategy in two phases: (1) the realization of dams in the Departments of Gers and Hautes-Pyrenees up to 10 Mm^3, which should lead to an increase of the Objective Flow limit (DOE) and (2) the satisfaction of the remaining demands for agricultural use by the mobilization of additional 37 Mm^3 which would require the construction of a new dam (CACG, 2000).

It is thus in this context of strong water deficit that the CACG manages the resource using: i) management strategies based on experience and observations of the past years ii) contractual relations with users fixing the subscription characteristics (water volume and maximum flow) and iii) a priority given to environment and domestic uses to the detriment of irrigation use (Leenhardt et al., 2004b).

In the Neste system, data from the General Agriculture Survey (2000) indicate that maize covers 2/3 of the agricultural irrigated areas. Due to the large water requirements of this crop and to the limited water resource in the Neste basin, corn growers are often criticised by environmentalists and other members of the society.

At the farm level, the risk of water shortage and pressures from the society could lead farmers to have a more in-depth water management. For that, they should build their irrigation strategies in order to both reduce the amount of water used and keep or improve the profitability of irrigated crops. Two major ways can be used to achieve this purpose: i) optimizing the irrigation of the different crops; ii) modify the cropping system in order to increase the areas with winter crops or drought-tolerant crops.
Regarding the first point, Bergez et al. (2002 and 2004) showed that models can be used to increase water efficiency of irrigated corn crop in this region. A "base" strategy was tested first and compared with an optimized strategy based on starting, returning and ending rules for irrigation. This improved strategy lead to a lower yield but significant water conservation and an increase in gross margin of the crop. This strategy could allow to finish earlier irrigation cycle and so to reduce some withdrawals during the low-flows period. Of course, these irrigation rules modifications are not the only way to reduce the water requirements of the farm's crops. Strategies based on decreasing crop inputs (nitrogen, plant density) and modifying sowing date in order to avoid water stress period could also be a good strategy to reduce water requirements of irrigated cropping systems (Nolot, 2003).

Regarding the second point, an adaptation of the cropping systems by a modification of irrigated/non irrigated crop proportion is a way to both reduce water used and to be able to face the multi-goal crop production -profitability, quality, environment and society' expectations- (Nolot, 2003). Limiting the UAA of irrigated crops (mainly corn) in favour of drought-tolerant or winter crops is a solution often proposed by environmentalists and some agricultural experts of the Gers. Such modification of the farms' crops allows farmers to reduce the peak of water withdrawals and to have less production damage in case of a legal or contractual reducing of available irrigation water.

2.4.1.2 Water quality

Because of the limited number of industries and inhabitants of the sector covered by the Neste system, agriculture is the main source of pollution of the Gascon rivers (Comité de bassin Adour Garonne, 2004b). Furthermore, "Gers presents the poorest water quality standard of Midi-Pyrenees towards pesticides" (website MISE).

The watershed of the Garonne comprises three hydrographic units, over ten, that presents an average or bad ecological quality (based on biological and physico-chemical criteria, Table 3). The "Gascon rivers" with more than 90 % of its streams contaminated is one of them. Beyond the problems of hydromorphology, the unit of the Gascon rivers is the only one where degradation of the ecological quality of waters is essentially bounded to the agricultural activity (Comité de Bassin Adour Garonne, 2004b).

Chemical quality (contents in nitrate, pesticides and metals) of these rivers on their half downstream is also bad (Comité de bassin Adour Garonne, 2004b; Agence de l'eau Adour-Garonne, 2004). In term of nitrogen and pesticides of agricultural origin, they present an average pressure on their upstream and a strong one on their downstream (Comité de bassin Adour Garonne, 2004b) (table 3) and (figure 5).

Table 3. The water quality status of Gascony rivers'groundwaters (Comité de bassin Adour Garonne, 2004b)

.	% of groundwater		
	Good status	**Average status**	**Bad status**
Chemical quality	9	39	52
Biological quality	6	73	21
Ecological quality	3	52	45

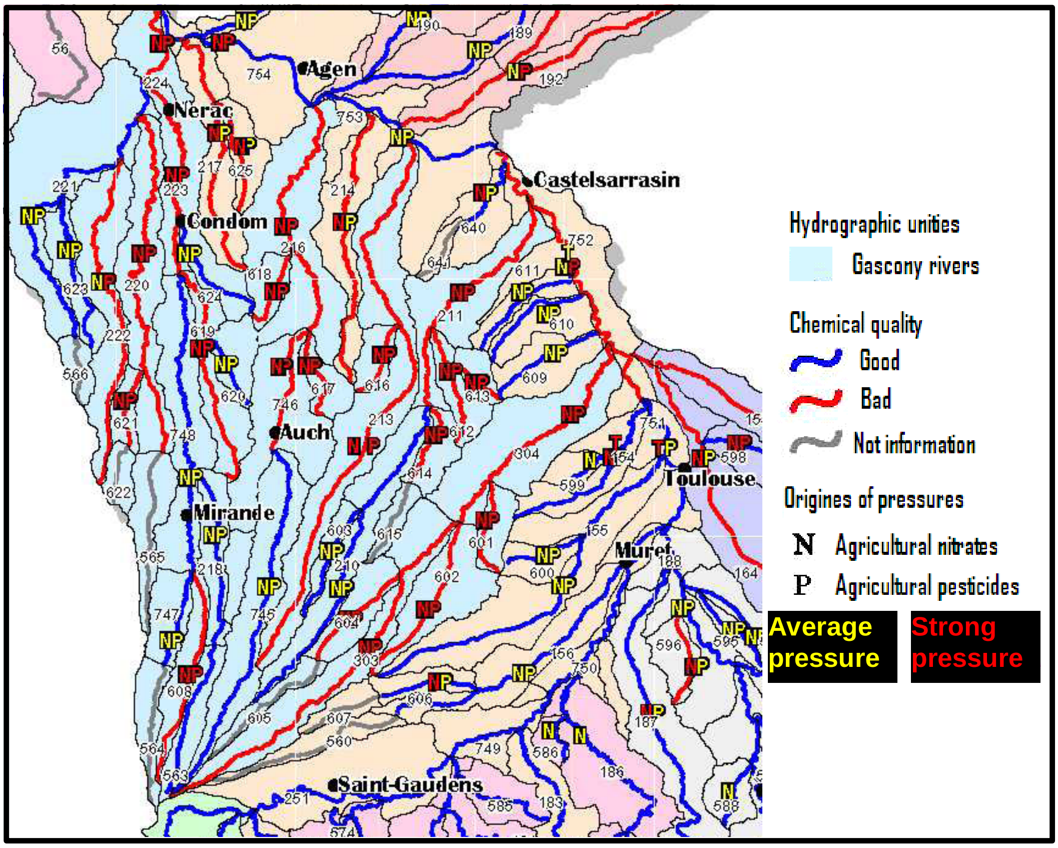

Figure 5. Chemical quality of the water in the Gascony rivers (Comité de bassin Adour Garonne, 2004b).

The environmental impact assessment realized within the framework as application of the Water Framework Directive allowed to establish the state of water resources.On the basis of this assessment and of a scenario of evolution, this study estimated the conditions to achieve the environmental objectives of the DCE. For the farming sector, this scenario corresponds to a “no increase” of the agricultural pressures (nitrate and pesticides) connected essentially to the influence of the CAP and to the stabilization of the impact of the irrigation on low-water by an in-depth management of the resource. The results of this simulation determined an ecological and chemical “Risk of Not Achievement of the Good Status” (RNAGS), in 2015, for fourteen groundwaters of the Gascon rivers over a total of sixteen. The hydrographic unit of the “Gascon rivers” is one of the unit of the watershed of the Garonne presenting the highest rate of RNAGS in 2015 of its groundwater (table 4).

Table 4. The RNAGS ("Risk of Not Achievement of the Good Status") **of Gascony rivers (Comité de bassin Adour Garonne, 2004b)**

	% of groundwater		
	No	**Uncertain**	**Yes**
Ecological RNAGS	6	18	42
Chemical RNAGS	30	9	61
RNAGS 2015	6	18	42

Within the framework of the DCE, management of the pressure in nitrogen and pesticides was identified as a major concern in the watershed of the Garonne and in the unit of the Gascon rivers. Although measures to be implemented to reduce the diffuse pollutions by nitrate and pesticides are now known (reasoned agriculture, organic agriculture, agri-environmental measures, reconstruction of ripisylves,…) their implementation on the whole zone, which is required to have a real efficiency, is not yet achieved (Comité de Bassin Adour Garonne, 2004b; Comité de Bassin Adour Garonne, 2005).

At the farm level, the cropping system is the meaningful level to assess the impacts of fertilization and pesticide application on water quality (Verdier *et al*, 2001). Farming systems in the Gers can be characterised by two major cropping systems which are soil dependent: (i) winter cereals systems (mainly wheat associated with sunflower and sometimes soybean, sorghum, maize) associated to calcareous-clay soil of the Gascony hillsides, and (ii) irrigated systems based on maize monoculture or in rotation with soybeans essentially localised on loamy "boulbène" or alluvium soil (Verdier *et al*, 2001). To obtain an impact assessment on the water quality of these cropping systems, a network of measurement points of water pollution by pesticides and a program of improvement of weed control techniques has been implemented in two catchments basins "Auradé" and "Sousson" in the Neste system. The first basin is essentially covered by rain fed farming systems while irrigated systems are present in the second.

The first results in the "Auradé" catchment basin indicate that reasoning pesticides applications by choosing pest resistant variety and an in-depth observation of the crops (therefore better identification of timing, dose and product of the application depending on pest pressure) could allow to reduce water pollution by pesticides. Similarly, implementing grass strips along rivers allowd to reduce strongly pesticides quantity in the stream (Gille, 2001).

Because maize herbicides are the major pesticides detected in water in Midi-Pyrenees, the action program in the Sousson basin is oriented on the improvement of weeding techniques of this crop and /or plots layouts (e.g. with or whitout grass strips). Regarding cultural practices, no-tillage and mixed weeding techniques (chemical and mechanical) give also good results in the reduction of pesticides use. At environmental level, as in the Auradé basin, grass strips play a purifying role leading to an important reduction of residues transferred to water (Comité Technique Sousson, 2003) (figure 6). At catchement basin scale, another proposition to reduce herbicides transfer in the stream is to spread their application over a large period which using pre- and post emerging stages of corn cropweeding technics. This may reduce the peak of pesticide in the rivers. However, it is more difficult to implement this action because it requires a collective agreement between most, if not all, farmers in the catchment basin.

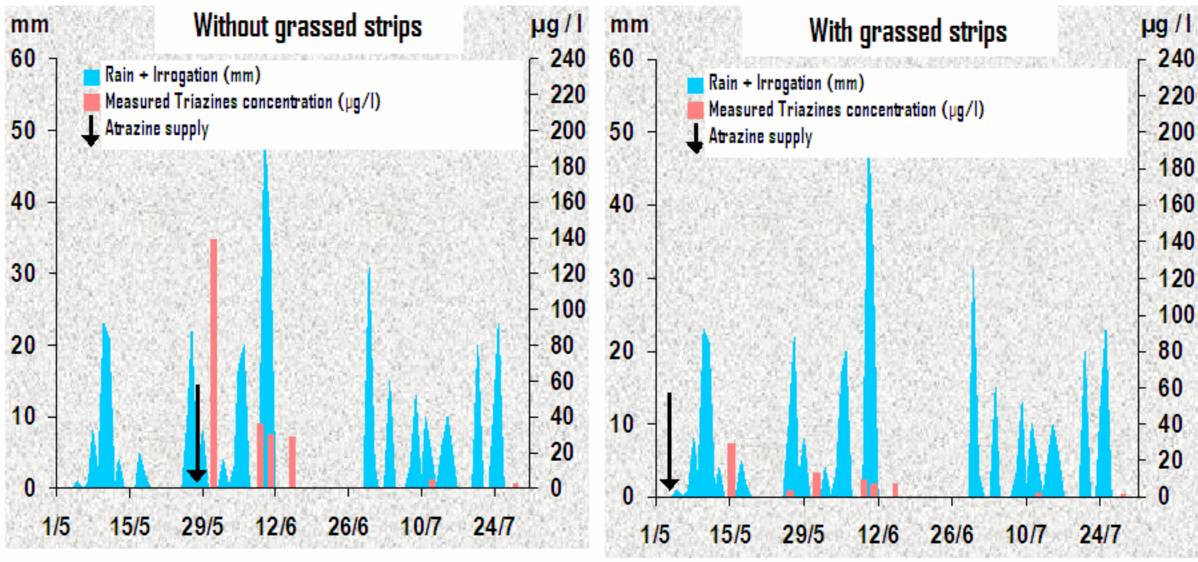

Figure 6. Effect of the grassed strips on water Triazines concentration (Comité Technique Sousson, 2003).

Of course water pesticides pollution is not the only problem of water quality due to agricultural pressures. Of course, nitrate pollution is also a key problem. But, as this pollution is better known than pesticides and have been more studied in the past years, it was not assessed in these two basins. Optimisation of irrigation to reduce drainage of water (Bergez *et al*., 2002), grassed strips (Gilles, 2001 and Comité Technique Sousson, 2003), implantation of nitrate catch crops are the best solutions to cut loss of nitrates in the Neste system. They have been included in the framework of "Contrat d'Agriculture Durable" and the implementation of Nitrates Directives (see chapter 3.5.1).

2.4.1.3 Water stakes

In the system Neste, one of the main issues on both water resource and quality is the management of the withdrawals during the period of low-water (Conseil Régional Midi-Pyrénées, 2004). Today, conflicts about potential interests regarding water uses are essentially managed by the Management Plan of Low-waters and the Organization and Management Plan of Waters[4]. However, the DIREN Midi-Pyrénées (2003) notes that the financial organisation of the water distribution is still not well established: "the distribution of the costs of artificial recharges and the payment of the water on a real consumption by farmers are still to be defined".

Due to the obligation of a target flow in the Gascony rivers for the drinking water and the environment, the agricultural consumption of water must be adapted to the constraints of the Neste System shortage resource. In this framework, beyond building new dams, the development of cropping systems more efficient and with lower water requirements is essential for the sustainability of agriculture in this zone. To reach this objective, the implementation of the Nitrate and Water Framework Directives in the Gers would provide a good way to define priority actions to improve the agricultural water use.

[4] « Schéma d'Aménagement et de Gestion des Eaux » (SAGE), in French.

2.4.2 In the PYRZYCE Region (Poland)

2.4.2.1 Water use

Irrigation in Poland is less common than management of water flows in agricultural lands (drainage, removing excess of water). In the past the concern was mainly to remove excess of water due to relatively high precipitation in some seasons of the year. Although drainage system was one-way oriented on removing surplus of water from agricultural land, negative consequences for agricultural sector in the past decades were not visible, when extensive farming systems dominated in Polish agriculture. Intensification of agricultural production and typical for Polish climate lower precipitation in spring months, critical for growth of crops, recently led to shortages of water, especially in regions with light soils.

The irrigated area and use of water for irrigation of agricultural land and forests in Poland is presented the table 5.

Table 5. Irrigation of agricultural land and forests in Poland in the years 1980 -2003. (Own calculation based on **Environment Protection 2004 and Statistical Yearbook of Agriculture 2001– Statistical Publication House)**

POLAND	1980	1985	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003
Irrigated area in 1000 ha	339,5	343,3	301,5	201,1	144,9	134,1	121	89,4	99,1	89,3	90,6	83,3
Water usage in hm^{3*}	327	588,7	518,8	208,9	137,9	114	116,8	94,1	112,6	86,2	91	89,4
Water usage in m^3/ha of irrigated area	963	1715	1721	1039	952	850	965	1053	1136	965	1004	1073
Water usage in m^3/ha of agricultural area	17,1	31,1	27,6	11,2	7,4	6,1	6,3	5,1	6,1	4,7	5,0	4,6

* hm^3 – cubic hectometer (1 milion of cubic meters [m^3])

A significant reduction of water use for irrigation is observed after the year 1990. To a large extent this is the result of transformation processes in the agricultural sector (privatization of state farms) and de-capitalization (in some cases devastation) of infrastructure used for irrigation (channels, dams, weirs).

In Zachodniopomorskie (NUTS2 in which the Pyrzyce region is included, as well as in Pyrzyce region, irrigation is still of lesser importance (table 6), because of fertile soils and higher precipitation than in some other parts of the country, with more favorite distribution of rainfalls. In addition, due to a low altitude above sea level, flat land relief and a high share of surface waters in the total area, supply of crops with water in critical periods is relatively good. Although there is no statistic available on irrigation for Pyrzyce region it can be assumed that consumption of water for irrigation per hectare is similar to that of the entire NUTS2 region. It may be expected, however, that in more intensive farming systems irrigated area may be increased in the near future, especially for potatoes, vegetables and sugar beets.

It can be concluded, that at present reduction of water use for irrigation is not the important issue for Pyrzyce test-case. Having in mind a possible growth of irrigated area in the future, an approaches to an efficient use of water for irrigation can be considered in modeling.

Table 6. Irrigation of agricultural land and forests in Zachodniopomorskie region in 2000 and 2003 (Own calculation based on **Statistical Yearbook of Agriculture 2001 and Environment Protection 2004 – Statistical Publication House).**

	Irrigated area [ha]			Share of irrigated area in agricultural land [%]	Water use for irrigation dam^3			water use in m^3/ha of irrigated land
	Total	by way of irrigation			Total	by way of irrigation		
		Subsurface irrigation	Sprinkling			Subsurface irrigation	Sprinkling	
2000								
POLAND	99089	94631	4458	0,53	112561	109967	2594	1136,0
Zachodniopomorskie	4903	4106	797	0,44	2853	2703	150	581,9
2003								
POLAND	83292	78318	4974	0,45	89394	85358	4036	1073,3
Zachodniopomorskie	2419	1657	762	0,22	1011	922	89	417,9

2.4.2.2 Water quality

- Water pollution by nitrate

On the basis of the research made by the Voivodship Inspection for Environmental Protection in Szczecin (WIOS) in the years 2001-2004 the nitrate concentration and eutrophication of rivers in Zachodniopomorskie Voivodship (NUTS 2 region) was evaluated.

Table 7 presents river cross-sections where the maximum concentration of nitrate exceeded 40 mg NO_3/L.

Table 7. River cross-sections where the maximum concentration of nitrate exceeded 40 mg NO_3/L. (WIOS, 2005)

No	Name of the river	Km	Exect point of monitoring	Nitrate mg NO3/dm3	
				maximum	average
1	Mlynski Canal	20,6	Sinica above Mielecin	47,8	9,1
2	Nieborowski Canal	16,4	on the road from Pyrzyce to Banie	47,8	12,5
3	Nieborowski Canal	7,8	Nieborowski Canal in Nieborow	45,1	10,0
4	Bielica River	5,2	bridge on the road from Bielice to Linie	50,9	18,1
5	Bielica River	2,3	below the mouth to Nieborowski Canal	42,9	11,8
6	Gowienica Miedwianska	7,3	above Debica	63,7	14,7
7	Gowienica Miedwianska	0,2	below the mouth to Miedwie Lake	56,2	11,7
8	Kunowski Ditch		below the mouth to Miedwie Lake	78,8	56,1

All the above mentioned river cross-sections are located in the basin of Płonia river, whose waters from the water-spring up to the cross-section in the 13,8rd km (in Szczecin), and Bydgoszcz Lake, Miedwie Lake, Plonno Lake, Plon Lake, Zaborsko Lake and Zelewo Lake were reported as vulnerable to nitrate pollution from agricultural sources. Arable land and farms located in the basin of Płonia river were reported as particularly vulnerable zone, from which nitrate run-off and leaching should be limited.

Waters of the lakes examined in years 2000-2004 are not excessively polluted with nitrate. No nitrate concentration in excess of 40 mg NO_3 /l was reported [unpublished WIOS data].
The eutrophication of rivers and lakes was also assessed. In the table 8, the annual average of eutrophication indicators are presented.

Table 8. The annual average of eutrophication indicators. (WIOS, 2005).

No	Indicator	Unit	Running waters (annual average)	Sea waters (internal)
1	Phosphorus	mg P/l	> 0,25	> 0,3
2	Nitrogen	mg N/l	> 5	> 7
3	Nitrate	mg NO_3/l	> 10	> 15
4	Chlorophyll „a”	µg/l	> 25	> 50/30*

** mouth section of Odra river > 50 µg/l / the rest of the rivers > 30 µg/l.*

The acceptable values of the above mentioned indicators were exceeded in 53 cross-sections within 33 rivers in the region. Water lakes in the Zavhodniopomorskie region are eutrophic or have tendency to eutrophication.

Margin values of water eutrophication indicators were exceeded in the following monitoring points located in the basin of Plonia river:

1) Plonia river beneath Plon lake;

2) Plonia river above Mlynski Canal;
3) Plonia river above Kolbacz;
4) The mouth of Młynski Canal to Plonia river;
5) The mouth of Ostrowca river to Miedwie lake;
6) The mouth of Gowienica river to Miedwie lake ;
7) The mouth of Kunowski ditch to Miedwie lake.

Margin values of water eutrophication indicators were exceeded also in a number of lakes located in the basin of Plonia river.

Animal production is a major source of pollution of waters in the region (table 9). That is why development of facilities for storage of manure is one of the most important activities in the implementation of Nitrate Directive in Pyrzyce region.

Table 9. Pollution load (Nitrogen and Phosphorus) from agricultural and non-agricultural sources in Pyrzyce Region. WIOS, 2005.

Specification	Total area [ha] based on GIS	Pollution load (households without sewage system)		**Livestock units (cattle, sheeps, pigs, poultry)**	**Pollution load (animal husbandry)**	
		N (kg/year/ha)	P (kg/year/ha)		**N (kg/year/ha)**	**P (kg/year/ha)**
Bielice*	9330	0,704	0,16	**1019**	**11,206**	**3,414**
Kozielice*	9669	0,497	0,113	**469**	**5,561**	**1,786**
Lipiany*	10661	0,492	0,112	**459**	**5,936**	**1,944**
Przelewice*	16140	0,437	0,099	**2053**	**17,314**	**5,214**
Pyrzyce*	20500	1,173	0,267	**1862**	**12,545**	**3,788**
Warnice*	8574	0,796	0,181	**940**	**11,477**	**2,872**
Powiat Pyrzyce (NUTS 4)	**74874**	**0,73**	**0,17**	**6802**	**11,44**	**3,42**
Województwo zachodniopomorskie (NUTS 2)	**2381230**	**0,92**	**0,21**	**186612**	**23,80**	**5,07**

* NUTS 5

- Water pollution by pesticide
In Poland pesticides use varies between years, being strongly correlated with financial performance of farming sector. The total usage of pesticides active ingredient in the period 1990-2003 is shown on figure 7. The average use of pesticides is lower than 0,65 kg/ha of arable land.

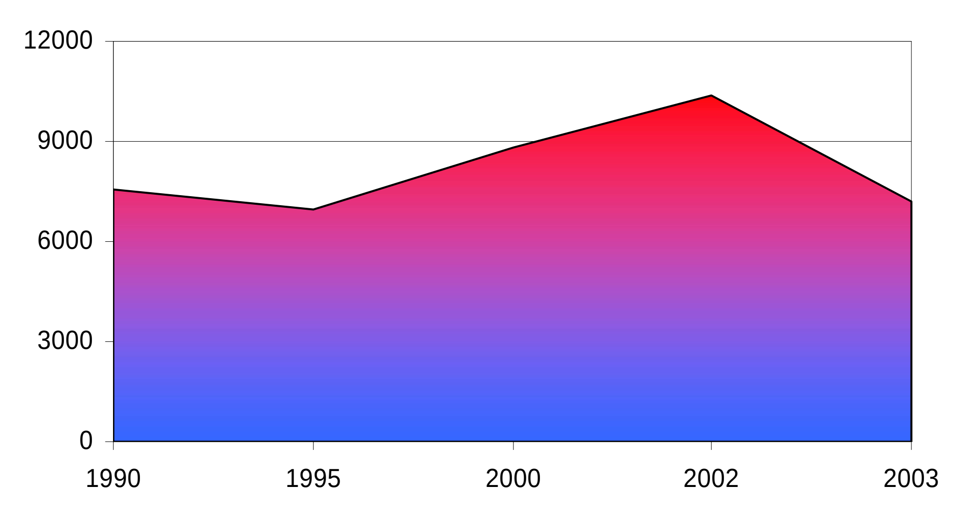

Figure 7. Pesticides use in Poland (tonnes of active ingredient) (Environment Protection 2004 and Statistical Yearbook of Agriculture 2001– Statistical Publication House).

The pollution of surface water in Pyrzyce region is monitored by Voivodship Inspection for Environmental Protection in Szczecin (WIOS- Wojewodzki Inspektorat Ochrony Srodowiska). River Plonia and lake Miedwie are the main drinking water sources in the region. Table 10 presents the results of main pesticides pollution indicators for period 1993-2003. In all cases the level of contamination of water by pesticides is far below the drinking water standard (0,10µg/l), which was set by the Ministry of Health Regulation on 19 November 2002, and in many cases it is decreasing.

Table 10. Pesticide water pollution indicators in Pyrzyce region (river Plonia catchment) **(Voivodship Inspection for Environmental Protection in Szczecin (WIOS) – unpublished data).**

Place of measurment	Data of measurement	GAMMA _HCH mg/l	DDE mg/l	DDD mg/l	DDT mg/l	DMDT mg/l	PCB_ BIPHENYL mg/l
Płonia below estuary of Mlynsky Canal	1993-08-04	0,0120	0,0040	0,0020	0,0100		
	1994-08-03	0,0060	0,0020	0,0010	0,0030		
	1996-10-21	0,0060	0,0020	< 0,001	0,0030	< 0,004	
	1998-06-01	< 0,001	0,0000	< 0,001	0,0000	< 0,004	< 0,001
	1999-06-28	0,0020	0,0040	< 0,001	0,0060	< 0,004	< 0,001
	2000-06-05	0,0020	0,0090	< 0,002	0,0120	< 0,004	< 0,002
	2001-06-26	0,0020	0,0020	< 0,002	0,0070	< 0,004	< 0,002
	2002-06-12	< 0,002	0,0020	0,0020	< 0,002	< 0,004	< 0,002
	2003-06-09	< 0,002	< 0,002	< 0,002	< 0,002	< 0,004	< 0,002
Ostrowica above Miedwie	1993-08-04	0,0060	0,0030	0,0010	0,0060		
	1994-08-03	0,0070	0,0010	0,0010	0,0030		
	1996-10-07	0,0030	0,0030	< 0,001	0,0030	< 0,004	
	1998-06-01	0,0080	0,0060	< 0,001	0,0090	< 0,004	< 0,001
	1999-06-28	0,0020	0,0040	< 0,001	0,0070	< 0,004	< 0,001
	2000-06-05	0,0010	0,0030	< 0,002	0,0050	< 0,004	< 0,002
	2001-06-11	0,0030	< 0,002	< 0,002	0,0040	< 0,004	< 0,002
	2002-06-12	< 0,002	0,0130	0,0070	0,0140	< 0,004	< 0,002
	2003-06-09	< 0,002	< 0,002	< 0,002	0,0000	< 0,004	< 0,002
Płonia below Miedwie Lake	1993-08-04	0,0120	0,0060	0,0020	0,0110		
	1994-08-03	0,0120	0,0020	0,0010	0,0030		
	1996-10-21	0,0040	0,0020	< 0,001	< 0,001	< 0,004	

	1998-06-01	0,0040	0,0060	< 0,001	< 0,001	< 0,004	< 0,001
	1999-06-28	0,0030	0,0040	< 0,001	0,0080	< 0,004	< 0,001
	2000-06-05	0,0030	0,0080	< 0,002	0,0120	< 0,004	< 0,002
	2001-06-26	0,0030	0,0020	< 0,002	0,0070	< 0,004	< 0,002
	2002-06-12	< 0,002	< 0,002	< 0,002	0,0030	< 0,004	< 0,002
	2003-06-09	< 0,002	< 0,002	< 0,002	< 0,002	< 0,004	< 0,002
Gowienica Miedwianska estuary to Miedwie	1993-08-04	0,0120	0,0060	0,0020	0,0140		
	1994-08-03	0,0070	0,0080	0,0010	0,0050		
	1996-10-07	0,0020	0,0050	< 0,001	0,0030	< 0,004	
	1998-06-01	0,0030	0,0060	< 0,001	0,0000	< 0,004	< 0,001
	1999-06-28	0,0040	0,0070	< 0,001	0,0100	< 0,004	< 0,001
	2000-06-05	< 0,002	0,0050	< 0,002	0,0050	< 0,004	< 0,002
	2001-06-11	< 0,002	0,0020	< 0,002	0,0040	< 0,004	< 0,002
	2002-06-12	< 0,002	< 0,002	< 0,002	< 0,002	< 0,004	< 0,002
	2003-06-09	< 0,002	< 0,002	< 0,002	< 0,002	< 0,004	< 0,002
Plonia below Szczecin Dąbie	1998-06-01	0,0060	0,0160	0,0180	0,0040	< 0,004	< 0,001
	1994-08-03	0,0060	0,0030	0,0010	0,0080		
	1996-10-21	0,0070	0,0050	< 0,001	0,0040		
	1999-06-28	0,0020	0,0050	< 0,001	0,0070	< 0,004	< 0,001
	2000-06-05	< 0,002	0,0030	< 0,002	0,0050	< 0,004	< 0,002
	2001-06-26	0,0030	0,0050	< 0,002	0,0090	< 0,004	< 0,002
	2002-06-12	< 0,002	< 0,002	< 0,002	< 0,002	< 0,004	< 0,002
	2003-06-09	< 0,002	< 0,002	< 0,002	< 0,002	< 0,004	< 0,002
Miedwianka estuary to Miedwie	1993-08-04	0,0090	0,0040	0,0020	0,0080		
	1994-08-03	0,0080	0,0030	0,0010	0,0050		
	1996-10-07	0,0040	0,0030		0,0040	< 0,004	
	1998-06-01	0,0020	0,0040	0,0040	< 0,001	< 0,004	< 0,001
	1999-06-28	0,0010	0,0050	< 0,001	0,0060	< 0,004	< 0,001
	2000-06-05	0,0030	0,0170	0,0040	0,0170	< 0,004	< 0,002
	2001-06-11	0,0030	0,0050	< 0,002	0,0050	< 0,004	< 0,002
	2002-06-12	< 0,002	< 0,002	< 0,002	< 0,002	< 0,004	< 0,002
	2003-06-09	< 0,002	< 0,002	< 0,002	< 0,002	< 0,004	< 0,002
Kunowski Ditch estuary to Miedwie	1993-08-04	0,0160	0,0070	0,0020	0,0150		
	1994-08-03	0,0120	0,0020	0,0020	0,0050		
	1996-10-07	0,0080	0,0040	< 0,001	0,0040	0,0030	
	1998-07-01	0,0090	0,0040	0,0030	0,0070	0,0080	< 0,001
	2001-06-11	0,0030	0,0030	< 0,002	0,0050	< 0,004	< 0,002
	2003-06-09	< 0,002			< 0,002	< 0,004	< 0,002

2.4.2.3 Water stakes

In Poland the Bureau of Water Management has been established under Ministry's of the Environment Ordinance No. 4 of 22 February 2000. This organisation aims at providing the conditions for uniform activity to be made by the Regional Boards for Water Management. The Boards' activities are aimed at rationalizing the use of water resources, their maintenance and protection in accordance with the principle of sustainable development. One of the specific tasks of the Board is to identify water protection areas. Approximate area of these vulnerable zones in Poland is 7,75 km2, which is about 2,5% of the country's area (Rural Development Plan for Poland 2004-2006; Ministry of Agriculture and Rural Development).

The area of vulnerable zone identified in the Zachodniopomorskie region is 1068 km2. Among this area, the whole region of Pyrzyce (726 km2), which will be used in Test Case 1 and 2, is classified as vulnerable zone (Figure 8). The central point of the zone is Miedwie lake, which is supplied mainly by surface water from Plonia river (73% of total supply), which flows from the South to the North across the test-case region.

It was estimated that in the years 1983-1994 about 48% of the average yearly amount of nitrogen brought into Miedwie lake (129 tones) was carried out by Plonia river. However observations for the period 1993-2000 showed a significant increase of Plonia river shares in transportation of Nitrogen (70%), as well as of Phosphorus (80%) into the lake.

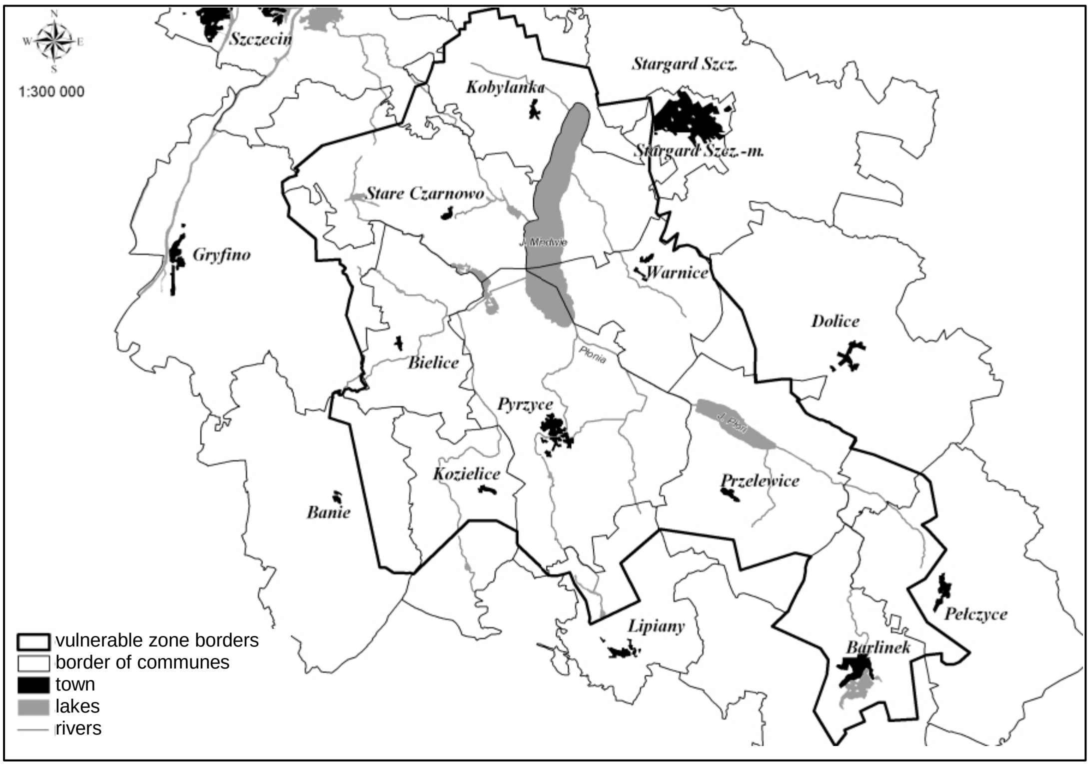

Figure 8. Nitrogen vunerable zone in Pyrzyce region (Regulation 9/2003 form 28 November 2003 of Regional Boards for Water Management)

2.4.3 In the MASSIF CENTRAL region (France)

This study on water and biodiversity problems in Massif Central zone is illustrated by data from the Cantal subregion.

This test case region is a mountainous area (in a range from 600 to 1800 m asl) of extensive grasslands with precipitation between 900 to 1500 mm/year (even 2300 mm on the top of mountains). Numerous rivers find their springs in the Massif Central which is considered as the ‘water tower’ for all France.

2.4.3.1 Water use

Even if the dry years could be a problem for farmers to assure summer pasture or to harvest a sufficient amount of silage or hay for the next winter- mainly in shallow/sandy soils parts of the area – irrigation is almost inexistent (less than 1% of the agricultural area, French agricultural census 2000). Actually, the cost of irrigation is higher than the benefit which could be got, according to the risk of dryness.

2.4.3.2 Water qualities

- Ground water

The area is characterized by a very high number of public water catchments (several hundred), which is due to the dispersal of rural housing and to the fact that historically each little hamlet had its own catchments.

The rock is crystalline or volcanic and therefore there is no large and deep water tables. The water comes mainly from underground streams or springs.

Water samples over the standard of 50 mg NO_3/l (Decree N°2001-1220) are exceptional. The pesticides content of water is also at a very low level. This good situation of the chemical water quality can be linked to the extensive situation of agriculture in the zone and to the permanent cover of soils by the meadows (Perez et al, 2005). Actually pesticides are not used or are used at a very low level on permanent grasslands and nitrate leaching stays at a low level under permanent meadow if the grass is mowed or, when it is grazed, if the stocking rate is not too high (the main risk occurs in fall) (Simon & al, 1989 ; Sherwood & Ryan, 1990).

In the area the main problem of ground water quality comes from the microbiological flora which is frequently over the limit (figure 9). This frequent situation in mountain areas and processes involved in this type of pollution are less known, compared to the nitrate's case. Causes are multiple and likely not only agricultural (Trévisan, 2004). Moreover, current models do not simulate this risk of water pollution

- Rivers

The water quality in the rivers is also at a very good level (figure 9). For nitrate, the average samples on the two main rivers of the zone are at a concentration lower than 10 mg/l (well below the threshold of 50 mg NO_3/l), except localised problems coming from little industry or from pollution by slurries and whey (in farms producing their own cheese) when poured in the streams. The use of pesticides is at a very low level in the region (due to the farming system based on permanent meadows) (cereals area represents less than 3% of total agricultural area), and moreover the meadows protect the rivers from run off.

2.4.3.3 Water Stakes

Regarding to water, the main stake in the zone is to sustain the water supply at a high level in quantity and quality. Actually, the zone belongs to a very important up-stream catchment basin and provides water for down streams populations and activities.

The question is not to improve water quality (except microbiological quality in catchments and local problems of pollution by whey due to cheese production in farms) but to analyse what could be the consequences of agricultural evolution on the water quality and availability ; for instance, in the event of an intensification of agriculture in the zone (due to an increase in milk or meat prices), or more likely in case of land abandonment in the least favourable parts and concentration of cattle husbandry in small areas (which would also have consequences for biodiversity and landscape management– which are other main stakes in the zone).

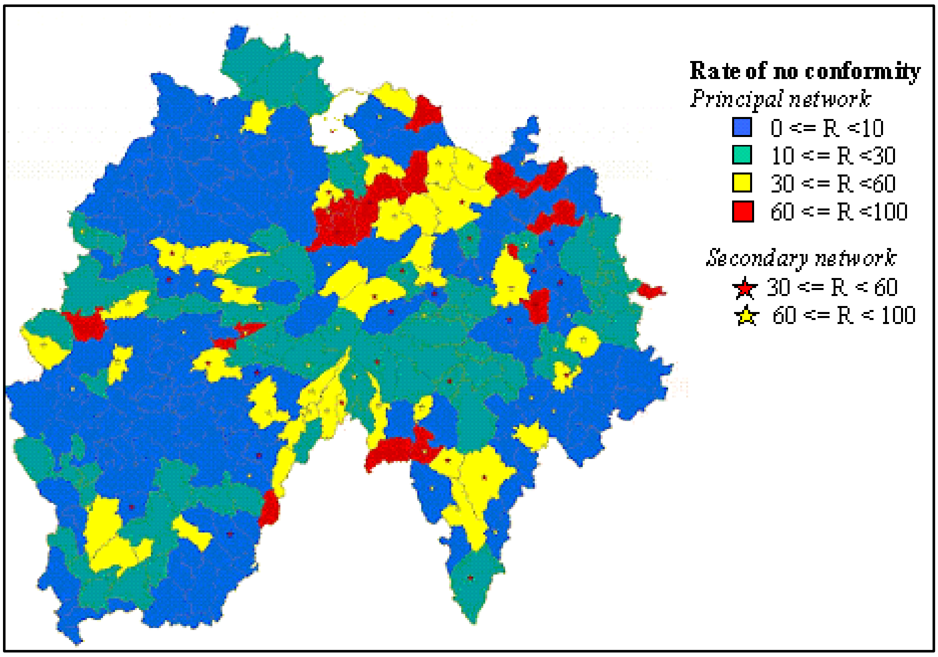

Figure 9. Qualities of drinking water in Cantal (NUTS3) : bacteriological conformity. (DDASS, 2004)

3. European regulations and directives to reduce water use and pollution and to preserve biodiversity

3.1 Overview of the directives

Water is one of the most comprehensively regulated area of EU environmental legislation. Several programs and leglislations were initiated between 1973 and 1980. This first wave of water legislation included water quality standard legislation on fish waters (1978), shellfish waters (1979), bathing waters, Dangerous Substances Directive (1976) and groundwaters (1980) (EEA, 1996). A second wave of water legislation followed a review of existing legislation and an identification of necessary improvements and gaps to be filled. This phase of water legislation included the Urban Waste Water Treatment Directive (1991) and the Nitrates Directive (1991) (EEA briefing, 2003).

In 1997, the European Environmental commission established a Water Framework Directive in order to achieve the following four objectives of a sustainable water policy (EEA, 2003) :

- sufficient provision of drinking water
- sufficient provision of water for other economic requirements
- protection of the environment
- alleviation of the adverse impact of floods and droughts.

The implementation of European Directives and other European policies will have an important impact in the EU and EU Accession Countries, specifically the Water Framework Directive. The Common Agricultural Policy will also influence the evolution of European agriculture and therefore the amount of water used for irrigation. One of the objectives of the Water Framework Directive is to promote sustainable use of water, based on a long-term protection of available water resources, and to ensure a balance between use and recharge of groundwater, with the aim to achieve good groundwater status. In terms of water use efficiency, an economic analysis of water use has to be undertaken at river basin level and also Member States have to take into account the principle of cost recovery for water services, including environmental and resource cost (correct water pricing for irrigation water) (EEA, 1999c).

The environmental objective of the Directive is to achieve "good status" for all groundwaters and surface waters by 2010 at the latest. To this aim, it establishes river basin management based on an assessment of the characteristics of the river basin : monitoring of the status of its surface and groundwaters; definition of quality objectives; establishment of programmes of measures to achieve the objective. However, the administrative structure and local implementation policy to achieve this river basin management is left to the discretion of Member States (Table 11).

Table 11. Overview of the area (x 1000 km^2) of vulnerable zones identified by each Member State (2001) compared with the total Member State area (EEC, 2000).

Member state	Total area (*1000 km^2)	Vulnerable zone (*1000 km^2)	(%)
Belgium	31	2.7	9
Denmark	43	43	100
Germany	356	356	100
Greece	132	13.9	11

Spain	504	32	6
France	539	241	48
Ireland	69	0	0
Italy	301	5.8	2
Luxembourg	3	3	100
Nederland	37	37	100
Austria	84	84	100
Portugal	91	0.9	1
Finland	334	334	100
Sweden	448	41	9
UK	244	7.8	3
Total EU-15	**3216**	**1202**	**38**

3.2 Water quantity: How to reduce water consumption by irrigation?

One way to reduce agricultural water consumption is to apply a quota of water distribution or to increase water prices at farm or regional level. In general, this policy is accompanied by a reduction of farmers' income, due to reduction of yields or area of irrigated crops. In southern France (Tarn and Garonne region), Legrusse et al (2005) proved that it is possible to reduce water consumption to respect water quota by selecting those which return the maximum overall income while respecting a series of constraints and creating specific zones for all kinds of crops. These constraints are related to agronomy, the market, water consumption and nitrate leaching. Based on this methodology the main constraint was to reduce the water consumption about 20% compared to current situation. The main result of this study is that, to reduce water consumption, farmers must cultivate more rainfed crops (wheat and barley) and that percentage of irrigated maize and sorghum should decrease in soils with a low water holding capacity and be mainly grown on deep soils. This optimisation of land use was also accompanied by a decrease in nitrogen leaching.

Other conventional solutions to control water consumption are:
- Application of efficient irrigation systems (drip or sprinkler irrigation) (Belder *et al*; Vidal et al, 2001).
- Reduction of water use and/or increase of water use efficiency with scheduling of irrigation with regular monitoring of soil-plant water status in the field (Wu, 1999; Seckler, 1996)
- Adaptation of amounts and frequencies of irrigation to the hydraulic soil proprieties, climatic conditions and the crop type (Bouman and Tuong, 2001; Allen et al, 1998).

3.3 Water Quality

3.3.1 Nitrate Directive.

Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrate from agricultural sources complements the Urban Waste Water Directive by reducing and preventing pollution of water by nitrate from agricultural sources, i.e. chemical fertiliser and livestock manure, both to safeguard drinking water supplies and to protect fresh water and marine waters from eutrophication.

The Directive requires each Member State to draw up at least one code of good agricultural practices (EEC, 1991). This code (adpated to each region if required) has the objective of reducing pollution by nitrate, taking into account regional specificities across EU. It should contain provisions covering the following items, if relevant :

1. the land application of fertilizer to steeply sloping ground;
2. the land application of fertilizer to water-saturated, flooded, frozen or snow-covered ground;
3. the periods of the year when fertilizer application is not allowed
4. the conditions for land application of fertilizer near water courses;
5. the capacity and construction of storage vessels for livestock manures, including measures to prevent water pollution by run-off and seepage into the groundwater and surface water of liquids containing livestock manures and effluents from stored plant materials such as silage;
6. procedures for the land application, including rate and uniformity of spreading, of both chemical fertilizer and livestock manure, that will maintain nutrient losses to water at an acceptable level.
7. land use management, including the use of crop rotation systems and the proportion of the land area devoted to permanent crops relative to annual tillage crops;
8. the maintenance of a minimum quantity of vegetation cover during (rainy) periods that will take up the nitrogen from the soil that could otherwise cause nitrate pollution of water;
9. the establishment of fertilizer plans on a farm-by-farm basis and the keeping of records on fertilizer use;
10. the prevention of water pollution from run-off and the downward water movement beyond the reach of crop roots in irrigation systems.

On the basis of the results from monitoring networks specified in the Directive, zones vulnerable to nitrate pollution from agricultural sources have to be identified. In these zones action programmes have to be implemented consisting of mandatory measures, one of it being the requirement of application of the code of good agricultural practices by all farmers. Member States can decide to apply the measures in the action programmes across their whole territory, in that case they do not have to identify vulnerable zones. As shown in table 10, the strategy with regards to this classification is very different from one member state to the other.

3.3.2 How to reduce pollution of water by nitrate?

Several solutions are proposed by the EU to control and reduce surface and ground water nitrate pollution. Mainly, two kind of agronomic solution are distinguished: improved fertiliser management and crop rotation management.

The quantity and the nature of the nitrogen fertiliser can play an important role to determine yield and nitrogen leaching. Farmers often use high levels of nitrogen to achieve high and stable yields. However, relationships between nitrogen and yield are not linear and nitrogen use by plants is governed by the law of diminishing returns (Tremblay et al, 2001). Other factors unrelated to nitrogen fertiliser availability, such as heat units or growing degree-days, soil moisture (Martin et al., 1994; Ferguson et al., 1991), the genetic characteristics of the cultivar (Derici et al 2001; Guarda et al, 2004) and insufficient availability of other nutrients (Aulakh et al, 2005) can limit crop yield. N fertilizerrequirements for a crop are therefore often overestimated, thereby leading to frequent N leaching and water pollution.

The period to apply nitrogen depends closely on the characteristics of the fertiliser. For example manure and compost, in which the mineral nitrogen fraction is directly exposed to leaching, must be incorporated very late in the season so that freezing occurs soon after, or in the spring and early summer, when the mineral nitrogen can be used immediately for crop growth, and temperatures favour mineralization.

In southern Europe, after a dry year, nitrogen fertilization should take into account the amount of nitrogen left in the soil by the crop during the previous season. In the french Mediterranean region, applying 200 kg of nitrate to a wheat crop after a dry year can double the amount of N leached compared to a rainy year (Legrusse et al, 2005). The major part of nitrogen leaching occurs in fall, when crop is not yet established and the amount of rainfall is important. Two ways are possible to reduce this risk of pollution: reduce fertiliser or grow a nitrate catch crop during the rainy season, between harvest of the previous crop and sowing of the next crop. Green manures can help to reduce nitrate leaching in two ways: they absorb nitrate and reduce the amount of drainage by taking up water during the rainy season (Tremblay et al, 2001). Some crops, such as oilseed radishes, mustard, and barley, have long root systems that are capable of removing nitrate from deep in the soil profile. But when the nitrate catch crop is suppressed to sow the next crop it becomes a green manure through the rapid mineralization of its organic matter. The timing of the green manure incorporation is the key to efficient nitrogen use. It should be incorporated as late as possible in the season, so that organic matter will freeze before mineralisation can occur. When the ground thaws in spring, mineralisation will occur as temperature increases and oxygen becomes available. This coincides with the beginning of the cropping season (Tremblay et al, 2001).

Irrigation management can also be a crucial element to minimise nitrate leaching. Irrigation rates and frequencies that induce drainage beyond the active rooting zone have therefore an impact on nitrate leaching (Brown et al, 1977; Snyder et al, 1984). The volume of water released during irrigation periods must be carefully managed. A soil saturated with water from irrigation or from a storm will inevitably lead to leaching. Excessive irrigation over a short period of time should also be avoided. In Tunisian semi arid conditions, the average nitrogen leaching for a corn crop increases from 10kg/ha to 30kg/ha while increasing the amount of water applied from 950mm to 1300mm (Belhouchette, 2003).

Finally, cultural practices to reduce nitrogen pollution must involve a combination of planting dates, seeding rates, row spacing, fertilisation, irrigation, and the use of adapted varieties to have a rapid canopy closure for a high level of light interception and therefore high nitrogen needs.

In cattle farm regions, practices to avoid nitrate pollution concern:
- the choice of fodder (permanent meadow better than temporary meadow better than maize for silage),
- the stocking rate ,
- the increase of storage capacity allowing a best period to spread manure in regions where winter and rainy months are longer than 3 months,
- the kind of stable particularly with accumulated litter which makes easier storage,
- the involvment of manure in fertilisation management,
- the composting of manure to increase the period and the area of its spreading.

3.3.3 Pesticide legislation.

The current drinking water directive (80/778/EEC and 98/83/EC) defines rules for pesticide authorisation prior to approval for use on farms. Community rules also exist that define maximum residue limits in food and drinking water, and that relate to the aquatic environment through the Water Framework Directive (EC, 1998). As shown in the previous paragraph, those directives seem to be insufficient to control water pollution by pesticide (PAN, 2005). For this reason the European Environmental Bureau (EEB) and Pesticides Action Network Europe (PAN Europe) have released a

proposal of Directive on Pesticides Use Reduction in Europe (PURE). The text aims to speed up the European Commission's to develop effective legislation on the sustainable use of pesticides.
In order to comply with this objective, the main target of the suggested legislation is to attain a 50% reduction in the frequency of applications of pesticides at national level within 10 years. It is proposed to achieve this objective by promotion of alternative methods including organic farming, and by mandatory application of integrated pest management (IPM) for non agricultural situations and integrated crop management (ICM) on all cultivated land not yet in organic (PAN, 2005).

3.3.4 How to reduce pollution of water by pesticides?

Good management practices can reduce ground and surface water pollution by pesticides. Several ways are mentioned and tested through the word to decrease risks linked to pesticides application. Generally, the main reason of pesticide losses is soil tillage through its effects on surface and soil flows of water. Conventional land preparation and cropping strategies require many field operations, especially in winter. This is associated with breakdown of soil aggregates, which significantly increases soil erosion susceptibility, surface sealing and capping which in turn encourages production of surface runoff. Together, these processes result in increased soil losses, sediment concentrations and runoff volumes. The eroded sediments, including pesticide contaminants, are transported to water bodies, deteriorating its quality by turbidity. Many studies have shown the sensitivity of aquatic ecosystems (flora and fauna), even to low levels of water pollution by sediment. There is, in Europe, a considerable gap between what is known about the principles behind soil conservation practices and what is applied in practice (Van Lynden and Lane, 2004).

It is clear that reducing tillage includes both advantages and disadvantages when it comes to reducing pesticides in runoff. In effect, reduced or conservation tillage, which has been shown to decrease runoff and erosion, has some potential to reduce pesticide runoff losses. For example, in Iowa ridge tillage reduced runoff by 35%, erosion by 62%, and pesticide loss by 52% (ISU, 1999) compared to conventional tillage. However, reduced tillage is to some degree in conflict with soil incorporation. More crop residues on the soil surface, increases, by both rain and wind, the possibility of spray interception and subsequent pesticide washoff and volatilization, because of little pesticide interaction with the residue compared to soil adsorption.

The amount and the way pesticides are applied are a second way to reduce pesticide losses. Reducing the rate of pesticide application is usually the most effective way to lower pesticide concentration and losses to water resources. Practices such as banding, which reduce the area and therefore the rate of application, should decrease pesticide concentrations and losses. Keeping application equipment properly calibrated is important to accurately control the amount of pesticide applied. Soil incorporation, nature of pesticide (less persistent, more strongly adsorbed, and of lower volatility), timing of application, crop rotation and grass strips at the bottom of the fields are other potential ways to reduce pesticide use and/or prevent pesticide losses.

3.4 Biodiversity preservation

In 2001, when EU states launched the EU Sustainable Development Strategy in Gothenburg, they declared that the decline in biodiversity must be halted by 2010 (Gothenburg, 2001). A '2010 target' also exists at the international level: during the 2002 World Summit on Sustainable Development in Johannesburg, world leaders committed themselves to significantly reduce global biodiversity loss by 2010 (Johannesburg, 2002). The aim of EU policy is to reach these targets and to include nature protection into other policy areas, such as farming, fishing and industry. Two EU Directives deal with the conservation of European wildlife, focusing on the protection of sites as well as species (EC, 2004).

3.4.1 The EU Birds Directives

The EU Birds Directive (Directive on the Conservation of Wild Birds, 79/409/EEC) was adopted in 1979. It deals with protection, management and control of all species of naturally occurring wild birds in the European territory of the Member States (Halahan, 2000). It requires
Member States to take measures to preserve a sufficient diversity of habitats in order to maintain populations at ecologically and scientifically sound levels, and requires special measures to be taken in respect of rare or migratory species (EEA, 1999a).

3.4.2 The EU Habitats Directives

The EU Habitats Directive (Directive on the Conservation of Natural and Semi-natural Habitats of Wild Fauna and Flora, 92/43/EEC) was adopted in 1992. It lists in its annexes, habitats and species for which Member States are required to take special measures to maintain or restore natural habitats and wild species at a "favourable conservation status" in the community (EEA, 1999a). Each Member State is required to identify sites of European importance and to put in place a special management plan to protect them, combining long-term preservation with economic and social activities, as part of a sustainable development strategy. These sites, together with those of the Birds Directive, make up the Natura 2000 network - the cornerstone of EU nature protection policy (Halahan, 2000).

3.4.3 Natura 2000

Natura 2000 (Probstl, 2003) is the term used to describe the ecological network of protected sites, considered to be of outstanding international significance and therefore of importance to the maintenance of biodiversity in the European Union. The network of sites aims to conserve species and habitats of community interest listed in the annexes of the Birds and Habitats Directives, with an emphasis placed upon species which are endemic or largely restricted to Europe, which have undergone rapid recent declines, or which are considered rare (Hiedanpää, 2002). The Natura 2000 network already comprises more than 18 000 sites, covering over 17% of EU territory, and was due to be completed in 2004. It is co-financed through the Commission's LIFE programme (set up in 1992 to develop EU environmental policy) and other Community finance instruments (Halahan, 2000).

3.5 Implementation of the directives in the agricultural regions selected for Test Case 2

3.5.1 In the NESTE Region (France)

3.5.1.1 Water use

As above-mentioned, the management of water resource, a public service mission, entrusted to a semi-public limited company, the CACG. This company must assure a compromise between three competing needs: domestic consumption considered as an absolute requirement, sanitary and quality requirements and irrigation which can be restricted in case of shortage. For the two first needs, the CACG must assure a flow in the Gascony Rivers above the Minimum Target Flow (a French departmental regulation). This obligation determines the water available for irrigation. In this framework, the weekly management concerns the trade-off between releasing flows for environmental purposes and keeping water in storage to guarantee the contractual demand. In case of severe drought during the irrigation season, the contractual volume of farmers can be reduced to meet the water quality requirements (Lennhardt, 2004a and b).

Lack of natural water resource of the zone covered by the Neste system justified the classification of (1) the whole territory in "zone of distribution of waters" and (2) rivers in “water deficient rivers or recharged". This classification imposes that any new consumption is the object of an authorization and is compensated with the mobilization of an existing or new resource and\or with the reduction of the existing consumptions (Conseil Régional Midi-Pyrénées, 2004).

3.5.1.2 Water qualities

Implementation of the programs of action of the nitrate directive and the implementation of the Water Framework Directive (WFD) are two main frame/tools to reduce the water pollution from agricultural origin.

The Vulnerable Zone (V.Z) of the Nitrate Directive of the Gers covers more than 70 % of the department. It is one of the most important vulnerable zone of Midi-Pyrenees (DIREN, 2004). Within the framework of the program of action of the Nitrate Directive of the Gers, every farmer in V.Z. must:

- draws up a plan of manure and reports every manure practices done during the year.
- limits contribution of nitrogen contained in the animals effluents to 170kg N/ha/an,
- respects the restricted period to apply manure or fertilizing nitrogen (according to the type of fertilization and land use),
- respects the restrictions for manuring near surface waters (2 m for fertilizing mineral and 35 m for the others), on ground in strong hillside (> in 7 %), on flooded, ice-cold or covered with snow grounds,
- have a stock capacity adapted to the effluents produced by the herd,
- have a field specific management : management of residues, wintry activity of lands,…

Furthermore on the groundwater of the Water Framework Directive classified as “Risk of Not Achievement of the Good Status” in the Neste system it is foreseen:

- the implementation of a program of monitoring and additional measure,
- the definition of adapted objectives through technico-economical study to justify infringements,
- the reinforcement of preventive policies,
- the implementation of priority working area for the protection against pollution by pesticides. In 2005, this area covers more than 2/3 of the hydrographic unit of the "Gascon rivers",,
- after 2009, the definition of conditions for development or installation of activities and targeting of the public financing on these zones (Comité de bassin Adour Garonne, 2004a).

Finally, on the scale of the farm, implementation of the Territorial Contracts of Exploitation (TCE) followed up by the Contracts of sustainable (“Durable” in french) Agriculture (CDA) aims at reducing the impact of agricultural practices on the environment. These contracts allow to develop and to preserve extensive and ecological practices. They identify, as priority, issues on water, biodiversity and grounds. These concerns determine agro-environmental measures which the farmers can sign within the framework of the new CDA (DIREN, 2003).

3.5.1.3 Biodiversity

In the Gers, the zonings of protection of natural zones (e.g. “Natura 2000”)cover only a very small part of the territory (1 %). At present, only 13 100 ha benefit from a measure of management or from protection in framework of Habitat Directive. There is in this French department no other form of conservation (DIREN, 2004).

The natural zone of ecological, faunal and floral interest "ZNIEFF"[5] of the Gers represents also a small area in this department . The 13 "ZNIEFF" (natural zone of ecological, faunal and floral interests) of type 2 of the Gers concern various habitats: alluvial valleys, wood, ponds, karstic environment. The 118 "ZNIEFF" of type 1 are small dimensions area translating the importance of the division of these habitats. They concern mainly ponds and wood, cover less than 11 km2 and often overlap in the "ZNIEFF" of type 2. The three Inventories of the Habitat Directive in the Neste area cover the ponds of Armagnac and the Mediterranean grasslands of certain dry hillsides of Gascony (DIREN, 2004).

The various types of permanent meadows of the Neste system concentrate the main habitats of community interest. However, as in 6 departments on 8 of Midi-Pyrenees, "surfaces always in grass" of the Gers declined strongly from 1999 to 2003 (DIREN, 2003). In this zone of crops, the network of permanent grasslands does not allow any more to insure the preservation of the biodiversity and consequently the functioning of the ecosystems (DIREN, 2004).

Thus, because of the intensification and the concentration of the farms, the fixed elements of the landscape (hedges, copses and isolated trees, etc) and their functions (refuge, biological corridor) also tend to disappear (DIREN, 2003).

Finally, the conservation of the permanent and semi-natural grassland and of the hedges stays the major issue of the biodiversity in the Neste system.

3.5.2 In the PYRZYCE Region (Polland)

3.5.2.1 Water use

The main national law for water use is "Prawo wodne" (Act of water use) form 18 July 2001. It defines the legal framework for water use in Poland. The local legislation for water use is given by Regional Boards for Water Management (RZGW). There are 7 such boards in Poland. Pyrzyce region in managed by the Szczecin RZGW. Most of regulations given by RZGW describe protection zones for drinking water (for surface and groundwater). There are also regulations for fishery on public surface water and regulation implementing Nitrate Directive (delimitation of vulnerable zones) mentioned above.

3.5.2.2 Water qualities

* Implementation of nitrate directive: On the basis of the Regulation of the Szczecin RZGW from 28.11.2003, the basin of Plonia river from the water-spring up to the cross-section in the 13,8rd km (in Szczecin) was classified as vulnerable to nitrate pollution from agricultural sources.

A special programme to limit run-off of nitrate from agricultural sources in this area was set up. This programme was brought into effect through the Szczecin RZGW Regulation from 22.04.2004. The

[5] The inventory of natural heritage (fauna, flora, geology and mineralogy) is established on all the national territory under the responsability of the French ministry of environment (RF law n°2002-92, RF law n°2002-276). This inventory distinguishes two types of zones 'ZNIEFF' (Natural zone of ecological, faunal and floral interests :

- type 1 corresponds to small areas with species or habitat of great ecological values for the region, country or even Europe.
- type 2 corresponds to large natural areas with one or several type 1 zones and important potential to maintain ecological equilibrium.

main aim of this programme is to improve environmental standards and to level up water quality to standards specified by regulations, especially waters of Miedwie lake and the rest of eutrophic waters in the basin of Plonia river.

The key principle of this programme is that the environment cannot be protected at the cost of farmers, but by increasing their awareness and knowledge and by introducing technologies, which will lead to increase fertilizer's efficiency and reduce environment pollution by fertilizers, especially water pollution. During the first four years of programme implementation, bad practices related to fertilizers application should be eliminated.

The program includes the following activities:

1) Improvement of agricultural practices including: changes in application of fertilizers and land use management;
2) Training and consultancy on good agricultural practices;
3) Controlling of pollution from agricultural sources;
4) Monitoring state of agriculture and monitoring programme implementation results (including: water and soil monitoring where nitrate pollution from agricultural sources is significant);
5) Assisting activities, connected with using obligatory means of prevention by farmers, training, consulting and monitoring.

In order to improve land fertilizer management in the area of Plonia river basin, the "Environmental protection in agriculture" (OSR) program was implemented. Within this program investments in manure storage facilities were made. In the year 2004 in Pyrzyce region within this programme such facilities were constructed in 31 farms.

* Legislation on plant protection: The basic legislation on plant protection in Poland is "Ustawa o ochronie roslin" from 18 december 2003 (Act on Plant Protection). According to this law, farmers must use only registered pesticides, keep records of applied chemicals for at least 4 years since application. Workers applying pesticides must be qualified (certificate of plant protection training) and the spraying equipment has to be tested and certified every year by Plant Protection Services (Inspekcja Ochrony Roslin i Nasiennictwa). This act also gives recommendations for proper application of pesticides eg. minimum distance from buildings, surface water and water intakes.

The use of pesticides in Pyrzyce test case region is higher than the average of Poland, especially in more intensive crop farms, where the amount of active ingredient reaches 2 – 2,5 kg per hectare, while the average of Poland is just 0,65 kg/ha. Herbicides dominate in the composition of active ingredient applied.
In Pyrzyce region threats of water pollution by pesticides were not reported. Plonia and Miedwie lakes have intakes of drinking water and thus are monitored for pesticide pollution. Over the last 12 years there where no incidents of exceeding limits of pesticides which are set for drinking water.

3.5.2.3 Biodiversity

The implementation of UE Directives in the area of natural resources was conducted through the new Act on nature protection from 16th August 2004, which included regulations on implementing NATURA 2000 in Poland.

Financing of NATURA 2000 within 2004-2006 is also specified in the Act from 16th August 2004 and in the regulation of the Minister of Environment. According to the above, creating NATURA 2000 net in Poland will be financed by the Ministry of Environment with the help of National Fund for Environmental Protection and Water Management and EkoFunduszu foundation.

There were 256 zones proposed for Natura 2000 by the Polish government and 265 zones proposed by the non-governmental organizations. These 265 propositions have not yet been taken into consideration by the EU Commision.

According to the data of the Ministry of Environment on 256 zones, there are 184 habitat zones (1 185 288,9 ha – 3,7% of the territory of Poland) and 72 bird zones (3 311 396,3 ha – 7,8% of the territory of Poland) recorded, for the total of 4 118 062,6 ha.

In the area of Zachodniopomorskie Voivodship (NUTS 2) 20 habitat zones and 9 bird zones were recorded and sent to the EU Commision (figure 10).

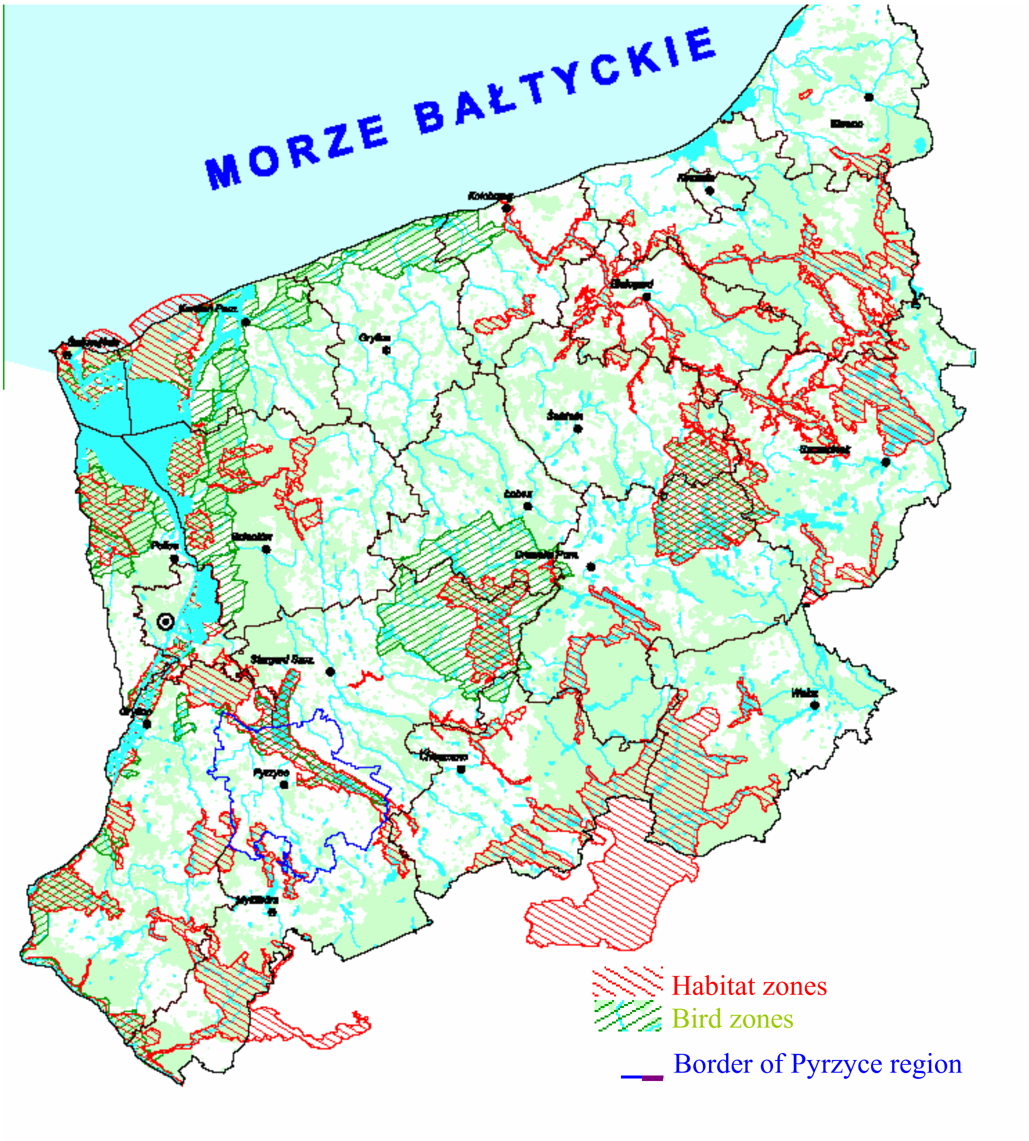

Figure 10. Proposal of zones for NATURA 2000 in Zachodniopomorskie voivodship (NUTS 2). (WIOS, 2004).

Among 20 habitat zones from Zachodnipomorskie Voivodship indicated for Natura 2000 there is the area of Plonia River Valley and Miediwe Lake (21 253,9 ha), located in the test case region. Currently there are a landscape park and 3 nature resrves in this area, and further 15 nature reserves are planned (table 12).

Table 12. Area of habitat zones in different locations within Plonia River Valley and Miedwie Lake area **(Ministry of Environment)**

Zone	Area (ha)	Voivodship (NUTS 2)	Specification	Area (ha)
Plonia River Valley and Miedwie Lake	**21253.9**	**ZACHODNIO- POMORSKI**	Pełczyce	10.5
			Pełczyce	901.0
			Stare Czarnowo	2 259.9
			Barlinek	556.4
			Barlinek	2 099.2
			Bielice	809.3
			Przelewice	3 819.1
			Pyrzyce	124.6
			Pyrzyce	5 278.3
			Warnice	2 063.7
			Dolice	329.7
			Kobylanka	396.5
			Stargard Szczeciński	2 605.6

Among 9 bird zones from Zachodnipomorskie Voivodship indicated for Natura 2000 there is the area of Miediwe Lake and the nearby: Zelewko Lake, Bedgoszcz Lake, Plonia River and Plonski Canal (15 782 ha) (table 13, figure 11).

Table 13. Area of habitat zones in different locations neighbouring with Miedwie Lake (Ministry of Environment)

Zone	Area (ha)	Voivodship (NUTS 2)	Specification	Area (ha)
Miedwie lake and the nearby	**15 782,0**	**ZACHODNIOPOMORSKIE**	Stare Czarnowo	2065.4
			Bielice	809.3
			Przelewice	2491.2
			Pyrzyce	124.6
			Pyrzyce	5216.0
			Warnice	2063.7
			Kobylanka	365.6
			Stargard Szczeciński	2646.2

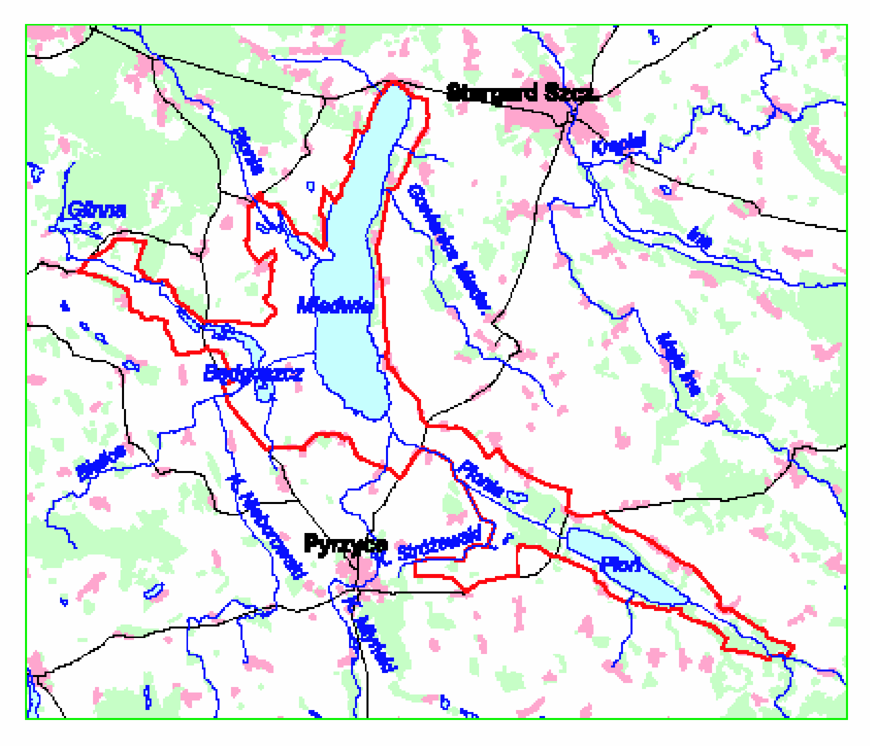

Figure 11. Plonia River Valley and Miedwie Lake. (WIOS, 2004).

3.5.3 In the MASSIF CENTRAL Region (France)

3.5.3.1 Water use

According to the geographical context, the prefect (ie the NUTS3 headmaster) may temporarily adopt restrictive measures, in very exceptional dry periods during summer.

3.5.3.2 Water qualities

This Massif Central zone is not classified as vulnerable, thus the policy dealing with agriculture and water pollution is the basic one:

- sanitary departmental policy (RF prefecture Cantal, 1983) determines for all the farms :
  - the distances between a new stable, a new effluents storage or the manure spreading and a water place (35 m minimum), a swimming place (200m minimum) or a third party building (50m minimum and 100m for liquid manure),
  - the storage capacities : 2 to 3 m^2 /LU (Livestock unit) for manure area and 3 to 4 m^3 /LU for liquid manure,
  - the minimum of storage duration : 90 days of slurries production in mountainous areas.
  - the conditions forbidden to spread manures, specially frosty and hard rainy periods.

- Classified installations (FR. Decree n°93-1412) concerns farms with more than 40 milk or suckled cows, and cheese making. According to gravity about agricultural pollutions, two kinds of farms are distinguished :
  - A declaration is just required for farms with 50 to 200 calves or fattened animals, for farms with more than 40 suckled cows, or farms between 40 and 80 milk cows hold. For cheese making, the storage capacity of milk must be superior to 7 000 l/d and inferior to 70 000 l/d.
  - An authorisation is necessary for farms with more than 200 calves or fattened animals, or more than 80 milk cows, and for cheese making with a storage capacity of milk, superior to 70 000 l/d.

    Farms with authorisation must present a storage capacity for effluents above 120 days of production and must register a spreading plan.

According to the statistics 2003 (DRAF 2005), less than 20% dairy farms and about 35% of suckled livestock have to respect authorisation directives. Moreover, Regional Council and Ministry of Agriculture give subsidies to farms with more than 90 LU for improving effluents storage and Departmental Council attributes subsidies to smallest farms also for improving effluents storage.

In grassland regions, the French code of good agricultural practices, (MAP, ME, 1993) concerns particularly mineral and organic fertilisations.
Farmers must respect the code of good agricultural practices to benefit from certain French subsidies of the RDR as: 'ICHN', the compensatory subsidies for natural handicaps (which is particular to mountainous and disadvantaged regions) ; 'PHAE', the agro-environmental subsidy for grasslands (for maintaining meadows utilisation); or 'CAD', the contract for sustainable agriculture. The requirements of the code are verified at the time of the demand and during a possible visit.

Moreover, the 'PHAE' requires a records of organic and mineral fertilisations and limits its total level to an average of 120 uN /ha/year.
In the special case of CAD, Auvergne farmers can introduce specific measures to decrease the fertilisation level (more than 20% for crops and even 40% for meadows) of some fields and consequently can receive compensatory subsidies.

Nearly all the 3 565 farmers of the zone receive one or several of these subsidies.

3.5.3.3 Biodiversity

Almost a quarter of Auvergne area (NUTS2) is classified as ZNIEFF type 2, and 400 ZNIEFF type 1 represents 9% of the regional area (table 13).
Since the Council Directive 79/409/ EEC, the French ministry of environment had been inventorying the Important Zones for Birds Conservations (ZICO). Three ZICO in the test zone, totalize more than 20% of the area of the region (table 14).

Table 14. Environmental inventories in Auvergne and in the test case region.

	Number in NUTS2	Area (ha) in NUTS2
ZNIEFF 1	403	229 600
ZNIEFF 2	27	630 700
ZICO	14	352 450

In the test case region, the inventory registers wet zones and peat bog (with 23 protected plant species), some dry limestone hills with 9 rare species of orchids, and all the diversity which appears on lands varying from 600m to 1800m al (35 rare alpine and sub alpine plant species are counted above 1500 m). These areas are also natural habitats for different kinds of animals: invertebrates (Euphydryas aurinia, Leucorrhinia pectoralis, Lucanus cervus, Cerambyx cerdo, Margaritifera margaritifera, Austropotamobius pallipes), amphibians (Triturus cristatus), reptiles (Bombina variegata) and bats (Barbastellus barbastellus, Rhinolophus hipposideros, Rhinolophus ferrum-equinum, Myotis myotis). The highest zone: Monts et plomb du Cantal, located between 1300 and 1785 m, allows migratory stage for numerous raptors (Hieraaetus pennatus, Aquila chrysaetos, Falco peregrinus and various Circus and milvus…) and other rare species as Ciconia ciconia and Ciconia nigra, Lullula arborea or Turdus torquatus (DIREN 2003).

From these inventories, the ministries of agriculture and environment classify the zones in different levels according to their biodiversity richness (DIREN Auvergne 2000) :
- level 1: national or international interests (for example : Monts du Cantal, Margeride, Aubrac)
- level 2: regional interest (for example: Planèze de St Flour).

The biodiversity stakes in Auvergne and particularly in the test zone, are first, to maintain an agricultural population (population density is about 25 inhabitants / km^2), with extensive breeding to maintain plant diversity and limit the forest invasion; secondarily, to protect wet zones and peat bog from drying, orchids area from intensive agriculture (with financial backing to farmers), and then to protect the top of the hills from the rush of tourits during summer.

- Natura 2000
Since the EU Directives for 'habitat' and 'birds', France has determined Special Zones of Conservation (ZSC) and Special Protections Zones (ZPS) named together 'Natura 2000'. Twenty different Natura 2000 zones (from 30 ha to 5 883 ha) are recorded in the Test casa region, for a total of 14 308 ha and three rivers zones totalize 918 km (figure 12). The specifications of Natura 2000 zones suggest different agro environmental measures :

1°- the most important measure is the 'extensive meadows utilisation', to maintain plant diversity, insects presence (for bats areas) and to limit also the development of forests.
2°- drying is forbidden in wet zones and peat bog, although extensive utilisation is advised around the zone to protect typical plants.
3° - the decrease of fertilization to maintain a large diversity of plants, specially on the dry lands with orchids.
4° - a light maintenance of the rivers and their sides to keep habitats for mussels and crayfishes.

In the fields located in a Natura 2000 zone, French farmers could currently contract a 'CAD' (Contract for sustainable agriculture) to implement the specifications. But, as previously indicated, most farmers of the test case area receive already subsidies to maintain extensive meadows utilisation. Only one farmer in Cantal has contracted special Natura 2000 measures. In the agricultural bill, a proposition suggests to modulate the subsidy of the 'PHAE' according to the specifications of territories.

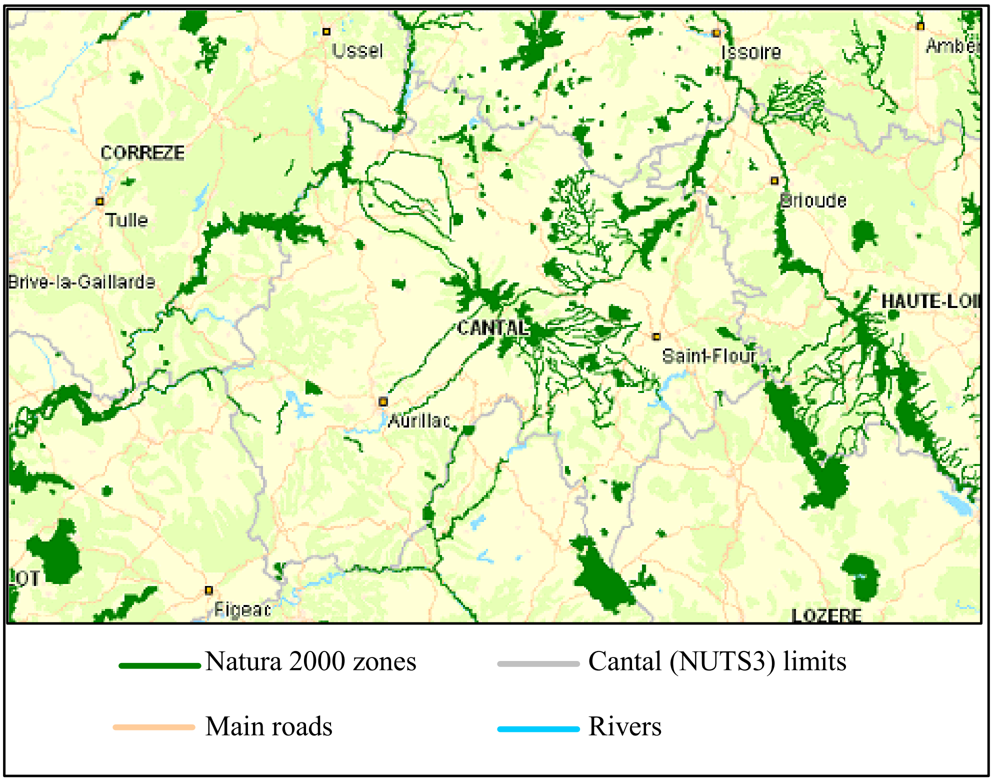

Figure 12. Localisation of Natura 2000 sites in Cantal (NUTS3).

- Protecting measures

The prefect or the Ministry of Environment may edit different orders ‘Voluntary Natural Reserves’ (with owners agreements), and ‘order of the prefect for biotope protection’, or ‘Natural Reserves’ (ministry order) to forbid in very limited areas, dangerous actions for natural systems. In Auvergne region (NUTS2), only 4 ‘Voluntary Natural Reserves’, 13 ‘order of the prefect for biotope protection’ and 4 ‘Natural Reserves’ protect 4 722 ha (less than 0,2% of the total area).

- The Regional Natural Park of Auvergne Volcanoes

Regional Council and government have instituted two important Regional Natural Parks in Auvergne on 707 000 ha (ie 27% of total area), (figure 13). In particular, the Regional Natural Park of Auvergne volcanoes was created in 1977 on 395 000 ha and 153 “communes”; its southern part is located in the Western part of the Test case area.

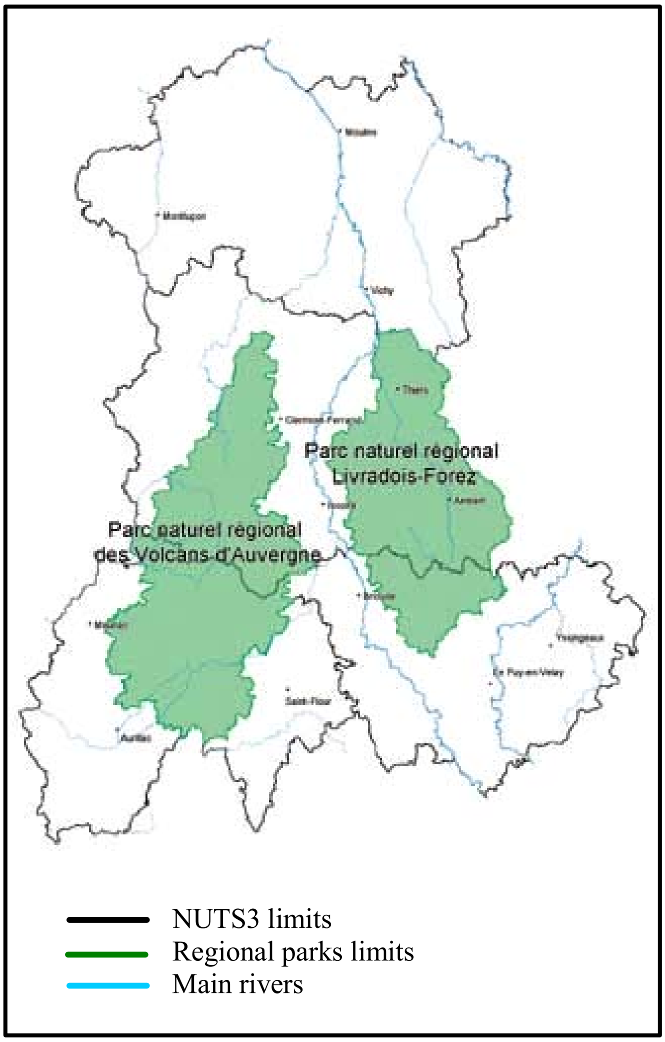

Figure 13. Localisation of the two regional natural parks in Auvergne region.

The regional park implements measures in favour of water, biodiversity, landscape and rural stakes as protecting river qualities, inventorying different species, organising shows about nature, laying out paths for tourists, etc…(PNRVA, 2000). With the other stakeholders (regional and departmental council, municipalities, associations …), the park proposes measures to maintain rural activities (in agriculture but also in tourism or in craft industry). Regarding to the biodiversity of the test case, the Regional Natural Park of Auvergne volcanoes intervenes directly about technical studies (for example, drawing up new orders of Natural reserves) and with financial aids to protect weak areas.

4. Agro-ecological innovations

Technological innovations will have a role to play in the improvement of farming systems competitiveness and in the reduction of environment pollution (Environmental Technology action Plan, 2004). Agro-ecological cropping systems (Dalgaard et al., 2003) could play a significant role in the reduction of water use and water pollution while keeping the agronomic performances (yield and quality of product) of the crop at a competitive level. By promoting attributes of natural ecosystems in cultivated fields these technologies can lead to significant reduction of pesticides and fertilisers use, improvement of soil fertility and reduced runoff. These technologies are the core of alternative means of agriculture such as Organic farming, Integrated Cropping Systems, Conservation Agriculture, Agroforestry and other forms of ecological agriculture. Among them organic farming, despite its technical and market limitations, is of particular interest since it is the main form of alternative agriculture recognised by a European directive and a specific market.

In spite of advantages of agro-ecological technologies, agro-ecological systems and technologies are still poorly adopted in Europe. A recent cross analysis of the attitude of farmers and experts in 6 EU member states and Switzerland towards no-tillage systems emphasised an existing contradiction between research results and the opinion of experts and farmers (Tebrügge et al, 2001). For this reason, recently the KASSA[6] project (Knowledge assessment and sharing on sustainable Agriculture) was created with the following 3 objectives (KASSA, 2005):

1- Comprehensive inventory, assessment and critical analysis of existing knowledge on sustainable agriculture;
2- Learning from local/regional past and ongoing experience;
3- Refining findings.

SEAMLESS-IF must be able to deal with a broad range of agro-ecological innovations, such as integrated water, nutrient and pest management, genetic improvements, changed crop rotations, organic production methods, conservation tillage and intercropping. Examples of such innovations comprise: new crop rotations; improvement of irrigation systems (Odgen et al., 1999; Holland, 2004; Vidal et al, 2001); better use of water and crop management taken into account the soil and the weather proprieties (Wu, 1999; Seckler, 1996); IPM; INM; conservation tillage and changing the (cropping) system, by for instance widening or narrowing crop rotations (Odgen et al., 1999; Palma et al., 2004; Liebman and Davis, 2000) .

The effect of agro-technological innovations can and must be assessed at different scales to reveal their full effect. Since the use of synthetic pesticide and mineral fertiliser are banned in organic agriculture, such technique can be very clean locally (Stolze et al., 2000; Hansen et al., 2001). The effect of organic farming on nitrogen pollution at farm or regional scale depends greatly on local conditions. Scottish German and Norwegian investigations thus demonstrated a higher nitrate leaching potential with conventional as opposed to organic farming (Younie and Watson, 1992; Eltun, 1994). Danish analysis showed no significant difference in this regard (Kristensen et al., 1994). As yields are generally lower in

[6] KASSA will be achieved through an inventory and analysis of experience and results on sustainable agricultures, the synthesis and sharing of lessons learned in Europe and Southern countries and gap analysis and fill-in

organic agriculture, the emissions per unit of product may be less advantegeous for organic agriculture, and when assessing organic means of agriculture at a more global scale, it must be considered that more land will be neeed for such type of agriculture and that total emissions may be very substantial.

In the rest of this PD, we will focus on a limited number of agro-technical innovations, i.e. conservation agriculture, agroforestry, intercropping, integrated grassland management and organic farming. More details and definitions for other technological innovations will be considered when the policy scenarios will be defined in the next deliverable (PD 6.2.4).

4.1 Technical innovations

4.1.1 Conservation agriculture

- Environmental benefits

Conservation agriculture refers to several practices which allow the management of the soil for agricultural production, while altering its composition, structure and natural biodiversity as little as possible and defending it from degradation processes (e.g. soil erosion and compaction). Direct sowing (no-tillage), reduced tillage (minimum tillage), non - or surface- incorporation of crop residues, relay-cropping with cover crops between two annual crops, are some of the techniques which constitute conservation agriculture (ECAF, 2005). Generally, conservation agriculture includes any practice which reduces changes or eliminates soil tillage and avoids residues burning to maintain enough surface residues throughout the year. As will be indicated later, the soil is protected from rainfall erosion and water runoff; soil aggregates are stabilised, organic matter and the fertility level naturally increase, and less surface soil compaction occurs. Furthermore, the contamination of surface water and the emissions of CO_2 to the atmosphere are reduced, and biodiversity increases (Olson et al., 2005; Reicosky et al., 2005; Roldan et al., 2005).

Conservation tillage can influence the environmental impact of pesticides in two ways. Firstly through modification of the soil structure and functional processes that consequently affect the fate of pesticides once applied. Secondly by influencing the levels of crop pests, diseases and weeds and thereby the need for pesticides (Holland, 2004). However, those effects depend on many factors, such as the proprieties of the pesticide, soil characteristics, environmental conditions and site's characteristics. There are many reasons to think that conservation tillage may increase the risk of leaching herbicides because usage may increase when combating weeds and soil borne disease, especially during the early transition years (Holland, 2004; Elliot et al., 1988). Moreover, the increase in soil macropores facilitates more rapid movement of water and the pesticides within and subsequently into watercourses (Odgen et al., 1999; Holland, 2004). This negative effect can be controlled and reduced by crop residues and the high infiltration rates generated by the conservation tillage (Elliot et al, 1988). Both will ensure that runoff and sediment loss is reduced and thereby lower the risk that pesticides will be transported directly into surface waters, in comparison with conventional tillage (Mickelson et al., 2001; Watts et al., 1996).

- Economic benefits

In conventional agriculture, tillage operations require considerably higher inputs in machinery investment and maintenance, fossil combustibles and labour inputs as compared to conservation agriculture, especially direct sowing/ no-tillage. Generally, conservation agriculture reduces the energy consumption of farming operations and increases energy productivity -i.e. the yield output per energy input- in the range of 15%-50% and 25%-100%, respectively (Hernanz-Martos et al, 1997, reported from European Conservation Agriculture Federation website: ECAF). These advantages generally lead to a higher economic efficiency of conservation agriculture compared to conventional agriculture. But those advantages are not always proved. In fact several studies shown that economic return for no-tillage relative to conventional or other conservation tillage systems varies with many factors such as management practices, crop rotation, and labor costs (Dick and van Doren, 1985; Griffith et al., 1988; Guy and Oplinger, 1989). Chase and Duffy (1991) in Iowa found that the economic return for corn under no-tillage was similar to that under mouldboard plow ridge tillage or chisel plow in a corn–soybean rotation when the hourly labor cost was $ 10. Therefore, its competitiveness relative to other tillage systems in the early years of the rotation (first 4–5 years) was maintained later on. The yield decline with no-tillage compared with other tillage systems was within 5% for a corn–soybean rotation, but often greater in continuous corn. However, no-tillage generally had economic return equal to or greater than other tillage systems in each 4- to 5-year phase and over the entire study period (from 1978 through 2001). Therefore, the adoption of no-tillage systems can be accomplished without lowering economic return from both short- and long-term perspectives (Al-kaisi et al., 2004).

- Biodiversity benefits

- Wildlife

Conventional agriculture leaves the soil bare for long periods of time. Lack of quality habitat and sparse nesting cover are a problem for many bird species. In contrast, high-residue crop production systems can provide food and shelter for wildlife at critical times. Several studies have shown that no-till fields have higher densities of birds (and nests) and are used by a greater variety of bird species during the breeding season than tilled fields (Best, 1995) Indeed, conservation agriculture provides better feeding (micro arthropods, wild plant seeds) for birds over a longer period of time, generally resulting in a more diverse and greater population of birds (European Conservation Agriculture Federation website: ECAF).

- Soil fauna.

Soil is hosting numerous and diverse organisms, from microscopic bacteria numbering up to 3 billion per gram of soil to earthworms up to 20 cm in length and numbering up to 9.5 million per hectare (Pautian et al, 1998). The vast majority are beneficial to plant productivity through their effects on soil formation, nutrient availability and biological control of pest organisms. Conservation agriculture systems allow the development of a more stratified soil structure that supports a greater abundance and diversity of soil organisms such as microorganisms, nematodes, earthworms and microarthropods (European Conservation Agriculture Federation website).

4.1.2 Agroforestry and intercropping

4.1.2.1 Sylvoarable Agroforestry (SAF)

Agroforestry Is based on the deliberate combination of trees and agricultural crops on the same land unit in some form of spatial arrangement or temporal sequence such that there are significant ecological and economic interactions between trees and agricultural components (Sinclair, 1999). Recent findings (SAFE project website) indicate that modern SAF (Silvoarable Agroforestry) production systems are efficient in terms of resource use. Therefore they are proposed as innovative agricultural production systems that can be both environmentally friendly and economically profitable in the context of EU agriculture. This would improve farming systems' sustainability and diversify farmers' income as well as provide new products to the wood industry, and create novel landscapes of high value (Palma et al, 2004).

The analysis conducted in the SAFE project shows that the investigated tree species could grow productively in SAF systems on 56% of the arable land throughout Europe (potential productive tree growth area). 80% of the European arable land were classified as potential risk areas for soil erosion, nitrate leaching and landscape diversity. Overlaying potential productive tree growth areas with the arable land, which were considered as environmental risk areas yielded target regions. They were found to represent about 40% of the European arable land among which SAF could contribute to soil protection on 4%, to mitigate nitrate leaching on 18% and to increase landscape diversity on 32% of European arable land (Reisner et al, 2005). Palma et al. (2004) predicted that with the SAF system soil loss will decrease by 80% compared with the existing arable system. Economic analysis showed that the NPV (Net present value) of densely planted, but widely spaced silvoarable systems could be similar to the NPV of existing arable systems.

SAF can reduce water losses and pollution of water by pesticides and nitrogen by reducing water runoff and drainage (Knight et al, 2002; Strizaker et al, 2002; Wallace et al, 1999). Originally, SAF was developed to improve nitrogen cycling and erosion control in the humid tropics regions (Connor, 2004). Later, it has also been proposed for incorporating trees into arid and semiarid agricultural areas to reduce soil evaporation, runoff and deep drainage (Knight et al, 2002). The key challenge of the SAF is to adopt strategies that will make optimal use of water available and nitrogen mainly in semi and arid agricultural areas where the runoff, drainage and evaporation of soil can be higher, e.g. in the semi-arid regions of the West Africa, direct soil evaporation from sparse barley or millet crops can account for between 30% and 60% of rainfall (Allen 1990, Wallace, 1991). Wallace et al (1999) showed that on the same regions and on annual basis a tree canopy can reduce soil evaporation by 35%, which is equivalent to 21% of rainfall.

For conserving surface water quality, several researches have demonstrated that inclusion of trees within the agricultural systems can improve water quality (Lowrance, 1992; Franco et al., 2001) and associated agroforestry with grass strip within the agricultural systems can reduce nitrogen in groundwater by 68% to 100% and in surface runoff by 78 to 98% and phosphorus concentration in surface waters by 50 to 85 % (Osborne et al., 1988).

SAF may have a fundamental impact on biodiversity. Trees very quickly attract all kinds of animals, insects and plants back to farm land. In return this may have positive effect on the cropping system. Various auxiliary species (those that prey on pests) have returned to fields converted into SAF, including insect-eating birds, bats, and insects such as syrphus flies whose larvae have a big appetite for aphids (Dupraz, SAFE website). Nevertheless this increased biodiversity could also have negative effects, such as encouraging the return of rodents, slugs and other harmful species (Palma et al, 2004).

Like all integrated cropping systems, SAF requires skillful management and careful planning. Both the crop and the trees have specific requirements which implies trade-offs between them. If either crop requires chemical herbicides or insecticides, the other must be tolerant of these treatments. This example indicates how crucial planning is to the ultimate success of an agroforestry system. Competition for water between the pasture and the trees may be a concern. For example, in a silvopasture with nut trees, seasonal water shortages during late summer can negatively affect nutfill and the production of fruit buds for next year's harvest. Irrigation is justified in such a situation if the trees are being managed for nut production. Occurrence of shallow water tables in which the trees can extract moisture, but not the crop, may also be a key factor in the performances of SAF (C Dupraz, personnal communication).

4.1.2.2 Intercropping

Intercropping, the practice of growing two or more crops simultaneously on the same land area (Vandermeer, 1989), represents an option to improve sutainability of cropping systems (Brummer, 1998; Altieri, 1999).

In annual crops the most common reason for the adoption of intercropping is yield advantage, which is explained by the greater resource depletion by intercrops than monocultures, particularly when cereals and legume crops are grown together (Vandermeer, 1989; Ofori and Stern, 1987; Fukai and Trenbath, 1993). Cereal crops form higher canopy structures than legume crops, and the roots of cereal crops grow to a greater depth than those of legume crops. This suggests that the component crops probably have differing spatial and temporal use of environmental resources (Willey, 1990; Ghosh et al., 2005).

The reduction of weed growth by crop interference, has been referred as another determinant of yield advantage of intercropping, being a viable alternative to reduce the reliance of weed management on herbicide use (Liebman, 1988; White and Scott, 1991; Liebman and Dyck, 1993; Midmore, 1993; Liebman and Davis, 2000).

Furthermore, the multifunctional profile of intercropping allows it to play many other roles in the agro-ecosystem, such as resilience to perturbations, protection of plants of individual crop species from their host-specific predators and disease organisms, more competition towards weeds, improved product quality and reduced negative impact of arable crops on the environment.

Nitrogen fixing legumes can be included to a greater extent in arable cropping systems via intercrops. Legumes contribute to maintaining the soil fertility via nitrogen fixation, which is increased in intercrops due to the more competitive character of cereals for soil inorganic N. This leads to a complementary and more efficient use of N sources. Intercropping of grain legumes and cereals therefore offers an opportunity to increase the input of fixed nitrogen into agro-ecosystems without compromising cereal N use, yield level and stability (from the Intercropping of cereals and grain legumes European project Website).

In perennial crops such as vineyards (Gary et al, 2005) and orchards the promotion of intercropping (with legumes, cruciferae, grasses or mixtures) could be justified by the following reasons (Celette et al., 2004; Hauggard-Nelson et al., 2004; Jensen et al., 2004):

1- Improvement of fruit quality (especially in vineyards). This objective can be reached through the effect of the associated grass or mixture on the development of an optimal water and nitrogen stress at key stages of yield and quality determination across the vine cycle.
2- Reduction of herbicide use, nitrate leaching and soil erosion by continuous land cover and reduction of runoff.
3- Increase of soil fertility and reduction of nitrogen fertilisation by the beneficial role of roots and residues of the intercrop on soil structure, biodiversity and biological activity.
4- Reduction of pesticides use if the intercrop is properly chosen and managed to stimulate insects, fungy and nematodes which prey on disease and pests of the crop.
5- Reduction of cost of production associated to the above advantages or to the reduction of tree or vineyard vigour.

Several experiments on intercropping system involving many rainfall regimes, soil types and crop management proved that intercropping system can increase water saving by reducing evaporation, runoff and drainage and by improving water utilisation efficiency (Ozier-Lafontaine, 1997; McIntyre et al., 1997; Walker et al., 2003; Bavec et al., 2004; Jensen et al., 2004). The capture and utilization of water by sole and intercrops are compared by decomposing crop production/unit area into uptake/unit area (capture) and production/unit uptake (utilization efficiency) (Morris, 1993). Comparisons are made by contrasting data from the intercrops against weighted means from the sole crops, with weights based on the proportion of each species in the intercrop. Water capture by intercrops differs from water capture by sole crops only slightly (usually between −6 and +7%). Water-utilization efficiency by intercrops, however, greatly exceeds water-utilization efficiency by sole crops, often by more than 18% and by as much as 99% (Morris, 1993). In Mediterranean region, Celette et al (2004) showed that the introduction of grass cover in vineyards in southern France did not lead a higher water stress for the vine.

In general, when two or more crops are growing together, each must have adequate space to maximize water use and minimize competition between them. To accomplish this, four things need to be considered (Sullivan, 2003):

1) spatial arrangement (Grossman et al., 1993; Rodrigo et al, 2004),

2) plant density: Willey et al (1972) found that the greatest intercrop advantages in a maize-common bean intercrop were obtained at higher plant populations than those required for maximum yields of sole crops. The proportions at which intercrop components are sown may be of great significance in determining water and production efficiency of cereal–legume intercrop systems (Ofori and Stern, 1987; Tsubo et al., 2005),

3) maturity dates of the crops being grown: Nordquist and Wicks (1974) reported that corn dry matter was reduced by up to 47%, and grain yield was reduced up to 31% when alfalfa (Medicago sativa L.) was inter-seeded at the time of corn planting. However, corn yields were unaffected when corn was intercropped with alfalfa seeded 4 weeks later (Vrabel, 1981) or when corn is intercropped with legumes or grass such as rye and reygrass (Zhou et al, 1999),

4) plant architecture: plants with different aerial and subterranean architectures growing on the same fields might increase the resource use efficiency for light, water, and nutrients (Mason et al., 1986; Sullivan, 2003).

Intercropping systems can make more efficient use of nutrients than crops grown separately. Thus, it is possible to increase N uptake, thereby reducing potential nitrogen leaching by winter rains (Zhou et al, 2000; Jackson, 1993). Intercropped annual or perennial crops with grass species (Steenvoorden, 1989; Jackson, 1999) or legumes (Scott et al, 1987; Ranells and Wager, 1996) characterised by its high dry-matter production and extensive root system, decreases the loss of nitrogen through leaching, by uptake of soil nitrogen (Zhou et al, 2000). Also the ability of the legume crops to absorb and recycle the nitrogen can be exploited in the principal crop productions systems to decrease nitrogen accumulated in soil and nitrogen leaching (Scarpello et al, 2004; Seddaiu et al, 2004). Zhou et al (2000) showed that the association corn-ryegrass decreased soil nitrogen content on the first metter depth of the soil profile in the fall and less denitrification due to intercropping, demonstrating that this system, especially when ryegrass has a good growth later in the season, may be an effective practice for increasing soil N uptake and reducing N losses, without reducing corn grain yield, at least when adequate N and moisture are available.

Despite all its advantages, intercropping has largely been ruled out by the development of plant breeding, mechanisation, fertiliser and pesticides during the last 50 years. As indicated by recent results on legume-cereal associations (Intercropping of cereals and grain legumes European project Website), on vineyards (Gary et al., 2005) and the extensive use of this practice in orchards, intercropping may become compatible with modern agriculture if environmental impacts and quality of the products are considered.

4.1.3 Integrated grassland management

4.1.3.1 Definition and stakes

Management is often call « the fourth production factor ». It is usually defined as the process of allocating and utilizing resources to achieve specific goals through proper analysis, decision making, planning implementation, monitoring and control (Duru and Hubert, 2005 and Vellingra, 2004). It has a great impact on agricultural (economic) and environmental farm performances. It should be assessed at this level. Designing grassland management practices well fitted to primary production factor (land, labour and capital) could be a way for innovations.
The importance and complexity of management has increased greatly during the last decades because of the changing decision environment (many regulations coming from European politics) and the consideration of multifunctionality of grasslands.

Integrated management corresponds to an optimisation at farm level of:

- different fluxes of matter within farm and between fields (forage, animal dejections….)
- land use allocation to different type of animals or of crops, or grasslands to different set of animals
- different inputs (applying fertiliser to particular set of grasslands, giving concentrates to particular sub set of animals…..)

These allocations (land, input) are potentially more diversified when there was great heterogeneity within a farm, i.e. type of soils and field characteristics (slopes, orientation…).

Integrated management is justified by expected economical (returns) or social (less labour) benefits, but it often leads to environmental benefits. In that sense integrated grassland management is a form of sustainable agriculture. For example, habitat heterogeneity (number of crops…) is associated with higher biodiversity (invertebrate, birds…); a mosaic of different fields connected by noncropped habitat help species persistence and biodiversity (Benton, 2003). Most often, integrated management corresponds to farming systems combining the best of traditional farming with appropriate modern technology and monitoring at farm level.

For mixed farming system, the key point is the complementarity between crops and grassland: crops grains and residues could be used to feed animals and manure could be used to fertilize crops.
For integrated grazing system, 2 key points must be considered:
- efficient use of nutrient:
- efficient use of diversity in vegetation type, and in topologic and topographic plots characteristics, particularly for farms located in harsh environment

Research most often fall to give relevant insights because studies are not made at the right scale (most often field and not farm), or they focus separately on each of the main management practices (grazing, cutting and N fertilizer).

Studies on grazing have most often been conceived in a perspective of optimisation in order to maximize efficiency of fertilizer use or herbage utilisation, each variable being considered alone. Agronomists have tried above all to optimise the use fertilizer inputs from the point of view of production, by calculating the N recovery. On the other hand, researchers working on the grass-animal interface have tried to optimise livestock production by defining appropriate stocking levels (Béranger, 1985) and, since some decades, by defining optimum states of sward which allow high grazing efficiency level (ratio of herbage intake to herbage growth) (Hodgson, 1985 and Parsons, 1988). To define optimum management, “management indicators” (herbage nitrogen index, height of sward) have a far more general value than the definition of norms (quantity of nitrogen, stocking rate) which depend on local situations. Yet these references have always been conceived in a perspective of technical optimisation of the use of inputs (herbage mass per fertiliser unit) or of herbage growth (animal ouput per unit of herbage growth or of standing herbage mass).

4.1.3.2. Optimizing nutrient fluxes

In grasslands optimization of nutrient fluxes can be obtained with the following management techniques :

- Avoiding cases where fertilizer lead to luxurius plant nutrient status: a critical mineral content in relation to the quantity of accumulated herbage mass (Lemaire and Gastal, 1997) has been used to make crop N diagnosis independently of sites and years by defining, for example, a quantity of nitrogen required to maximise production, and above which N losses in the environment is increased (Jarvis, 1998; Jarvis et al., 1996).

Use of spreadsheet to establish a balance of nutrient fluxes in the plant, soil and animal components taking into account inputs (fertiliser, purchases of concentrates), outputs: leaching, volatilization, effluents losses, storage in the soil, and management variables (manure utilisation, storing). Nutrient balance calculations basically compare nutrient inputs with nutrient exports from a farm or a region. Different levels of detail are possible. For example, inputs and exports can be assessed in detail based on production parameters or standard values can be used. The appropriate level usually depends on the availability of input data and the background of the user. The model should be flexible enough to account for this.

In the N balance approach various types of factors have to be considered to calculate the balance:

* Factors that can be reliably quantified at farm level (e.g. breed, production, feed intake and composition, crop yield).
* Factors which cannot be quantified for individual farms, but for which reliable regional recommendations or statistics exist (e.g. nutrient demand of crops).
* Factors for which only qualified expert assumptions are possible.
* Factors that cannot be reliably quantified.

Factors in the first two categories must be integrated as variables that can be filled in by the user. For factors of the third category, region-specific expert assumptions must be integrated and factors of the last category must by omitted as long as no more reliable data is available. Furthermore, modellers must consider that the model should be appropriate for a wide range of user needs and backgrounds.

4.1.3.3 Choosing relevant consistency between fertilizer and grazing practices during key periods

By combining the two main action variables, fertilisation and utilisation, it is possible to define diverse management modes whose effects can be evaluated on the net production of herbage mass and its composition, and on the efficiency of the harvesting and use of nutrients. Intensive grassland management allows for high grazing efficiency, at least as long as the value of the residual leaf index does not hinder growth, whereas de-intensification, by reducing either inputs or intensity of use, enhances the nutrient use efficiency. We present below the state of the available knowledge about the biological mechanisms that can be steered by these two levers to manage grazing in different chosen ways.

The proportion of nitrogen application in the form of fertilisers found in the aboveground herbage mass decreases with the increasing quantity applied. The result is an increase in risks of loss by leaching and volatilisation (Jarvis, 1998). Furthermore, the efficiency of mineral elements (production of herbage mass by unit of nitrogen or phosphorus absorbed) increases when the dose applied decreases and when the growing period increases. Thus, the target of a non-limiting nitrogen nutrition level of the grassland necessarily leads to an accumulation in the soil of unconsumed nitrogen, likely to subsequently be lost. Low grazing frequency and small fertiliser inputs are therefore two factors favouring the efficient use of nutrients.

For a given grassland species, an optimum defoliation regime to maximize grazing efficiency has been defined. When the grazing height is too low, growth is reduced due to a leaf area index that is too low to capture the incident radiation, but beyond this threshold, reducing the intensity of use, either by lengthening the interval between defoliation or grazing, or by increasing the residual height after grazing, results in greater losses by senescence (Davies, 1988), in other words reduced grazing efficiency (Lemaire, 1999) and hence of stocking density (Hodgson, 1985 and Parsons, 1988). This type of farming is also concomitant with a reduction in the quality of the grass offered, either due to lignification of the tissue related to longer growth time, or due to a less favourable anatomic composition (Wilson, 1976) related to the length of the sheath estimated through the height of the grass (Duru *et al.*, 1999). Thus, variations in the intensity of use, either above or below the optimum, reduce grazing efficiency. Reduced nitrogen fertilisation also reduces grazing efficiency in so far as the rate of senescence remains the same whereas the production of herbage mass is reduced.

Consequently, it is not possible to simultaneously achieve both high grazing and N use efficiency regardless of the frequency of grazing events. Moving from frequent defoliation (intensive set-stocking) towards rotational grazing management by widening the defoliation interval increases the N use efficiency without decreasing grazing efficiency. In other words, net herbage growth can be the same while the N requirement for herbage growth decreases. A second option is to reduce the N fertilizer supply, particularly for short intervals between defoliation events. As it leads to a decrease in grazing efficiency, this option needs an increase in allocated grazing area which needs to be proportionally larger than the reduction in N supply.

These general trends need to be understood because it is possible to maintain high grazing efficiency by varying the grazing interval length. Compromise solutions may have to be found which may differ according to the season, the farmer's objectives (grazing season length), the amount of resources (available grazing area per cow) and the risk of N leaching. Several management strategies could be designed. These compromise solutions will be easier to find if it is expected to achieve optimal solutions having different aims throughout the whole growing season.

4.1.3.4 Building and maintaining biodiversity through management practices

Apart from its importance as a natural heritage (Nösberger and Rodriguez, 1998), biodiversity can have a functional role in livestock production.

**** Functional role at plant community level***

Specific diversity within a plant community gives it an advantage regarding its use by animals. At field plot level this means that grassland management no longer has the only aim of herbage off-take but also of maintaining or changing the botanical composition (Stuth et al., 1997). These changes can be brought about by the introduction of new species or regression in the quantities of existing species. Agricultural practices (fertilisation, defoliation) have a direct effect on survival rates of seedlings of species likely to grow there, on fertility rates of species already present, and indirectly on competitive relationships between these species. On a larger space scale, biodiversity is also a way of preserving those species which enable the botanical composition to evolve through the creation of different types of pasture with different characteristics in terms of the production levels of herbage mass and its composition.

**** Functional role at farm level***

In grassland zones dominated by natural pastures, an important component of this biological diversity corresponds to the diversity of grassland species. This diversity is generally assessed at the field level (Grime *et al*., 1988; Bakker *et al*., 2004), between farms or across regions (Tenail and Baudry, 2004). These questions are particularly relevant in mountainous zones where the areas used for farming are constituted almost exclusively of (semi)natural grasslands (Flamant *et al*., 1999). In these situations, grazing or cutting operations make it possible to feed domestic herbivores, but are also a mean of preventing ligneous species from colonising these environments (Landsberg *et al*., 2003). The farm territory is considered by farmers to allocate land for a given use, linking it to field characteristics, because coordination of their decisions are made at this level (Papy, 1999). Thus, evaluating and predicting the impact of European policies on biological diversity requires to <u>consider the farm level</u> and assessing this diversity on the between-and within-farm scales. It is therefore at the between-field scale that management rules are likely to have an influence on the diversity of grassland vegetation.

In summary, the diversity in grassland vegetation types was a result of attributing different functions to the fields which led to different management practices (farming methods and fertilisation). Consequently, in farms where animal feed requirements vary according to the time of the year and according to the group of animals, we can put forward the hypothesis that diversity in the grassland vegetation types is a sound component of these livestock systems. Topographic and topologic constraints determine which grassland field vegetations can occur but these criteria are not sufficient. These findings agree with the lessons drawn by Stuth and Maraschin, (2000). Grassland managers aim to optimize vegetation growth over their entire grazing or cutting area, but also through time. Furthermore, White *et al*. (2004) insist on the need for greater vegetation diversity as spatial and temporal scales increase (from field to farmland; from a season to a year) particularly where there is considerable variability in soil type, slope, elevation, aspect and climatic conditions. In other words, grassland vegetation diversity has a functional role in farmland management, and this role of diversity could only be assessed over the entire managed area at farm level. As quoted by White *et al*., (2004), a functionally diverse plant community over the entire managed area should be promoted beside high localized species diversity within grasslands as done usually.

Grassland management in systems relying on heterogenous grassland-resources consists in a large set of strategies, tactical and operational decision rules, nested into a complex hierarchical system. The year-round sequence of grazing/cutting operations of each field is arranged in reference to the specific functions the farmer has for the particular field in the grassland system. In their decision rules for allocation of the functions and sequences to the various fields, farmers take into account both field-related and management period-related factors (Girard *et al*., 1999). They consider grass growth patterns which differed between vegetation types (Duru *et al*., 2005), but they also rely on a variety of additional issues, such the strategic and tactical options for the organisation of hay or silage harvesting at the farm level; the options for the arrangement of the herd into functional grazing groups in the different periods in the grazing season (Coleno *et al.*, 2005).

**** Assessing externalities at landscape level***
Landscape is most often constituted of a patchwork of biotopes in relation to land use. That corresponds to a diversity of crops and grasslands (modern agricultural landscapes in favoured areas having livestock system), and diversity of vegetation types between and within grasslands (traditional cultural landscapes in les favoured areas dominated by (semi)natural grasslands).

Anyway, the landscape could be considered as a mosaic which combine both spatial and temporal diversity (Bignal and McCracken, 2000). In a spatial context agricultural practices produce a patchwork of biotopes in relation to the nature of crop or grassland (meadows, pastures….) in modern agricultural landscapes, and a set of vegetation types in traditional cultural landscapes. In the latter, diversity comes the fact that in a temporal context, not all grasslands are managed in the same way at the same time leading to several levels of standing herbage mass. Farm level cannot be ignored because in a farming context, land use depends on the practicability of farming and on the reality of farm economics. Both leads to large differences in farm management, in such a way that farm typology, taking account differences in land use as described above, is needed.

4.2 Organisational innovations

In many regions and particularly in less favorable ones - in which costs of production are higher because of geomorphologic and climate conditions - a goal for the future is to support an agriculture able to maintain the landscape, a rich biodiversity and a high quality of water resource. Thus, the evolution of farmers income and farming practices will play a major role for the future of these landscapes. Apart from environmental subsidies, the income depends on diversification of the farms activities and/or added value of the agricultural products. Added-value can be created thanks to the quality of products *(Lagrange & Valceschini, 2000)* linked to particular practices and it could be a chance for many regions especially when quality can be linked to specificities of the landscape

Specifications associated to indications are means to manage the quality of products and to provide a signal towards the consumers, particularly for traditional products. They offer the opportunity of a special market for agricultural products and provide a possibility to get higher prices *(Lacroix & al, 2000)*.

Protected Designation of Origin (PDO) and Protected Geographical Indication (PGI) are geographical indications defined in European Union Law to protect regional foods. The legislation came into force in 1992 *(Council Regulation, 1992)*. These geographical indications are based on the hypothesis of an effect on the quality due to the interactions between specificities of the environment (climate, soil) and local and collective know how. For herbivorous animal products, this relation between environment and quality goes through the diversity of plant species in the diet *(Coulon & Priolo 2002)* and could be related to the biodiversity in the meadows.

Moreover geographical indications include specifications which define the authorized techniques at the farm level and in the processing technology. These specifications are often related to environmental factors and can be a mean of internalization of environmental externalities. For instance, in the case of PDO cheese, specifications are more and more strict and can lay down : banning of silage (grass silage), stocking rate limit, banning of GMOs in concentrates and limitation in their use, choice of traditional local breeds, etc. In the same way, for fruits production, specifications can involve limitation of irrigation, of pesticides use etc.

Thus, this way of quality management could appear as a mean to progress toward sustainable agricultural development in the economic, social and environmental dimensions. It can provide economic results which allow to maintain farms even in less favorable situations, it gives an opportunity to develop or sustain rural employment and can contribute to improve environment. But it also requires skills in management of the whole system (farming, technology processing and marketing) to reach success on both axis: economic (success on the markets, balance between added value and costs of production) and environmental (high environmental value due to specifications).

4.3 Combination of technical and organisational innovations

4.3.1 Organic farming

The development of organic farming in Europe is one of the ways to integrate environmental conservation practices into agriculture, while promoting food quality and reducing surpluses. Today's consumers are increasingly calling for access to information on how their food is being produced - 'from farm to fork' - and are looking for insurance that due care with regard to safety and quality has been exercised at each step in the process.

Available data (table 14) from the KASSA project show that zero tillage (NT), organic farming (OA) and GM crops (GMOs) have grown to several million hectares during the last decade, mainly in North and South America and Australia (table 15). The same table shows that about 84% of NT areas are in America (36.7% in North America, 47.5% in Latin America), 12.5% in Australia and only 1.2% in Europe. The most significant OA areas are in Australia (46%), Argentina (14%) and Italy (5%) while the OA area represents about 22% of the total in the whole of geographical Europe . 96% of GM crop areas are in the Americas: 68% in the USA, 22% in Argentina and 6% in Canada where there was a slight decrease between 1999 and 2001.

Table 15. Main no-till (NT) organic agriculture (OA) and GMOs crops adopters in the word. (KASSA, 2005)

	NT (2001/2002)		OA (2003)		GM crops (2001)	
	Area (x 1000 ha)	%	Area (x 1000 ha)	%	Area (x 1000 ha)	%
USA	22 410	31.1	950	4.2	35 700	67.9
Cairns group	47 103	65.4	15 457	67.8	15 200	28.9
Mercosur	33 406	46.4	4 208	18.4	11 800	22.4
Europe	9 554	13.3	5 000	21.9	Lees than 200	-
World	72 069	100	22 811	100	52 600	100

The first regulation on organic farming (EEC, 1991) [Regulation EEC N° 2092/91] was drawn up in 1991 and, since its implementation in 1992, many farms across the EU have converted to organic production methods. The conversion period is a minimum of two years before sowing annual crops and three years in the case of perennials. In August 1999 rules on production, labelling and inspection of the major animal species (i.e. cattle, sheep, goats, horses and poultry) were also agreed (EC, 1999) [Regulation EC N° 1804/1999]. This agreement covers such issues as foodstuffs, disease prevention and veterinary treatments, animal welfare, husbandry practices and the management of manure. Genetically modified organisms (GMOs) and products derived from GMOs are explicitly excluded from organic production methods.

Cropping activities in organic farms are defined by EU regulations N°. 2092/91 and in part by N° 1804/99 (EC, 1999). They are characterised by
i) Abandonment of mineral N-fertiliser compensated by higher input of manures and wider crop rotations with cultivation of legumes, green manures, etc. or higher stocking density
ii) Abandonment of synthetic pesticides compensated e.g. by the use of species or varieties more tolerant to disease and pests, stimulation of natural enemies, mechanical weed control, etc.
iii) Livestock reared preferably by feed from the unit, resulting in a higher requirement of arable forage, grassland or a reduced stocking density.

Based on an extensive farm survey in 2000, Häring et al (2003) have analysed, the impact of organic production methods in EU on farm structure, in comparison with conventional farming (Figure 14). Major characteristics of organic farms are :

• A lower share of cereals,
• A higher share of pulses,
• A lower share of root crops,
• A higher share of forages and leys,
• A higher share of permanent grassland,
• A lower share of other (intensive) land uses (vegetables, fruits, olives, vine, nurseries, permanent crops under glass and other permanent crops).

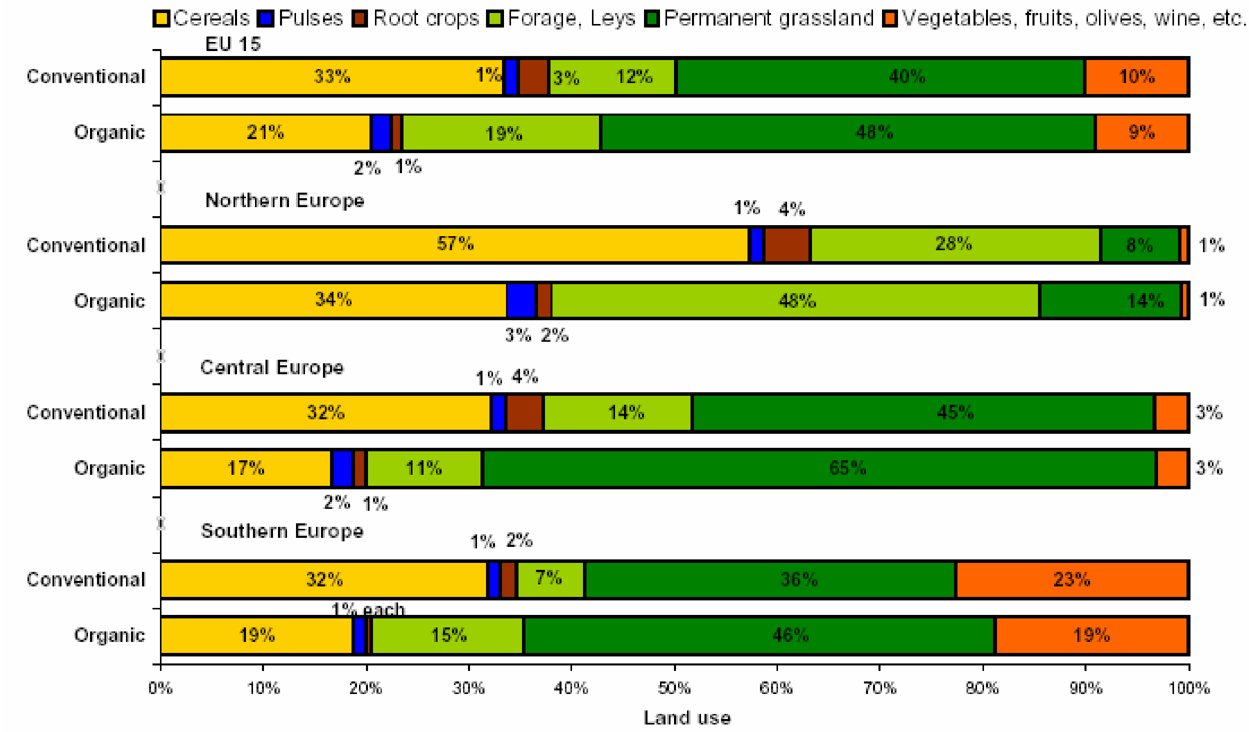

Figure 14: Land use in organic farms compared to coventional farms in Europe (Häring et al, 2003).

Organic farming can reduce the cost of crop production by reducing the cost of the pesticide and herbicide inputs. On the other hand, the increasing use of these input in conventional farming systems may make them progressively uneconomical (Upadhya, 1996). For example, the output /input ratio for wheat decreased from 16/1 to 7/1 between 1980 and 1995. This is primarily due to the constant increase of input quantities of chemical fertilizers needed to sustain the same level of output.

In the same way, Reganold et al (2001) have compared the economic and environmental sustainability of organic, conventional and integrated apple system in Washington State from 1994 to 1999. All three systems gave similar apple yields. The organic and integrated systems had higher soil quality and potentially lower negative environmental impact than the conventional system. When compared with the conventional and integrated systems, the organic system produced sweeter and less tart apples, higher profitability and greater energy efficiency. In this study the organic system ranked first in environmental and economic sustainability, the integrated system second and the conventional system last. Nevertheless, the large diversity of cropping systems inside each of the three categories make it difficult to generalize this type of results.

By suppressing the major source of pollution of water, i.e. the pesticides and especially the herbicides, organic farming is a practical solution to protect water ressources, used for example today by companies such as Perrier-Vittel (Wery et al, 2002; Gay et al, 2003). It is therefore frequently argued that the absence of mineral fertilisation in organic farming cannot allow a fine tuning of nitrogen availability and extraction by the crop. This means that organic farming would lead to excess of organic nitrogen fertilisation and therefore excess of nitrate leaching to maintain high yields especially in vegetable production. In practice, several studies have shown that organic farming, except in regions with a too high density of animals, does not lead to overfertilisation and increased nitrate leaching (Deffontaines et al, 1997; Arnaud et al, 2001; Gay et al, 2003), probably for the following reasons :

- high cost of fertilisers in organic farming (up to 5 time higher than in conventional agriculture)
- avoidance by the farmers of overfertilisatiions to reduce plant suceptibility to disease and aphids.

4.3.2 Present status of these technical innovations in the Test case regions

4.3.2.1 Neste

- Conservation agriculture

In France, the south-western part (where Neste is located) is the area where the establishment of crops without ploughing is the most developed (Agreste primeur, 2004). Nevertheless, it doesn't exist, for now, an accurate survey of conservation agriculture practices in the Neste system and Midi-Pyrenees.

The experts 'opinion of departmental and regional agriculture house, and the results of a general study (see Agreste primeur, 2004), estimate that 60 to 90 % of winter cereals and 10 to 15 % of the sunflowers are established without deep ploughing. Corn should be the crop showing the weakest rate of establishment under these conditions since it needs a deep rooting.

- Organic production

Since several years, Gers has been the 6th French department in term of organic production area and it is among the major ones for organic cereal production. In 2004, more than 13 400 ha were grown organic (i.e. 3% of the AAU vs 2.7% in Midi-Pyrenees and 1.9% in France) by 254 farmers in the Gers department. The major cultivated crops were cereals (38%), oleaginous and protein-rich plants (35 %) and forage (15%) (Agence française pour le développement et la Promotion de l'Agriculture Biologique, 2005). With the implementation of the CTE between 1999 and 2002, the number of farms converted to organic agriculture doubled (La volonté paysanne du Gers, 2003). However, since 2003 with the CTE cessation, the important annual increase of number of organic farmers and hectare stopped. In the Gers, this trend is confirmed by the strong decrease of hectare actually in conversion. Despite everything, contrary to France, Gers presents always a little annual increase of its organic acreage in 2004.

4.3.2.2 Pyrzyce

Share of organic farms in Polish agriculture is very low and its increase is rather slow, although the number of organic farms in Poland was constantly rising since 1990. There are two main factors limiting their expansion. Firstly, demand for ecological products is rather low. Secondly, existing organic farms are scattered throughout the whole country which makes creation of distribution channels more difficult. However, introduction of financial aid offered to organic farms caused an up-swing of interest in this type of production observed between years 1999 and 2000 (Figure 15). Significant rise in number of farms was observed in 2004 after CAP introduction and implementation of financial support measures. Presently the number of organic farms (certified and in conversion) in Poland is 3760 which represents about 0.2% of the total number of farms in Poland (about 1.6 million).

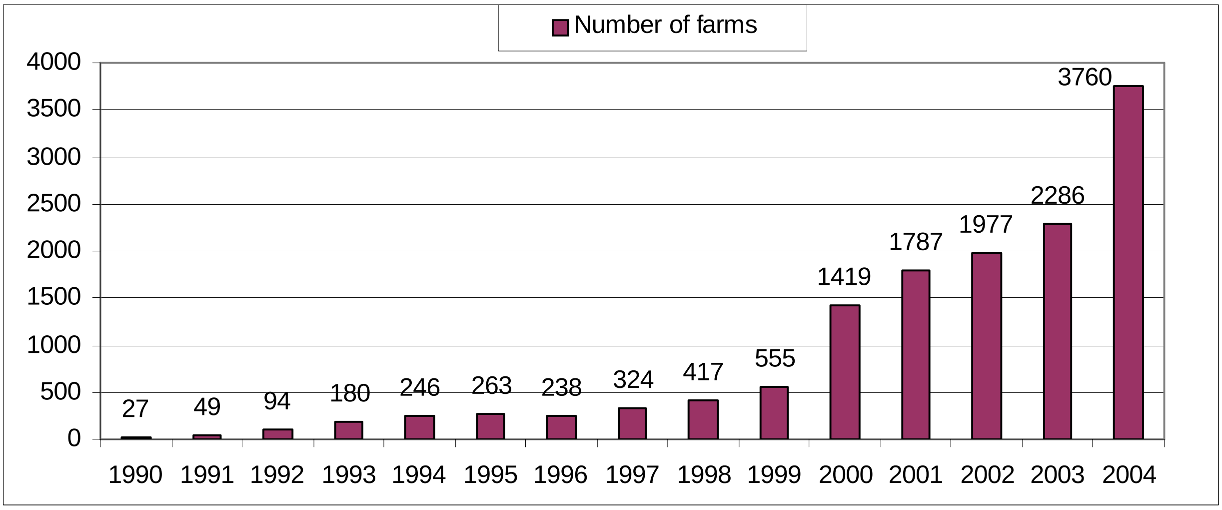

Figure 15. Number of organic farms (certified and in conversion) in Poland (1990 – 2004) (Rolnictwo ekologiczne w Polsce w 2004 roku, Warszawa, 2004).

Presently there are organic farms in every region of Poland, however their number varies among regions (Appendix II). For instance, there are only 16 certified organic farms in Opolskie, while at the same time there are as many as 302 in Swietokrzyskie. In the Zachodniopomorkie region (The Pyrzyce is part of this region) contain 106 farms in conversion and 70 certified farms (table 16).

Table 16. Number of organic farms certified and in conversion in Poland by regions (1999-2004) (Own calculation basing on: "Rolnictwo ekologiczne w Polsce w latach 1999 – 2000", Warszawa 2001; "Produkcja rolna metodami ekologicznymi w 2001 roku", Warszawa 2002; "Rolnictwo ekologiczne w Polsce w 2002 roku" Warszawa 2003; "Rolnictwo ekologiczne w Polsce w 2003 roku", Warszawa 2004; "Rolnictwo ekologiczne w Polsce w 2004 roku" Warszawa 2005

Region	Farms in conversion						Certified farms					
	1999	**2000**	**2001**	**2002**	**2003**	**2004**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Dolnoslaskie	9	24	37	45	58	108	7	9	17	37	52	89
Kujawsko-pomorskie	0	12	24	18	8	31	0	34	35	45	54	58
Lubelskie	99	135	123	91	58	183	19	58	165	162	205	210
Lubuskie	2	8	10	5	4	48	6	8	12	17	16	18
Lodzkie	4	6	8	15	11	38	9	13	16	19	23	33
Malopolskie	8	68	128	180	263	466	19	25	45	86	144	231
Mazowieckie	57	88	125	109	84	243	30	54	106	123	165	191
Opolskie	0	4	10	9	7	10	3	3	3	7	12	16
Podkarpackie	0	18	179	183	159	237	2	2	10	48	129	193
Podlaskie	6	21	40	73	77	117	7	11	16	30	45	90
Pomorskie	4	13	17	16	17	35	11	13	17	23	29	31
Slaskie	13	5	5	24	19	20	36	8	10	12	14	27
Swietokrzyskie	64	159	305	208	121	245	39	50	157	180	261	302
Warminsko-mazurskie	8	26	47	55	59	153	25	29	34	49	67	91
Wielkopolskie	6	14	22	11	8	37	14	17	19	28	32	33
Zachodniopomorskie	*2*	*10*	*29*	*53*	*46*	*106*	*4*	*4*	*7*	*16*	*39*	*70*
Zachodniopomorskie as share of total	*0.7%*	*1.6%*	*2.6%*	*4.8%*	*4.6%*	*5.1%*	*1.7%*	*1.2%*	*1%*	*1.8%*	*3%*	*4%*
Total:	**282**	**611**	**1109**	**1095**	**999**	**2077**	**231**	**338**	**669**	**882**	**1287**	**1683**

Although in Zachodniopomorskie there are only 70 certified farms, this number will rapidly increase because there are 106 farms in conversion in the region (Figure 16).

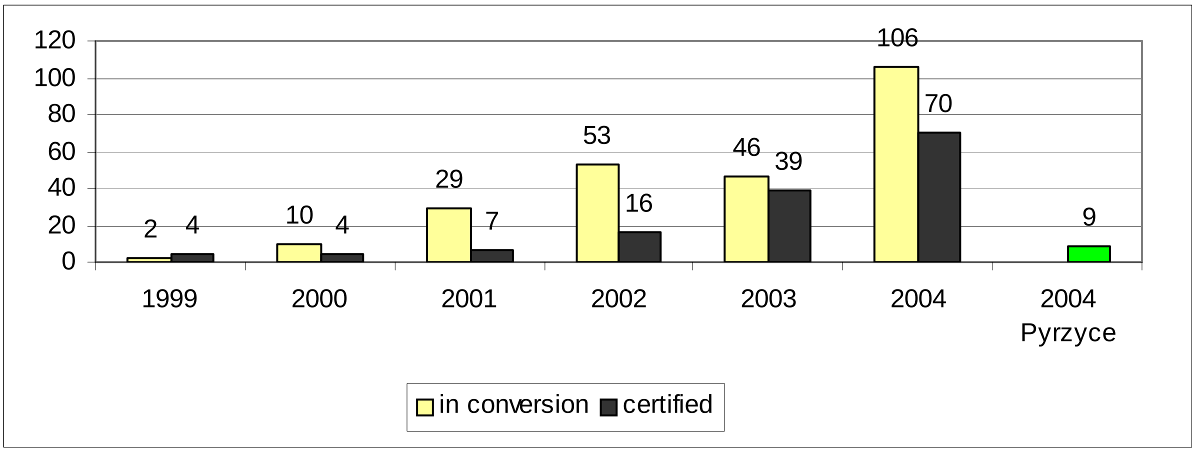

Figure 16. Number of organic farms (certified and in conversion) in Zachodniopomorskie (1999-2004) (Own calculation based on: "Rolnictwo ekologiczne w Polsce w latach 1999 – 2000", Warszawa 2001; "Produkcja rolna metodami ekologicznymi w 2001 roku", Warszawa 2002; "Rolnictwo ekologiczne w Polsce w 2002 roku" Warszawa 2003; "Rolnictwo ekologiczne w Polsce w 2003 roku", Warszawa 2004; "Rolnictwo ekologiczne w Polsce w 2004 roku" Warszawa 2005)

The structure of production in organic farms differs significantly when compared to the structure of production in Poland (figure 17). In certified organic farms share of cereals is significantly lower, while share of permanent grassland is much higher.

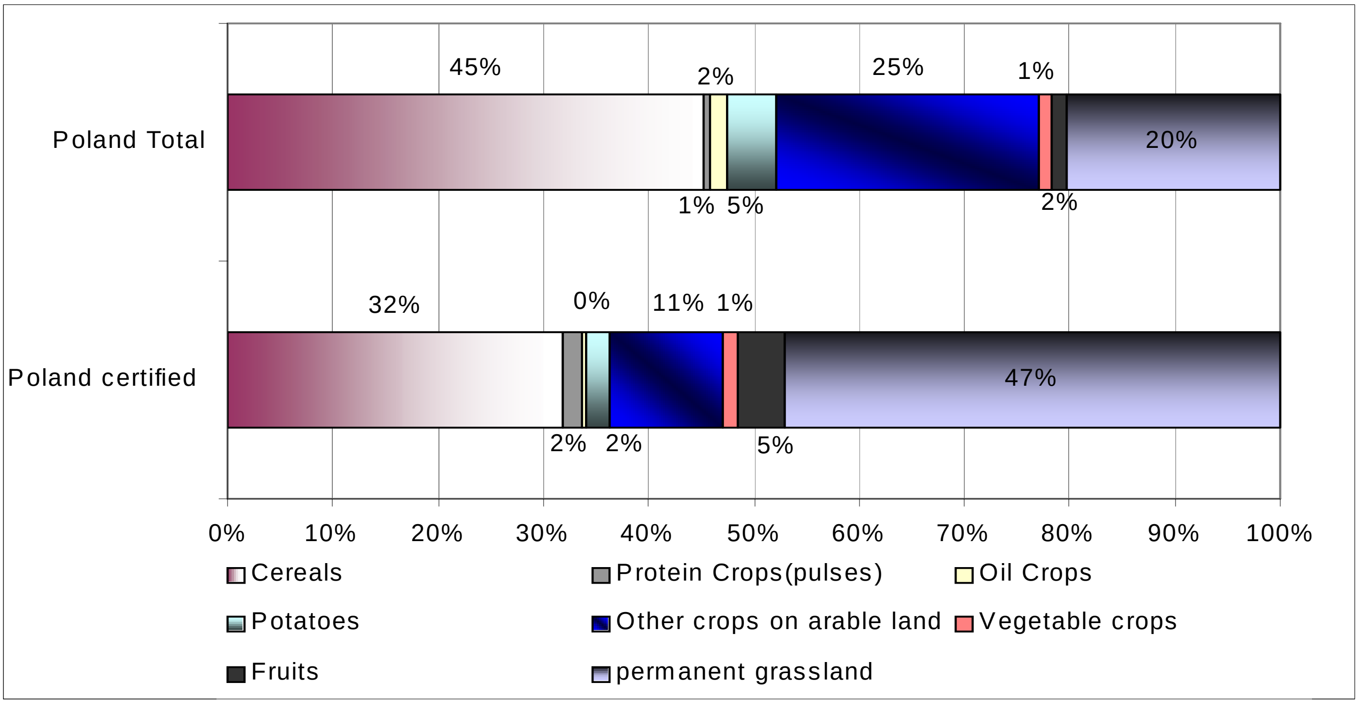

Figure 17. Organic production structure in comparison with the production structure in Poland (2004) (Own calculation basing on "Rolnictwo ekologiczne w Polsce w 2004 roku" Warszawa 2005; Statistical yearbook Poland 2004).

Number of certified organic farms in Zachodniopomorskie was constantly rising, however they still make only 0.2% of total number of farms in the region (Table 17, table 18). Their area covers 0.7% of total farm area in the region. These results suggest that on average organic farms are larger than average farm in the region. This counterintuitive conclusion is explained by the fact that in this region there is one organic farm covering about 600 ha.

Table 17. Number and area of organic farms (certified and in conversion) in Zachodniopomorskie (2001-2004) Own calculation based on: „Produkcja rolna metodami ekologicznymi w 2001 roku", Warszawa 2002; "Rolnictwo ekologiczne w Polsce w 2002 roku" Warszawa 2003; "R o l n i c t w o e k o l o g i c z n e w Polsce w 2003 roku", Warszawa 2004; "Rolnictwo ekologiczne w Polsce w 2004 roku" Warszawa 2005.

		Certified farms			2nd year of conversion			1st year of conversion		
		Number of farms	*Total farm area (ha)*	Arable land	Number of farms	Total farm area (ha)	Arable land	Number of farms	Total farm area (ha)	Arable land
2001	Zachodnio pomorskie	7	*1 414*	1 247	10	*499*	447	19	*2 546*	2 326
	Poland	**669**	***14 967***	**12 862**	**223**	***8 114***	**7 455**	**886**	***21 805***	**18 415**
2002	Zachodnio pomorskie	16	*1 839*	1 635	19	*2 747*	2 307	34	*3 690*	1 697
	Poland	**882**	***24 412***	**20 861**	**505**	***13 522***	**11 491**	**590**	***15 581***	**11 475**
2003	Zachodnio pomorskie	39	*6 032*	4 346	28	*2 309*	1 559	18	*1 148*	970
	Poland	**1 287**	***35 554***	**30 242**	**496**	***14 888***	**11 174**	**503**	***10 793***	**8 512**
2004	Zachodnio pomorskie	70	*7 015*	5 588	25	*1 082*	884	81	*7 444*	6 253
	share in the region	0.2%	*0.7%*	0.7%	0.1%	*0.1%*	0.1%	0.2%	*0.7%*	0.8%
	share in Poland	4.2%	*15%*	14.8%	5.7%	*10.6%*	10.8%	4.9%	*15.5%*	17%
	Poland	**1 683**	***46 817***	**37 724**	**438**	***10 248***	**8 210**	**1 639**	***47 868***	**36 796**

Table 18. Area of certified farms and farms in conversion in Zachodniopomorskie (2002-2004) (Own calculation basing on: "R o l n i c t w o e k o l o g i c z n e w Polsce w 2003 roku", Warszawa 2004; "Rolnictwo ekologiczne w Polsce w 2004 roku" Warszawa 2005)

		Arable crops (ha)		Permanent grassland (ha)		Vegetable crops (ha)		Orchards and berries (ha)		Total (ha)	
		certi-fied farms	farms in conver-sion	certi-fied farms	farms in conver-sion	certi-fied farms	farms in conver-sion	certi-fied farms	farms in conver-sion	certi-fied farms	farms in conver-sion
2002	Zachodnio-pomorskie	1 192	*1 753*	326	*1 321*	2	*20*	7	*83*	1 527	*3 177*
	Poland	**10 371**	***9 832***	**7 989**	***10 295***	**473**	***166***	**883**	***611***	**19 717**	***21 004***
2003	Zachodnio-pomorskie	2 491	*1 048*	277	*627*	19	*10*	28	*94*	2 817	*1 779*
	Poland	**14 139**	***7 602***	**6 167**	***9 566***	**549**	***170***	**1 197**	***538***	**22 001**	***17 645***
20	Zachodnio-pomorskie	1 929	*2 731*	1 854	*3 478*	37	*14*	134	*128*	4 953	*6 351*

	share in Poland	12.1%	*15.6%*	11.7%	*15.1%*	7.6%	*4.1%*	8.6%	*7.8%*	14.6%	*15%*
	Poland	**15 910**	***17 448***	**15901**	***22 960***	**487**	***342***	**1 553**	***1 650***	**33 852**	***42 400***

In the test case Pyrzyce region there are in 2005 nine organic farms (3 certified and 6 in conversion) as presented in table 19.

Table 19. Number and area of organic farms in Pyrzyce region (2005)

	organic farms in Pyrzyce		**all farms in Pyrzyce**	**organic farms as share of farms in the region**	
	certified	**in conversion**		**all organic farms**	**family farms**
number of farms	3	6	2 235	0.4%	0.3%
agricultural land	630 ha	759 ha	57 417 ha	2.4%	0.8%

Number of organic farms in Pyrzyce is very low, because there are rich soils suitable for intensive crop production. This discourages farmers from choosing ecological farming system.

4.3.2.3 Massif-central

- Geographic indication labels production

The bovine productions represent 70% of the agricultural production of Cantal (DRAF, 2004), ie 38% for slaughtered animals, 27% for milk and 5% for calves.

With 149 000 suckled cows, Cantal is the second department of Auvergne, which totalizes 11% of the national livestock. These cows produce 100 300 grass calves which are mostly exported in Italy and Spain and fattening is not important. But, in Aubrac region, heifers and beefs are fattened with specifications, to produce high quality meat : 'Race Aubrac' (red label) and 'fleur d'Aubrac' (certified quality).

The dairy production in Auvergne represents only 5% of the national production, but the region is the first one for PDO cheeses with a total near 25% of the french production (DRAF, 2005). Cantal department produces 29 091 T (ie 78% of the regional production), particularly in the four natural regions used for the Test cases: Monts du Cantal, Margeride, Planèze de St Flour and Aubrac. The five PDO cheeses: Cantal, Salers, Bleu d'Auvergne, St Nectaire and Fourme d'Ambert are mainly made by dairy industry and farms and they represent only 6% of the departmental production.

- Organic farming

In the Massif central area, there are about 40 organic farms (1.1% of total farms), on 3 800 hectares (1.7 % of total area). The main production comes from 1500 suckled cows with essentially, a grass-fed calves production. Less than 1.2 millions litres of milk are produced by 11 specialized or mixed farms (datum 2004).

Currently, French farmers receive subsidies only during the first five years of their conversion to organic farming (MAAPAR, 2004). The amount depends on the gross margin difference between conventional agriculture and organic production. For permanent meadows, the value is assessed according to a 10 % milk production decrease during the conversion period. The French agricultural bill foresees subsidies all along the duration of organic production but, at the moment their amounts are not yet known.

4.4 Conclusion

To sumarize, the implementation of agro-ecological technologies in farming systems presents four advantages (Sunding Zilberman, 1999):
Yield-Increasing innovations: An important criterion to assess technologies improving the performance of a new product or livestock system is the impact on output per unit. New high-yield varieties are beneficial primarily because of their yield-increasing effect. Similarly, the yield-increasing effect of new irrigation technologies has been a crucial element that led to their adoption.

Cost-Reducing innovations: Technologies can be classified as cost-reducing or cost-increasing. Here one may distinguish the impact of the innovation on the fixed costs and variable costs. Since costs are derived from a number of inputs, some cost-reducing innovations are categorized according to their impact on specific inputs of the production. For example, a new and improved type of harvesting equipment can be noted for its labor-saving effect. A new irrigation technology may be described according to whether and to what extent it has a water saving effect. In some cases, an innovation may have multiple effects. For example, the tomato harvester is labor-saving but capital- and energy-using. Modern irrigation technologies are yield-increasing, water-saving, and capital-using (Caswell and Zilberman, 1985).

Innovations that Enhance Product Quality*:* Given the inelastic demand for the main agricultural commodities and some products, one way to increase the added value of agricultural products is to improve product quality, which is one characteristic of new innovations. New genetic engineering varieties are expected to significantly increase product quality, for example, by enhancing shelf life, improving the nutrient content, or improving appearance (Huttner et al., 1995). Similarly the potential improvement of wine quality is a major driver of the renewed interest for intercropping in french vineyards (Gary et al., 2005).

Innovations that Protect Health and the Environment: The public is increasingly concerned about food safety, worker safety, groundwater contamination by pesticides, and other types of negative external effects of agriculture. The developments of technologies that improve environmental quality or at least reduce damages relative to existing technologies are becoming a major research and policy priority. Thus, a growing interest exists in innovations enhancing the viability of “green technologies” such as agroforestry, conservation tillage or organic farming.

Main constraints related to the use of new technologies can be: technical feasibility (related to the time and space), the economic feasibility (related to the cost) and social acceptance (e.g. GMO’s).

To which extend environmental EU policies, if implemented, would favour these technological innovations will be the major question adressed in Test case 2.

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- **http://www.europaworld.org/week129/currenteu16503.htm:** EuropaWorld reports on international development and humanitarian actions of European institutions, Governments and NGOs, including European based United Nations agencies. Its purpose is to inform Current EU legislation in the EU on GMOs.
- **http://europa.eu.int/comm/research/rtdinfo/43/article_1656_en.html**: Website for EU agricultural research.
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- **http://www.intercrop.dk/**: EU intercrop project website.
- **http://www.ecaf.org/:** Website for EU Conservation agriculture: for a better environment.
- **http://** www.silogic.fr/svhauvergne/**:** Qualité des eaux superficielles pour le département du cantal

EU project intercrop website: Intercropping of cereals and grain legumes for increased production, weed control, improved product quality and prevention of N-losses in European organic farming systems. http://www.intercrop.dk/.

Glossary

A definition is given only for terms which are specific to this deliverable. Others are important to understand the procedure but they have been or will be defined elsewhere.

Agroecological innovation: such as conservation agriculture, agroforestry, intercropping and integrated grassland is the innovation that integrates various components in a farming system, optimize the use of internal inputs (solar or wind energy, biological pest controls, and biologically fixed nitrogen and other nutrients released from organic matter or from soil reserves) and minimize the use of external inputs (nitrogen fertilization, treatments, soil and harvest tillage…), wished to promote the development of sustainable agriculture.
Agroforestry: is the combination of trees and agricultural crops on the same land unit.
Biodiversity: is used here to describe all the species living in a particular area such as birds and habitats.
Environmental policies: are policies based on nitrate directives or technological innovation (test case 2) to be tested to promote agriculture sustainability.
Integrated management: is a strategy based on optimisation use of land allocation and inputs to provide economic and environment benefits such as pest control, maintain soil fertility, etc.
Intercropping: is the practice of growing two or more crops simultaneously on the same land area
Natura 2000: since the EU Directives for 'habitat' and 'birds' is the term used to describe the ecological network of protected sites.
Nitrogen directives: several EU legislations to reduce nitrogen use.
Organic farming: farms characterised mainly by the abandonment of mineral N-fertiliser compensated by higher input of manures and a synthetic pesticides compensated e.g. by the use of species or varieties more tolerant to disease and pests.
Organisational innovation: is often about intentionally introducing and applying new ideas, processes or procedures such as Protected Designation of Origin (PDO) to significantly benefit a society and environment.
Pesticide legislation: several EU legislations to reduce pesticide use.
Test case regions or agriculture regions: are selected regions were policies scenarios will be tested with more details indicators that the European level.
Test cases: Are two tests representative of the types of questions that SEAMLESS-IF is designed to address, combining economic (test case 1) or environment issues (test case 2).
Water directives: are several EU legislations to reduce water use and pollution.
Water quality: mainly interest the water pollution by nitrogen and pesticide.
Water use