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RESEARCH FOR AGRI COMMITTEE - POLICY SUPPORT FOR PRODUCTIVITY VS. SUSTAINABILITY IN EU AGRICULTURE: TOWARDS VIABLE FARMING AND GREEN GROWTH

STUDY

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POLICY DEPARTMENT B: STRUCTURAL AND COHESION POLICIES

AGRICULTURE AND RURAL DEVELOPMENT

Research for AGRI Committee - Policy support for productivity vs. sustainability in EU agriculture: Towards viable farming and green growth

STUDY

This document was requested by the European Parliament's Committee on Agriculture and Rural Development.

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Abstract

This study presents the main trends in total factor and resource productivity in recent decades. The main pathways for sustainable intensification are explored through case studies and policy analysis. The paper presents a normative analysis of policy tools able to reconcile productivity and sustainability requirements and also provides policy recommendations to promote a resource-efficient, productive, climate-friendly and resilient EU agricultural sector.

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LIST OF ABBREVIATIONS

AIAB	Italian Association for Organic Farming
APO	Associations of Producer Organisation
BBSRC	Biotechnology and Biological Sciences Research Council
CAP	Common Agricultural Policy
CH4	Methane
CMO	Common Market Organisation
CO2	Carbon dioxide
CWR	Crop water requirement
DSS	Decision Support Systems
EAFG	European Agricultural Guarantee Fund
EASAC	European Academies Science Advisory Council
EFSA	European Food Safety Authority
EIP	European Innovation Partnership
EPSO	European Plant Science Organisation
EU	European Union
FADN	Farm Accountancy Data Network
F&V	Fruit and Vegetables
GDP	Gross Domestic Product
GHG	Greenhouse gas emissions
GJ	GigaJoule
GNPS	Global Navigation Positioning Systems
HA	Hectare
HCB	High Council for Biotechnology
IEEP	Institute for European Environmental Policy
IO	Interbranch Organisation
IPCC	Intergovernmental Panel on Climate Change
JRC	Joint Research Centre
KG	Kilogram
KJ	Kilo-joule
LAI	Leaf Area Index
MA	Managing Authorities

MBP	"Milieubelastingspunten" or "environmental impact points"
MPV	Marketed Production Value
MS	Member State
N	Nitrogen
NAP	National Action Plan
NGO	Non-Governmental Organisation
NO2	Nitrous Oxide
NPBT	New Plant Breeding Technique
NRN	National Rural Network
OECD	Organisation for Economic Co-operation and Development
OGs	Operational Groups
P	Phosphorus
PA	Precision Agriculture
PDO	Protected Designations of Origin
PGI	Protected Geographical Indications
PPP	Public-Private Partnership
PO	Producer Organisation
R&D	Research and Development
RDP	Rural Development Programme
SCP	Soil Conservation Practices
SI	Sustainable Intensification
SIP	Sustainable Intensification Pathways
TFP	Total Factor Productivity
TGAP	Taxe Générale sur les Activités Polluantes
TRP	Total Resource Productivity
UAA	Utilised Agricultural Area
UNFCCC	United Nations Framework Convention on Climate Change
UK	United Kingdom
WebGIS	(Web) Geographic Information System
WMP	Water Management Practice
WUA	Water Users Association

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EXECUTIVE SUMMARY

Background

After decades of continuous growth, the **agricultural output growth** rate has started to slow down while input growth has turned negative. This is partly due to the persistent world economic crisis which has contributed to a general slowdown of production and trade.

More recently, problematic international questions such as **food security and food access** have restored the issue of production levels and productivity to the heart of the international policy agenda, albeit in a slightly different way. The source of resource yield gain has shifted markedly from input intensification to improvement in total factor productivity which includes the effects of technical change.

Aim

The aim of the present study is to analyse factor and resource productivity trends and to discuss the main policy approaches to support green growth in agriculture, bringing some new conceptual considerations at the farm level and on regional pathways of **sustainable intensification**.

The report is organised in four chapters: in the **first chapter** we analyse the main trends in total factor productivity and in sustainability of agriculture production according to available measures. In the **second chapter** we will present the main areas to be developed in the EU in order to foster sustainable productivity growth. In the **third chapter** we analyse current instruments implemented at EU level and provide a general assessment through case studies that link specific good agriculture practices with the policy framework in place.

The case studies aim to support the on-going discussions on how to operationalise development of sustainable productivity growth in the EU, identifying the main obstacles. We present a **selection of farm practices that could enhance total resource productivity**.

An assessment of CAP instruments provides some indications of direction for the future Common Agricultural Policy (CAP) in order to build sustainable, productive and climate-friendly agricultural systems. **Chapter 4** gives some recommendations for the future of CAP instruments in the direction of inducing sustainable intensification strategies.

Main findings

In this study we have analysed changes occurring in the last decade in the volume of production of EU MS as a result of variations in land area and yields, which can arise from dis/intensification of the existing technology or from greater efficiency that is usually associated with innovation and implementation of new policies. We have adopted the concept of resource decoupling, meaning the reduction of the rate of use of (primary) resources per unit of economic activity. **Resource decoupling** leads to an increase in the efficiency with which resources are used. Impact decoupling, by contrast, requires increasing economic output while reducing negative environmental impacts. Such impacts arise from the extraction of required resources (such as groundwater pollution), production (such as land degradation, wastes and emissions) and the phase of use of commodities. Designing strategies for a decoupling of agricultural production growth from undesirable environmental impacts requires improved understanding of trends and their drivers.

The following table shows the main trends for a selected group of EU countries. A first group of countries (the Netherlands, Germany and Denmark) has had a positive trend in agricultural output, explained by gains in agricultural area and in TFP and, at the same time, has reduced unit GHG emissions and nitrogen surplus per hectare. Still, the indicators used to monitor the natural asset base (bird population and presence of permanent pastures) show a negative trend. In the last part of the table some of the drivers that at national level can explain these trends are reported: in particular, the higher investment in R&D, the lower average age of farmers, and the use of economic instruments as pollution taxes on environmentally-damaging inputs. In Eastern and Southern European MS the increase in factor productivity has not been sufficient to offset the negative trend in land area. Moreover the decoupling of growth from environmental impact is less evident, especially with regard to nutrient surplus. In most cases, the aging of farm managers and the lower rate of expenditure in R&D may partly explain these trends and help pinpoint the main areas for policy response.

Assessment of productivity trends and socioeconomic and policy drivers in some EU MS

	Factor Productivity			Resource Productivity			Socioeconomic and policy drivers			
Country	**Output growth**	**TFP growth**	**Land area change**	**Carbon Producti-vity**	**N Product-ivity**	**Farmland bird index**	**Gov R&D**	**Training**	**Farmers age**	**Pollution taxes**
Nether-lands	+++	+++	+	+	++	--	++	++	-	++
France	-	++	-	+	-	-	++	++	++	
Germany	++	++	+	+	++	-	++	++	++	
Austria	++	++	-	++	-	--	-	+	-	
Czech Republic	-	+	-	+	-	--	-	+	-	
Poland	+	++	--	+++	-	-	-	+	-	
Denmark	+	+++	+	+++	++	--	++	++	--	++
Italy	-	+++	--	++	-	-	+	++	--	
Greece	--	-	-	+	+	**Na**	-	++	--	
Portugal	+	++	--	-	-	**Na**	+	++	-	
Spain	-	++	-	+	+	**Na**	+	++	--	

With regard to policy instruments, many elements contribute to explain the main dynamics affecting TFP. Fiscal regimes regulating for R&D, which show a strong heterogeneity in MS legislation, seem to be quite controversial with respect to their real impact. At the same time, having an adequate legal framework is essential for the development of new technologies: though Europe's plant breeding industry and research have been very active, carrying out more than 50% of world research, the EU regulatory framework appears to be inadequate with regard to new breeding techniques. On the other hand, few MS have levied taxes on farm inputs as an instrument to address environmental issues.

Section 2.2 is dedicated to "*best practices*" and enabling conditions for SI identified in interviews with farmers and regional decision-makers in four EU regions. Considering farm level and regional pathways of **sustainable intensification (SI)**, four pathways have been mapped out: Agronomic Development, Resource Use Efficiency, Land Use Allocation and Regional Integration. **Sustainable intensification strategies depend on regional problem-setting and normally apply a combination of measures in several pathways. In order to steer agricultural systems towards SI, agricultural and**

regional development policy needs to incentivize the uptake of site-adapted strategies.

In chapter 3, we look at the role of CAP in the process of fostering green growth in agriculture. The CAP has gone through a deep reform process in the last 20 years, replacing market support mechanisms and payments that are potentially harmful to the environment with potentially more beneficial support, such as payments subject to cross compliance and the introduction of greening requirements. In most cases, in the EU, the main vehicles to encourage green growth in agriculture are the Rural Development Programmes through monetary incentives to adopt practices that go beyond what is required by compliance with existing regulations. Research and innovation in agriculture have had increasing importance within the second pillar of the CAP, while in the first pillar a shift from unconditional direct payments towards targeted ones has occurred with the latest CAP reform.

The **process of CAP reform** shows a slow but progressive shift from trade-off policies (production vs. environmental impact) to win-win policies that are able to make production goals compatible with sustainable management of natural resources. The new technology applied to farming, such as remote sensing control and robots, lead in this direction.

The table below focuses on two aspects: the first is the **growth of the policy tools that directly or indirectly have an effect on both the goals of sustainability and productivity;** the second is that **there is actually a considerable shift towards forms of integrated policies (win-win), while trade-off generation policies tend to be superseded.**

However, it is important to keep in mind that **the interaction of sustainability and productivity (the so-called '*sustainable productivity*') has not been officially adopted by the EU as a policy target**. Nevertheless, the attempt to reduce trade-offs and work on the win-win approach is quite openly recognised, with a view to building a significant body of tools in favour of sustainable productivity.

Specifically about **direct payments**, they are recognised to be more selective and more "*green*" than the past. **However, many studies maintain that the cost of the overall transfer of resources to farmers is undoubtedly out of proportion with the environmental effects.**

Classification of the main current policies according to the conservation/integration approach

Mac Sharry (1992)		Agenda 2000 (1999)	
Conservation	**Integration**	**Conservation**	**Integration**
(trade-offs)	*(win-win)*	*(trade-offs)*	*(win-win)*
		First pillar	
		Extensification (CMO)	Partial decoupling
Set aside	Partial decoupling	Set aside	
		Eco-conditionality	
		Second pillar	
Agro-environmental measures		Agro-environmental	Good agricultural practices
Fishler Reform (2003)		**2014-2020 Reform**	
Conservation	**Integration**	**Conservation**	**Integration**
(trade-offs)	*(win-win)*	*(trade-offs)*	*(win-win)*
First Pillar			**First pillar**
Eco-conditionality			Ecological payment
	Full de-coupling		Payments for young farmers
			Payments for disadv. areas
Second pillar			Active farmers
Environm. challenges	Quality package		Small farmers
	RDPs		Cross-compliance
			Specific support (coupled)
			Second pillar
			Removing of axes
		Agri-environm.	Diversification measures
			Risk management

The **European Innovation Partnership "Productivity and Sustainability"** seeks to promote the main goals of the CAP (efficient and competitive agricultural sector, sustainable supply of food, adaptation and mitigation to climate change etc.) while supporting better coordination between research, knowledge, technology and farmers, forest managers, rural communities, businesses, NGOs and advisory services. To date, the EIP AGRI service point has organised 23 focus groups on specific topics relating to needs, problems and opportunity of agriculture and forestry that involved some hundreds of experts from all EU countries while 94 RDPs envisage financing Operative Groups in 24 MS. **The need for more activities and information is highlighted together with the importance of supporting multi-region projects. At MS level evidence shows that the complexity of administrative procedures risks reducing farmers' participation.**

Another major issue on which the report focuses is the **relationship between viable food production and the level of productivity and intensification**. Among the CAP tools, it seems that Producer Organisations (POs) and their system are well designed to contribute to the improvement in farm incomes and the functioning of the food chain on an environmentally sustainable basis.

We present here the **case study of the Italian fruit and vegetable (F&V) sector**, which shows that PO expenditures on operational programmes are mainly devoted to actions aimed at improving product marketing and environmental concerns, enhancing production planning and improving or maintaining product quality.

The **quality regimes** (certified organic production, PDO/PGI system, certified integrated production, and private quality certification) taken into account within operational programmes allow the specific objectives of improving competitiveness in the F&V sector to be pursued and satisfied, protecting the environment and meeting consumer expectations. The long-standing experience of POs in the F&V sector suggests some recommendations that could be effective for all agricultural sectors, for which the last CAP reform has extended the possibility of building up POs. These regard **strengthening the market-oriented role of POs and supporting PO innovation and internationalisation processes**.

In conclusion, the framework and the cases make it clear that:

- EU farming has taken steps to become more sustainable and to combine productivity and sustainability: it results in TFP staying positive and in decoupling of growth and negative environmental effects.
- There are four different directions in which SI can take shape. It depends on regional cases what (combination) is most attractive.
- In the agronomic area there are often options to combine productivity and sustainability that are facilitated by better management by farmers, precision agriculture and new breeding techniques.
- However SI is strongest in NW Europe where, nevertheless, negative environmental effects are still considerable.
- Policy coherence and strategy matter. At the aggregate level, it is perhaps stronger in NW Europe (innovation, economic instruments in pollution) but there are interesting examples of SI paths in southern Europe as well, as shown by the Organic Valley case study in Italy
- Instruments such as PO, EIP and Research are thus extremely important to help regional communities achieve viable food production although several factors reduce their potential impact, such as the complexity of administrative procedures in the case of EIP, or the absence of an adequate legal framework for Plant Breeding. ICT constitutes a very interesting area in pushing towards SI solutions but more work has to be done especially in data science.
- In the on-going CAP reform discussion, increasing sustainable productivity should be officially recognized as a policy target in order to achieve stronger policy coherence both at the EU and MS level.

1. INTRODUCTION: TRENDS IN PRODUCTIVITY AND SUSTAINABILITY

This study is organised in four sections. In the first section the main trends in total factor productivity and in sustainability of agriculture production are analysed according to the data available. In the second section we present the main areas to be developed in the EU in order to foster sustainable productivity growth. In the third section we analyse current instruments implemented at the EU level and provide a general assessment through case studies that will link specific good agricultural practices with the policy framework in place.

The framework used in this study - elaborated by the OECD (OECD, 2011) - considers policy incentives and disincentives to innovation, structural change, access to and use of natural resources, and climate change, as the key drivers of productivity growth and sustainable use of resources. Improvements in agriculture productivity growth are required to meet the growing demand for food, feed, fuel and fibre, and must be achieved sustainably through the more efficient use of natural and human resources. A common finding is that a wide range of economy-wide policies affect the performance of the food and agriculture sectors, and thus need to be considered alongside agriculture-specific policies.

KEY FINDINGS

- Agricultural output growth rate has slowed down in recent decades while input growth has turned negative.
- The source of resource yield gain has shifted markedly from input intensification to improvement in total factor productivity that includes the effects of technical change and of using inputs of higher quality.
- Trends have not been homogeneous in Europe. Total Factor Productivity (TFP) has strongly increased in Southern countries but its growth has not been sufficient to compensate for the negative trends in the intensity in the use of inputs and the loss of arable land. Therefore output growth has been negative. In Eastern countries agricultural output has experienced even stronger negative growth in the last decade as a result of reduced input use that has not been offset by an increase in TFP.
- In most cases decoupling of GHG emissions from agricultural output is observed. Differences between countries remain high, showing room for further improvements. Several countries, namely Austria, Denmark, Poland, the UK and Bulgaria, have achieved full decoupling with carbon productivity in agriculture increasing at a higher rate than agricultural output.
- In many MS nitrogen surplus has been declining against agricultural output, reflecting increased efficiency by farmers and showing the reduction of risk of environmental pressures.
- Besides agricultural policies, drivers such as R&D expenditure, farmers' age and training, and the use of economic instruments such as pollution taxes are major factors in accounting for TFP and resource productivity trends.

Improvements in agricultural productivity growth are required to meet the growing demand for food, feed, fuel and fibres, and must be achieved sustainably through the more efficient use of natural and human resources. This concept is known as sustainable intensification (SI) and it entails improving resource efficiency in agriculture i.e. improving productivity whilst reducing negative environmental impacts of agriculture (leakage of nutrient emissions, soil erosion, biodiversity loss) and improving conservation outputs of agriculture. The OECD (2014) suggests that in many cases agricultural productivity growth conserves environmental as well as market resources. A common finding is that a wide range of economy-wide policies affects the performance of the food and agriculture sectors, and thus need to be considered alongside agriculture-specific policies. The framework used in this study - elaborated by the OECD - considers policy incentives and disincentives to innovation, structural change, access to and use of natural resources, and climate change, as the key drivers of productivity growth and sustainable use of resources.

In this section we analyse the main trends in total factor productivity and in sustainability of agriculture production according to the data available.

Total factor productivity (TFP)[1] is a well-defined concept that is widely used in evaluating efficiency and productivity at aggregate and sectoral level. TFP is the ratio between the aggregate quantities of total marketable outputs with the aggregate amount of total marketable inputs used in the production process. While fluctuations of agricultural TFP from year to year can be due to climatic conditions, in the long term it provides a measure of technological progress. In absolute terms TFP gives a measure of the technological level of a country, an industry or a firm, while TFP growth is a measure of technological progress. The main advantage of a TFP measure of productivity growth is that it clearly distinguishes between resource expansion, resource substitution, and technical or efficiency improvements in resource use as sources of economic growth (Fuglie, 2015)[2].

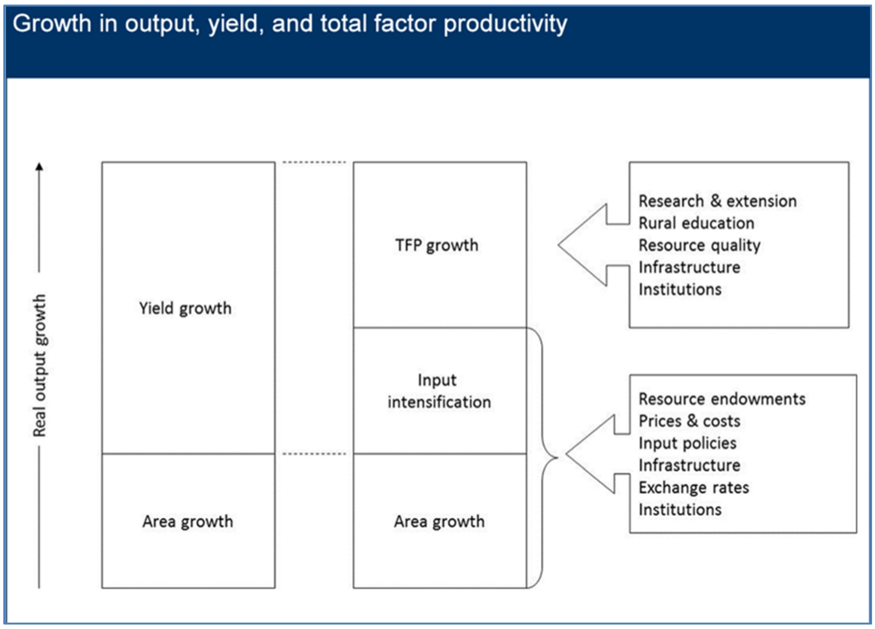
Productivity analysis based on an accurate measurement of agricultural total factor productivity (TFP) is critical to identifying areas for improving agricultural policies that have potential to influence agricultural productivity growth in the long term. These include building capabilities, such as investing in R&D (to increase the supply of innovations), education and training (to increase farmers' capacity to innovate and adopt innovations) and provision of farm extension and financial services (to encourage adoption of innovations).

Figure 1 gives a graphical depiction of the growth decomposition. Growth in real output is first decomposed into growth attributable to agricultural land expansion (extensification) and growth attributable to raising yield per hectare (intensification). Finally, yield growth itself is decomposed into input intensification (i.e., more capital, labour and fertiliser per hectare), and TFP growth, where TFP reflects the efficiency with which all inputs are transformed into outputs. Improvements in TFP are driven by technological change, improved technical and allocative efficiency in resource use, and scale economies (Fuglie, 2015).

1 The terminology of multifactor productivity is sometimes used to represent the concept of TFP because, in practice, it is often not possible to include all the inputs and outputs in its measurement.

2 For description and interpretation of productivity indexes, see the Annex.

Figure 1: Framework of major productivity determinants



Source: Fuglie (2015).

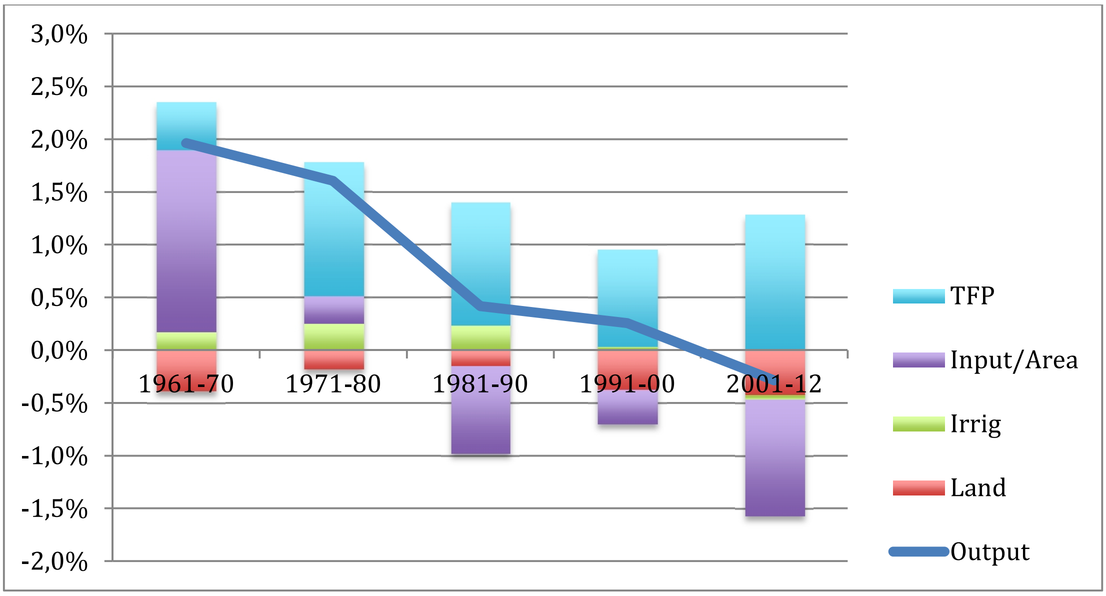
The decomposition of output growth into these components is both intuitively appealing and has some direct policy relevance: land expansion and input intensification are strongly influenced by changes in resource endowments and relative prices. Changes in TFP, on the other hand, are driven by changes in allocative efficiency and in technology which can be sustained through investments in research and development (R&D) (Evenson and Fuglie, 2010).

A comparison of agricultural TFP among countries shows that there are still significant cross-country and over-time disparities in agricultural TFP levels and growth, even within the EU (European Commission, 2016a).

At a national level, productivity analysis provides information on the efficiency of resource reallocation among farms and insights about the impacts of institutional arrangements that affect industry structure and adjustment. Improvements in resource allocation are an important source of productivity gains in agriculture. This largely takes place within existing farms, but is also as a result of farms entering and exiting the sector.

Figure 2 illustrates the decomposition of global output growth in Europe, across the last five decades. The agricultural output growth rate (the continuous line) is slowing while input growth has turned negative. TFP growth offsets the decline in resources from falling in absolute terms. The figure shows the contribution of irrigation, the change in land area and the growth rate in yield, which is further decomposed into growth due to input intensification (inputs per area) and TFP. The underlying source of resource yield gain has shifted markedly from input intensification to improvement in TFP. TFP estimates should be interpreted as including not only the effects of technical change, but also the effects of using inputs of higher quality.

Figure 2: Decomposition of global output growth into contributions from inputs and TFP in Europe 1961-2012

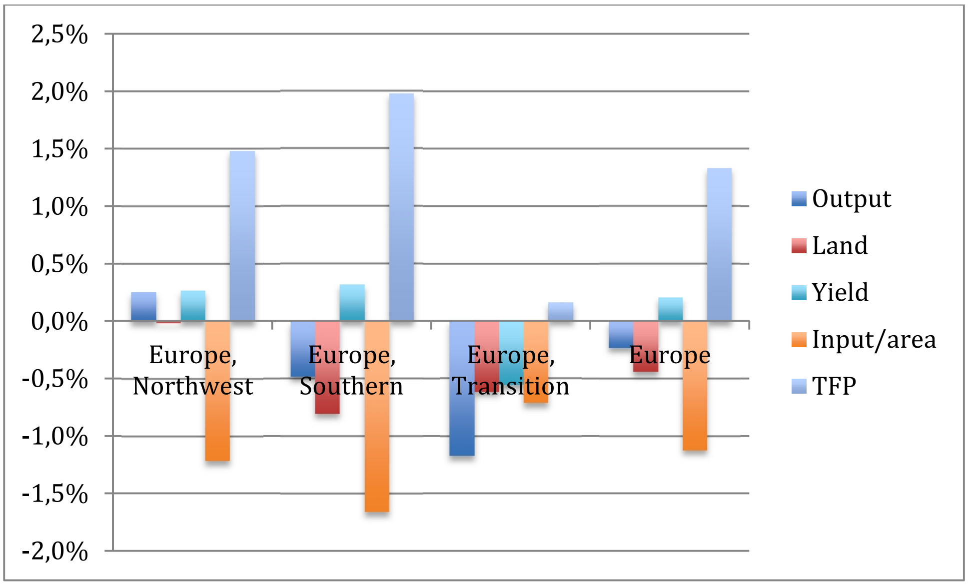


Source: Authors' calculations from http://www.ers.usda.gov/data-products/international-agricultural-productivity.aspx

The different patterns of growth in the last decade across various regions in Europe are shown in **Figure 3**. The height of the first column represents the average annual rate of output growth in the period 2003-2012.

From **Figure 3** it is clear that trends have not been homogeneous in Europe. TFP has increased in Southern countries more than anywhere else but its growth has not been sufficient to offset the negative trends in the intensity in the use of inputs (-1.6% per year) and the loss of arable land. Therefore output growth has been negative. In Eastern countries agricultural output has experienced an even stronger negative growth in the last decade – at an average rate of -1.2% per year – due to reduced input use that has not been offset by an increase in TFP.

Figure 3: Output growth determinants, Europe 2003-2012



Source: Authors' calculations from http://www.ers.usda.gov/data-products/international-agricultural-productivity.aspx

A broader issue in agricultural productivity measurement is the consumption of unpaid (but socially valuable) environmental resources. Most existing metrics of agricultural productivity, however, do not fully account for the use of environmental goods and services in agricultural production. Thus they provide only limited means for assessing the long-term sustainability of agricultural productivity growth. **Total resource productivity (TRP)** attempts to extend TFP to include environmental goods and services that are not valued by the market. While market prices or private opportunity cost derived from market-based values are typically used to aggregate outputs and inputs in constructing TFP, non-market valuation methods are required to derive comparable "*shadow prices*" or social opportunity costs of environmental goods and services for the estimation of TRP. Among the key challenges of including environmental concerns in productivity metrics is valuing environmental services in a way that is comparable to market goods and services. Some natural resources that have well-defined property rights, such as land, will have market prices that reflect at least some environmental services, like soil fertility. But other environmental services provided by the resource, such as soil carbon sequestration, may not. In some cases, policies may create markets for environmental services (water markets and ***cap-and-trade*** systems for GHG, for example) and their prices can be observed. In most cases, however, prices are not observed for environmental services and alternative approaches are needed for valuation.

Government ***statistical agencies*** have invested considerable resources in assessing the status and value of natural assets and environmental services. The European Framework for Integrated Environmental and Economic Accounting for Forests (European Commission, 1999) and the United Nations-sponsored Millennium Ecosystem Assessment (1985) are examples of international efforts to assess the status and value of natural resource capital and their environmental services. International organisations such as the OECD and the United Nations have made attempts to compile data on or construct estimates of environmental services from agriculture in a consistent fashion across countries and over time.

Considering the OECD classification for green growth indicators (OECD, 2011) we have selected for each group a subset of indicators (**Figure 4**) to be complemented with socioeconomic context indicators. This should allow us to analyse the multi-dimension of the environmental outcomes and the country specificity of some environmental issues.

Figure 4: Indicator groups and topics covered

Environmental and resource productivity	Carbon productivity Nitrate balance
The natural asset base	Pasture land
Environmental dimension of quality of life	Farmland bird index
Economic opportunities and policy responses	Technology and innovation Skills and training Regulations and economic instruments
Socioeconomic context and growth characteristics	Economic growth Productivity

Source: Adapted from OECD (2011).

The approach that we have adopted for monitoring progress towards sustainability relies on the concept of resource productivity i.e. the effectiveness with which a production process uses natural resources. We analyse technical efficiency i.e. the amount of

resource inputs required to produce a unit of output expressed in physical terms. Improving resource productivity is often assumed to reduce environmental impact. Nevertheless, it should be pointed out that productivity trends – and their inverse, decoupling trends – show whether production has become greener in relative terms but do not indicate whether, in absolute terms, environmental pressure has also decreased[3].

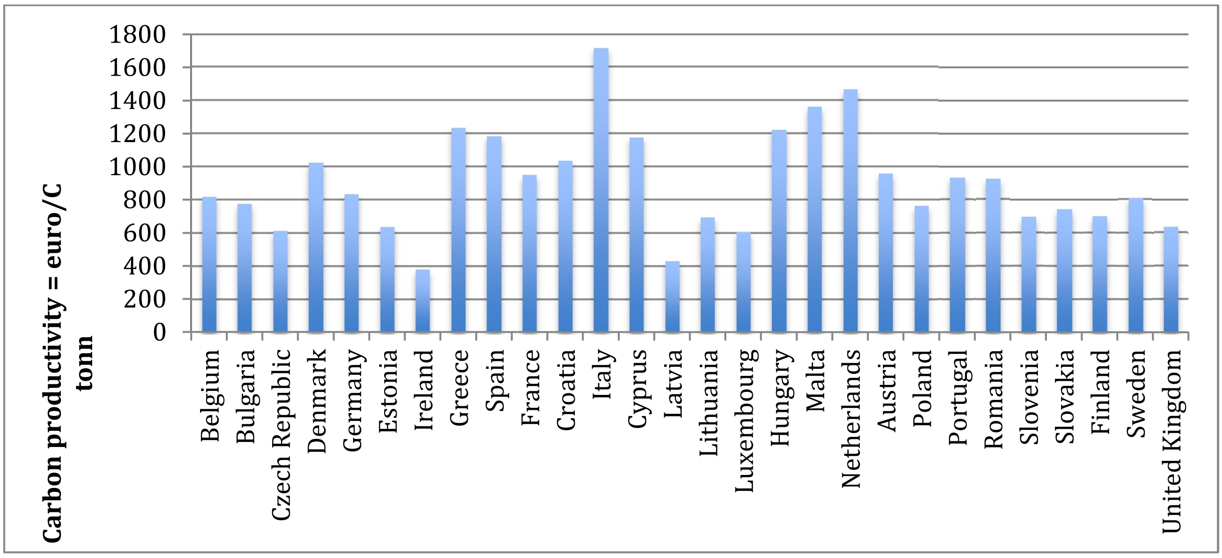
The concept of **decoupling environmental impacts** from economic growth is a core goal of OECD green growth strategy (OECD, 2002). We refer to absolute and relative decoupling, indicating in the former case the situation where agricultural output is growing while the environmental variable is stable or decreasing while in the latter case output is growing at a faster rate than resource use, but resource use is still increasing. **Resource decoupling** means reducing the rate of use of (primary) resources per unit of economic activity. This 'dematerialization' is based on using less material, energy, water and land resources for the same economic output. Resource decoupling leads to an increase in the efficiency with which resources are used (UNEP, 2011). Impact decoupling, by contrast, requires increasing economic output while reducing negative environmental impacts. Such impacts arise from the extraction of required resources (such as groundwater pollution), production (such as land degradation, wastes and emissions) and the use phase of commodities. Designing strategies for a decoupling of agricultural production growth from undesirable environmental impacts requires improved understanding of trends and their drivers.

We have selected two indicators that we consider relevant to all European countries in the area of resource productivity: **carbon productivity**, i.e. the level of GHG emissions per unit of output, and **nitrogen balance (N)**.

According to the IPCC Fourth Assessment Report (FAR) (Rogner *et al.*, 2007) agriculture accounts for 13.5% of 2005 global anthropogenic GHG emissions. In particular, the sector is responsible for about 60% of nitrous oxide (N_2O) and about 50% of methane (CH_4) global emissions. Agricultural GHG emissions have become central in the debate on policies to combat climate change in developed countries and - although there are no specific commitments under the United Nations Framework Convention on Climate Change (UNFCCC) to reduce GHG emissions - the EU has developed several policies aimed at reducing emissions and promoting the carbon sink function of agriculture. **GHG productivity** is a widely accepted indicator at international level to monitor green growth (OECD). Differences within the EU are still high, as shown in **Figure 5**.

[3] The relationship between resource decoupling and impact decoupling is explained in annex following UNEP (2011).

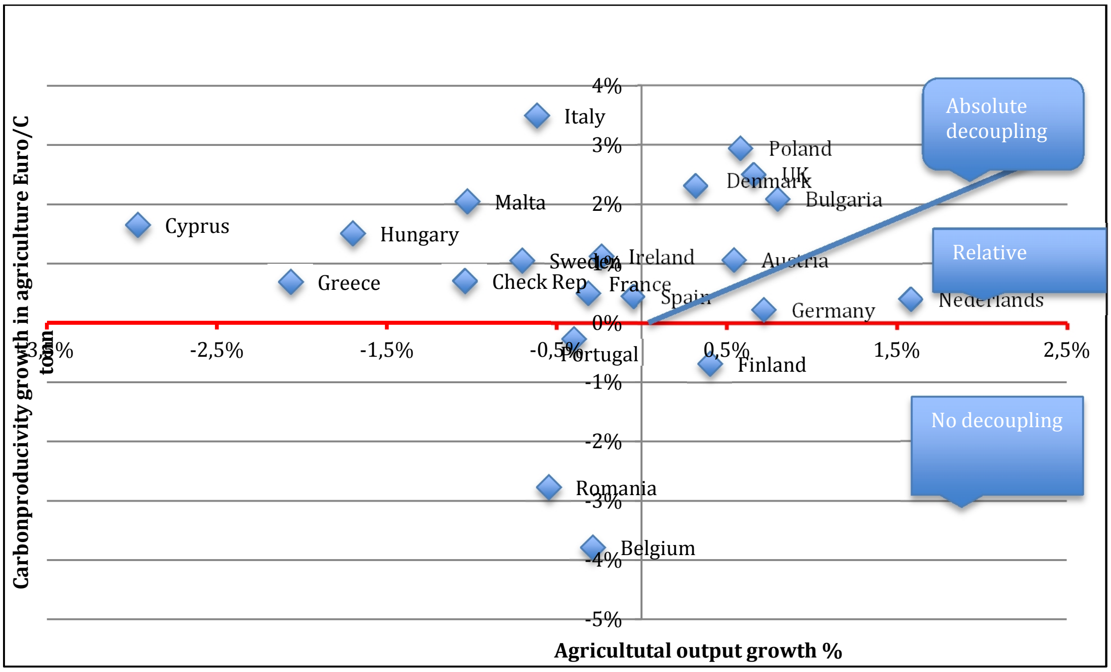
Figure 5: Agricultural GHG productivity in the EU /average 2012-2014)



Source: Eurostat.

In Europe, in most cases, decoupling of GHG emissions from agricultural output is observed (**Figure 6**)[4]. Nevertheless, differences between countries remain high, showing room for further improvements. Several countries, namely Austria, Denmark, Poland, the UK and Bulgaria, have achieved full decoupling with carbon productivity in agriculture increasing at a higher rate than agricultural output. The Netherlands and Germany are in the area of partial decoupling where carbon productivity has increased but at a lower rate with respect to agricultural production, as well as Italy, France, Ireland, Sweden, and Malta where agricultural production has decreased but has gained efficiency with respect to GHG emissions.

Figure 6: Agricultural output growth and GHG emissions (carbon productivity growth 2002-2013)



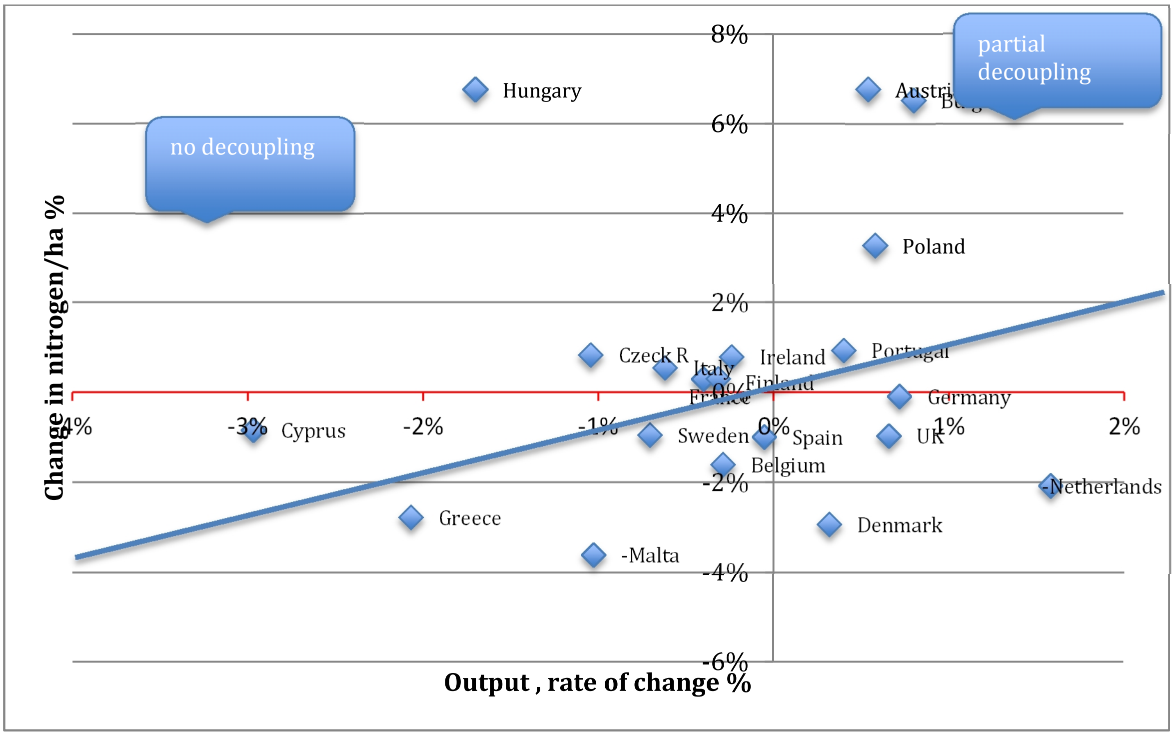
Source: Eurostat.

[4] UNFCCC inventories are the main data source. Emissions are expressed in CO_2 equivalents. Emissions are affected by climate, agronomic and technological conditions.

In a recent study, Coderoni and Esposti (2014) found that after a period of apparent unsustainability, due to the prevalence of the scale effect, emissions sustainability can be eventually achieved due to the increasing contribution of the technological and, above all, of the intrasectoral composition effect.

The second indicator that we have chosen to illustrate environmental efficiency in agricultural production is the change in **nitrogen (N) intensity**, expressed as the gross N balance per ha of agricultural land related to changes in agricultural production (**Figure 7**). This indicator is a proxy of the risk of environmental pressures associated with agricultural production. It is calculated as the difference between N input entering an agricultural system (fertiliser and manure) and the quantity of N leaving the system as uptake by crops and grassland. A nitrogen deficit is an indicator of declining soil fertility while a surplus indicates a risk of pollution.

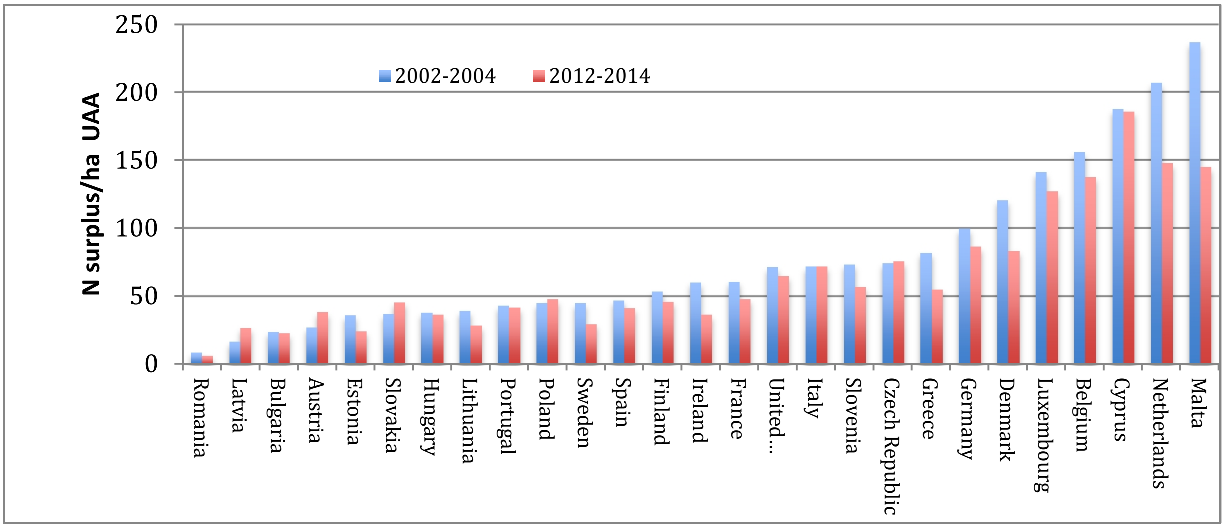
Figure 7: Nitrogen balance/ha, rate of change (%), 2002-2013



Source: Eurostat.

In many EU countries the nitrogen surplus has been declining relative to agricultural output, reflecting increased efficiency by farmers and showing the reduction of risk of environmental pressures. This is particularly true for those countries that had higher absolute levels of surplus, but still in many cases the annual nitrogen surplus is over 50 Kg/N/ha and over 100 for the Netherlands, Belgium, Malta and Cyprus (**Figure 8**).

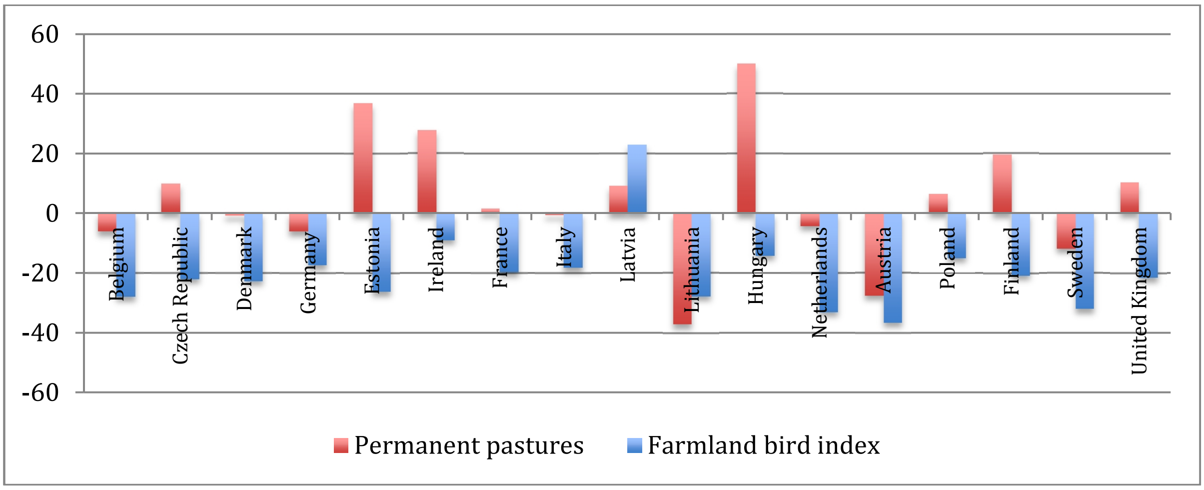
Figure 8: Nitrogen balance intensity (surplus/ha) in the EU MS



Source: Eurostat.

With regard to the natural asset base and the environmental quality of life we have chosen one indicator of **biodiversity**, the farmland bird index, considered a barometer of the health of the environment (OECD, 2015) by reflecting changes in the ecosystems. This indicator is strongly associated to changes in permanent pastureland areas which gives a good measures of pressures on competing land uses (**Figure 9**).

Figure 9: Main trend in natural assets



Source: Eurostat.

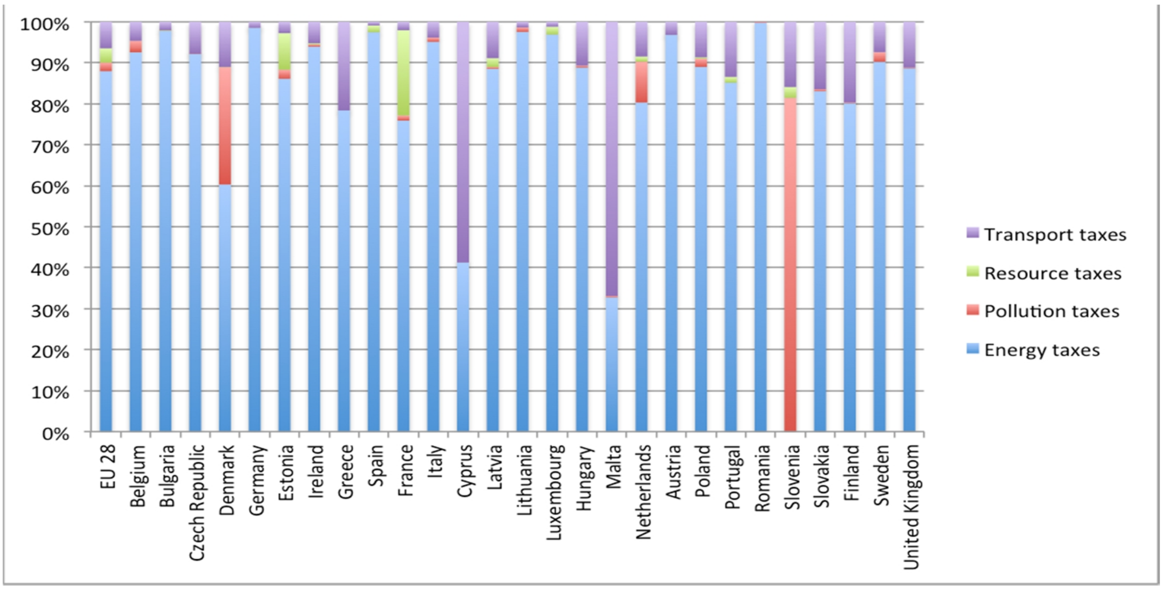
In this area it is more difficult to monitor progress because of incompleteness in databases and difficulties in establishing functional relationships between different variables.

The last group of indicators has been selected in order to ascertain the effectiveness of different policy approaches in delivering sustainable productivity growth in agriculture. These include policy instruments in the sphere of prices and taxes, technology and innovation, training and skills. All these aspects are important factors in shaping farmers' behaviour with regard to adopting innovations that minimize negative environmental externalities of agricultural production. One policy response is the removal of subsidies that can be detrimental to the environment: CAP decoupling was intended to go in this direction and will be analysed in section 3.4.1. Environmental taxes may provide signals to producers and influence their attitude towards more sustainable technologies.

Eurostat provides information on environmental taxes in agriculture divided between energy taxes, transport taxes (on vehicles), pollution taxes (on estimated emissions and generation of wastes, resource taxes (on water abstraction or extraction or other resources). Taxes on energy are the most important source of environmental taxes in agriculture (**Figure 10**). The average rate of energy tax/ GJ in agriculture is lower than in the whole economy because fuel is often exempted from tax in agriculture. The highest rates of energy tax are observed in Ireland, Denmark, the Netherlands and Slovakia.

The Netherlands introduced levies on off-farm nutrient emissions above a set limit in 1998 (Dutch National Institute for Public Health and the Environment,2016). Since 2006 this policy has been replaced by application standards. Environmental taxes are more often applied on the sale of inputs identified as having a potentially adverse impact on the environment (Denmark, Finland, Italy, Sweden).

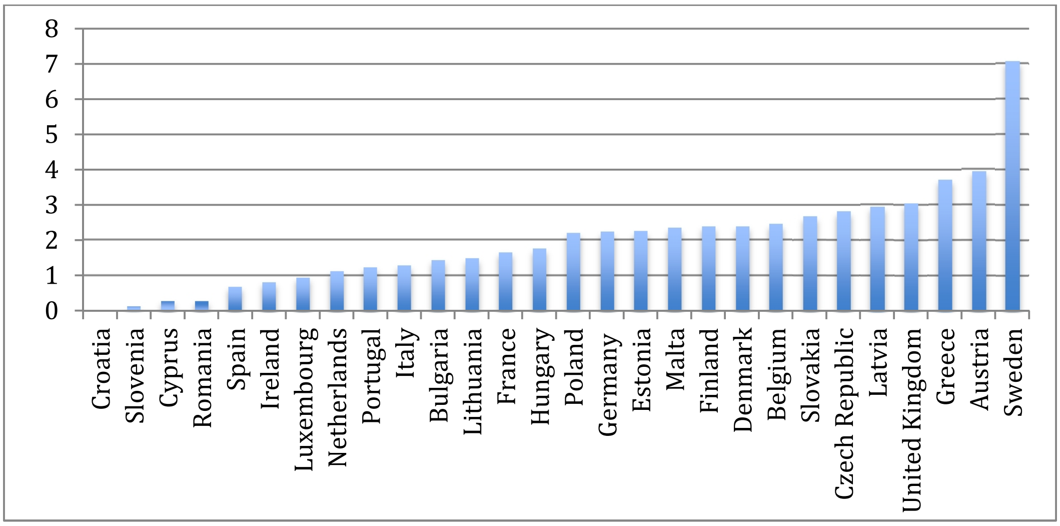
Figure 10: Environmental taxes in agriculture by type: share on total (%) 2013



Source: Eurostat.

The rate of environmental taxes on agricultural product is shown in **Figure 11**.

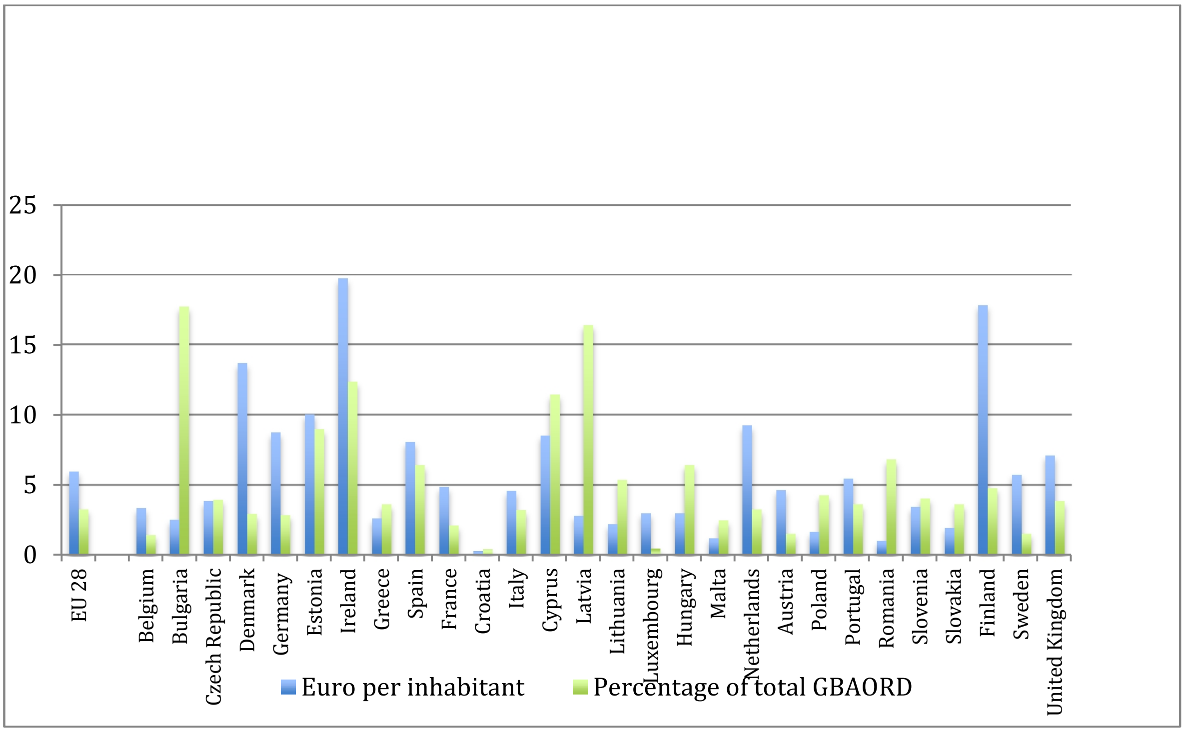
Figure 11: Environmental taxes/ Gross product - EU, 2013 - %



Source: Eurostat.

Technological development can contribute to efficient and viable production and, at the same time, enhance environmental performance in agriculture. Several factors impact on the availability of new technologies and the willingness to adopt innovation. On the one hand, we can consider public investment in R&D or in agricultural training; on the other, the level of education and R&D expenditure measures the degree of investment in generating new knowledge but it does not reflect a green growth outcome (OECD, 2015). The age of farmers is considered a proxy of innovative behaviour. Data on agricultural R&D are expressed as a percentage of total research expenditure and provide a measure of the relative importance of the former. On average, government agricultural R&D in the EU 28 amounts to around 3% of total government research expenditure and 0.02 % of GDP. **Figure 12** shows that there are some disparities between EU MS in terms of public research expenditure per inhabitant and as % of the total public research, with some Northern countries showing a high level of expenditure per inhabitant while several Eastern countries and Ireland have a larger share of agricultural research on the total government expenditure for R&D.

Figure 12: Government R&D expenditure in agriculture - Main indicators (average 2002-2014)

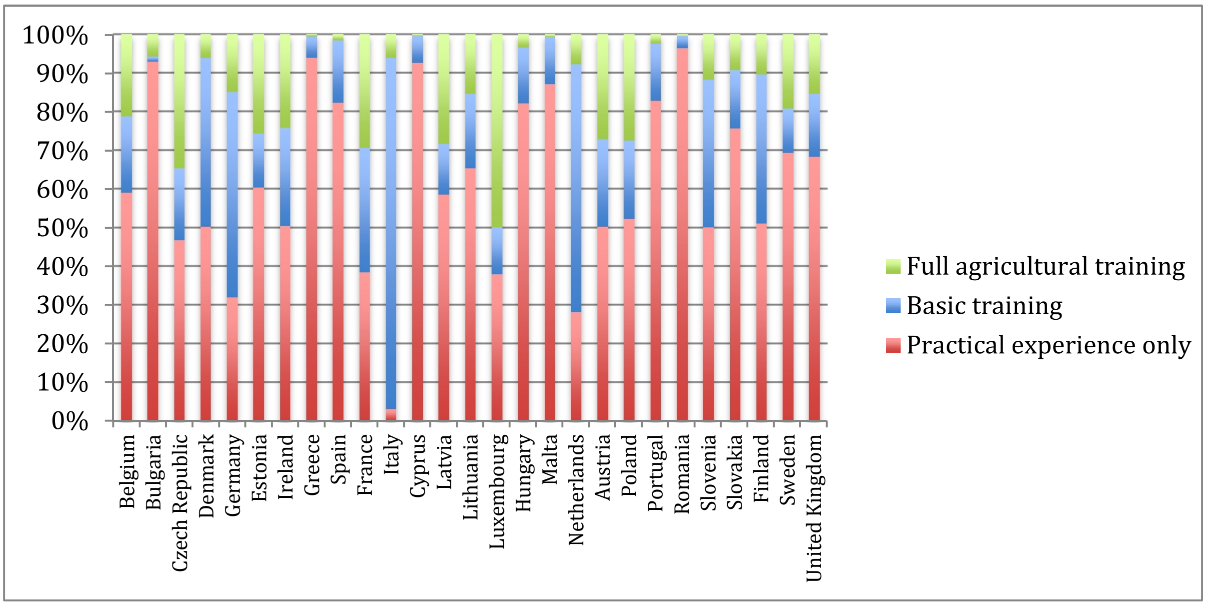


Source: Eurostat.

In absolute terms government R&D in agriculture has decreased in some countries (Denmark, Italy, Portugal and Greece) and has increased mainly in Sweden and in Eastern economies. According to the OECD the number of green patents has been increasing in the last decade, mainly with respect to water-related agricultural technologies (crops and irrigation) and waste management (OECD, 2014).

Farmer ability to innovate can be monitored by proxies such as the share of farmers with training, the share of young farmers and government expenditure on agricultural training and education. Farm managers are classified as "*with only practical experience*", "*with basic agricultural training*" and "*with full agricultural training*". Results show that learning by practical experience is the most common training of European farmers. On average, 10% of farmers have had full agricultural training and 30% some form of training but the share of untrained farmers is higher in Portugal, Greece, Spain and in transition economies and new access countries (**Figure 13**).

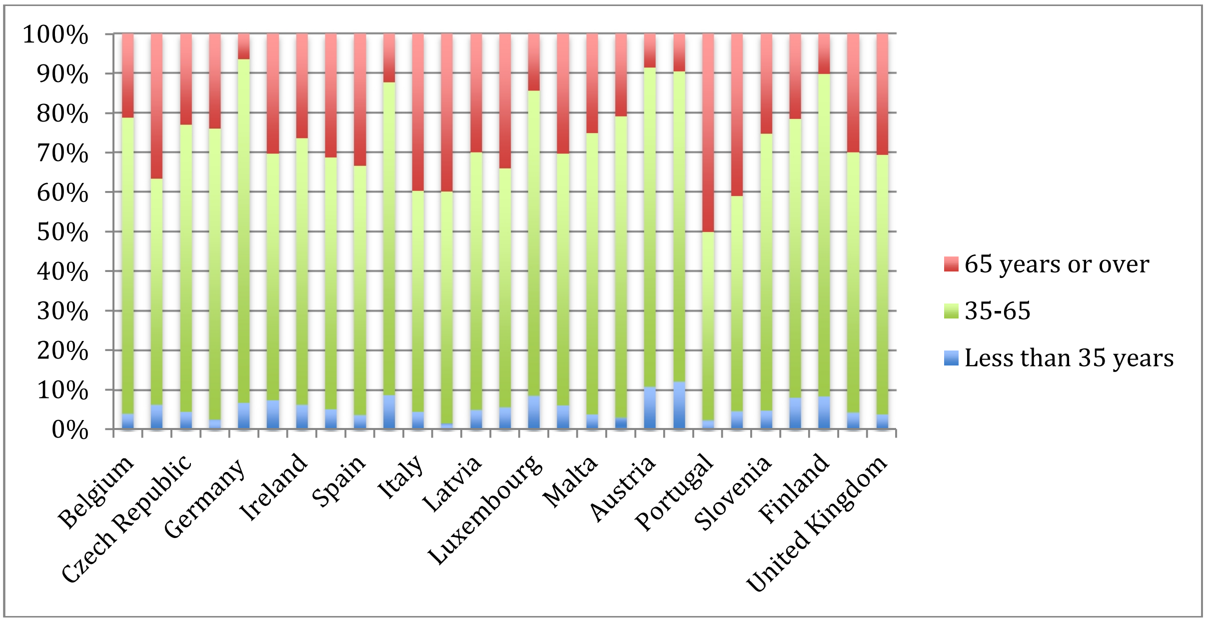
Figure 13: Agricultural training of farm managers: number of farms (%)(2013)



Source: Eurostat.

Also, generational renewal in agriculture is a key factor in shaping the attitude to innovation adoption. Fig.14 shows the distribution of agricultural holdings by age of the manager. The share of young managers is generally below 10%. At the same time, some countries, namely Portugal, Italy, Romania and Lithuania, have an above-average share of elderly farmers. This indicator is also correlated with the previous one as elderly farmers have a lower level of training.

Figure 14: Number of holdings by age of manager (2013)



Source: Eurostat.

According to the World Economic Forum analysis of the most problematic factors for doing business in the last 15 years, in most European countries, access to finance has replaced labour regulations as the most problematic factor for doing business in those countries.

The relative level of concern among firms around restrictive labour regulations has indeed progressively decreased in southern Europe. Firms in the Eurozone have improved their level of innovation, with southern European countries showing few signs of convergence with their northern counterparts.

Table 1: The most problematic factors for doing business in 2007 and 2015

Advanced economies			
2007		2015	
Factor	Score	Factor	Score
Government bureaucracy	13.6	Government bureaucracy	14.2
Restrictive labour regulations	13.6	Tax rates	13.1
Tax rates	11.9	Restrictive labour regulations	12.8
Complexity of tax regulations	10.7	Access to finance	10.8
Inadequately educated workforce	9.0	Complexity of tax regulations	8.8
Emerging Market Economies			
2007		2015	
Factor	Score	Factor	Score
Government bureaucracy	12.3	Access to finance	11.7
Corruption	11.4	Corruption	11.4
Access to finance	9.8	Government bureaucracy	11.3

Source: World Economic Forum, Executive Opinion Survey, 2007 and 2015 editions.

Table 2 shows the main trends for a selected group of EU countries. A **first group of countries** (the Netherlands, Germany and Denmark) has had a positive trend in agricultural output, explained by gains in area used for agriculture and in TFP and, at the same time, have reduced their unit GHG emissions and nitrogen surplus per hectare. Still, the indicators used to monitor the natural asset base (bird population and presence of permanent pastures) have a negative trend. In the last part of the table some of the drivers that at national level can explain these trends are reported: in particular, the higher investment in R&D, the lower average age of farmers, and the use of economic instruments such as pollution taxes on environmentally-damaging inputs.

Table 2: Assessment of productivity trends and socioeconomic and policy drivers in some EU MS

	Factor productivity			Resource productivity			Socioeconomic and policy drivers			
Country	Output growth	TFP growth	Land area change	Carbon productivity	N productivity	Farmland bird index	Gov R&D	Training	Farmers age	Pollution taxes
Netherlands	+++	+++	+	+	++	--	++	++	-	++
France	-	++	-	+	-	-	++	++	++	
Germany	++	++	+	+	++	-	++	++	++	
Austria	++	++	-	++	-	--	-	+	-	
Czech Republic	-	+	-	+	-	--	-	+	-	
Poland	+	++	--	+++	-	-	-	+	-	
Denmark	+	+++	+	+++	++	--	++	++	--	++
Italy	-	+++	--	++	-	-	+	++	--	
Greece	--	-	-	+	+	Na	-	++	--	
Portugal	+	++	--	-	-	Na	+	++	-	
Spain	-	++	-	+	+	Na	+	++	--	

A **second group of countries** comprises eastern and southern European countries. Here the increase in factor productivity has not been sufficient to offset the negative trend in land area. Moreover, the decoupling of growth from environmental impact is less evident, especially with regard to nutrient surplus. In most cases, the aging of agricultural managers and the lower rate of expenditure in R&D can in part explain these trends and help identify the main areas for policy response. In task 3, this analysis will be completed by looking at the role of CAP in the process of fostering green growth in agriculture.

2. ANALYSIS OF THE MAIN AREAS TO BE DEVELOPED IN EU POLICIES

KEY FINDINGS

- Fiscal regimes for R&D show a strong heterogeneity in MS legislation and controversial evidence about their real impact.
- Having an adequate legal framework is essential to the development of new technologies: though Europe's plant breeding industry and research have been very active, carrying out more than 50% of world research, the EU regulatory framework appears to be inadequate with regard to new breeding techniques.
- Few MS have levied taxes on farm inputs as an instrument to address environmental issues.

2.1. Main policy approaches to support green growth in agriculture

The efficient use of resources is a key priority for sustainable growth strategies. Farm practice and adoption of new technologies that increase productivity, sustainability and resilience of agricultural systems should be encouraged. The same applies to research and policy developments aimed at the same goals. The extent to which farmers will adopt sustainable farm practices greatly depends on the policy framework that is in place. Besides, how much diverse policy and technology approach will deliver needs to be tested and assessed taking biophysical and social contexts into account (Garnett *et al*., 2013, EurActiv, 2016).

Policies for improving productivity and resource efficiency comprise a fairly broad array of instruments that are consistent with the objective of increasing productivity sustainably. They range from traditional regulatory approaches to a much wider set of tools including information and education, cooperation, R&D, technology and innovation. Given that intensity and sustainability of agricultural systems vary from site to site, SI development paths will differ between locations, farming systems and individual farms (Buckwell *et al*., 2014). In this section we will first develop the discussion on the main policy approaches to support green growth in agriculture (**Box 1**) on the basis of a literature review focusing on the EU experience. Then we will introduce some new conceptual considerations on farm level and regional pathways of **sustainable intensification** (see case study 1 below) grounded in the literature, validated through stakeholder assessments and illustrated in European case study regions. This conceptualisation offers a structured portfolio of solutions that can be applied to support regionally-adapted green growth and sustainable land use.

Box 1: Main policy approaches to support green growth in agriculture

Research and innovation: Research and innovation are considered key factors in fostering green growth in agriculture as in the whole economy, as stated in the EU's growth strategy for 2020. The rationale for policy actions to foster eco-innovation rests on well-known market failures referred to as the double externality paradox (OECD, 2011) that concern underinvestment from the private sector and weak market signals to internalise/avoid environmental externalities. Within this context agriculture presents a sectoral specificity due to factors such as adequate farmer level of education and training, and access to credit in the case of high initial investment required. The European Innovation Partnership (EIP) is the approach proposed by the EU with the objective to accelerate the adoption of research findings together with the development of research and innovations.

Market-based instruments: Market intervention measures influence economic decision-making and aim to encourage actions through (positive or negative) economic incentives, such as rewards, grants, fiscal exemptions or facilitative measures. These tools aim generally to address market failures through price signals. They include on the one hand environmentally related taxes, charges and fees, tradable permits and subsidies for reducing pollution. The CAP has gone through a deep reform process in the last 20 years, replacing market support mechanisms and payments that may be harmful to the environment with potentially more beneficial support as payments subject to cross compliance and the introduction of greening requirements. In most cases, in the EU, the Rural Development Programmes are an important vehicle to encourage green growth in agriculture through monetary incentives to adopt practices that go beyond what is required by the respect of existing regulations[5].

Regulatory instruments: Regulations are authoritative instruments that are formulated to prohibit or restrain unwanted actions and developments through negative sanctions and penalties. Regulatory approaches are common in agriculture to prevent negative impacts on the environment. They concern the use of chemical inputs, manure, water, machinery and relate to soil, water and air quality, biodiversity, food safety and quality. In most cases, within the EU, commitments derive from the national implementation of EU Directives and Regulations. The objectives of this legislation are embedded in the CAP through the cross compliance mechanism.

Other non-market instruments: In many MS farmers are involved in voluntary agreements aimed at improving productivity and environmental sustainability. Examples are the Environmental Certification for Farms in France that involves the areas of biodiversity, plant protection, fertiliser management and water use, the green deals in the Netherlands that have set zero-emissions goals for agriculture and dairies, and the Origin Green Programme in Ireland that covers the areas of energy, waste, water and biodiversity.

Research and innovation: Productivity and sustainability in agriculture can be enhanced by appropriate development of new ***technologies*** that can contribute to green growth. Research and innovation are considered key factors in fostering green growth in agriculture as in the whole economy, as stated in the EU's growth strategy for 2020. The rationale for policy actions to foster eco-innovation rests on well-known market failures referred to as the double externality paradox (OECD, 2011) that concern underinvestment from the private sector and weak market signals to internalise environmental externalities. Alston and Pardey (2014) comment that, despite compelling evidence for high rates of returns of R&D and productivity slowdown, public support for agricultural research has waned in high

[5] In chapter 3 we will focus on the two pillars of the CAP, and specifically on two major instruments of support: green payments (first pillar) and EIP (second pillar).

income countries and, moreover, an increasing share of money spent has been allocated to off-farm issues, such as health and nutrition, food safety, biofuel technology and the environment.

Cooperation between various public and private actors within and across national agricultural innovation systems is considered essential to improve the tailoring of innovation to demand, and thus ensure wider diffusion and impact (OECD, 2010a, 2010b, 2013). In particular, Public-Private Partnerships (PPPs)[6] are considered an interesting option to facilitate cooperation between innovation actors at national and international levels. For both the public and private sectors, the benefits from PPPs come from the pooling of resources and the complementarity of capacities, but governance and implementation issues need to be carefully considered to ensure success (OECD, 2016). PPPs can help improve the transfer of knowledge from public research institutions, and leveraging scarce public research funding is another driver. Due to their fragmentation, farmers are often represented in PPPs by producer groups, farmers' organisations, community representatives, or extension services. OECD recommendations in the area of PPS for agricultural innovation focus on the conditions to enter a PPP, on governance and on the needs for capacity building. The main issues are the need for a flexible approach, the role of government in enabling PPPs by providing a stable business environment, developing an appropriate legal framework, or facilitating the sharing of experience and knowledge, the need to define targets and governance rules clearly. Within the EU innovation strategy, the European Innovation Partnership for Agricultural productivity and Sustainability (EIP-AGRI) - launched by the European Commission in 2012 - aims to foster a competitive and sustainable agriculture and forestry sector that "achieves more from less" by bringing together innovation actors (farmers, advisors, researchers, businesses, NGOs, etc.) and connecting EIP Operational Groups and multi-actor projects, to facilitate the exchange of knowledge, expertise and good practices and to establish a dialogue between the farming and the research community.

A favourable environment for the development and uptake of innovation encompasses both general factors and those specific to agriculture. On the one hand, non-specific factors regard some framework conditions such as macroeconomic policies, tax and financial systems or pressure from society towards sustainable growth, while some major factors comprise the presence of adequate levels of farmers education and training, access to advice and credit or regulatory issues that can inhibit both the development and uptake of some innovations.

The analysis of fiscal regimes for R&D in Europe has shown a strong heterogeneity in MS legislation and controversial evidence about the real impact of various regimes. Every country has a different mix of **direct and indirect R&D support**. There are two types of tax incentives: volume-based incentives, found in most countries, and incremental-based incentives which are more efficient for government but entail complexity in implementation. As of 2013, Ireland, Italy, Portugal and Spain use a mixed system of volume-based and incremental tax credits. Some countries have introduced fiscal measures to stimulate innovation more broadly by extending the eligible base to expenses in advanced technology solutions (such as "green" technology in Belgium) and acquisition of intangibles such as patents, licences, know-how and design (e.g. Spain, Poland). Tax incentives are more generous for SMEs in France, the Netherlands, and the United

[6] PPPs for innovation are defined as "any formal relationship or arrangement over fixed-term/indefinite period of time, between public and private actors, where both sides interact in the decision-making process, and co-invest scarce resources such as money, personnel, facility, and information in order to achieve specific objectives in the area of science, technology, and innovation" (OECD, 2004).

Kingdom. R&D target-specific tax incentives are found in Hungary in the case of collaboration, in France for new claimants and in Belgium, France and the Netherlands for young firms and start-ups. France, Ireland, Netherlands, Spain and the United Kingdom impose ceilings on the amounts that can be claimed for R&D projects. There are some countries that do not provide any R&D tax incentives: Estonia, Germany and Sweden (Cozmei and Rusu, 2015).

In terms of the total government support to business R&D as a percentage of GDP and GDP per capita for the year 2011, France, Slovenia and Belgium have a higher share of 0.2% of GDP in terms of total government support to business R&D and a GDP per capita exceeding $30,000 while Luxembourg is the only country with less total government support to business R&D as a percentage of GDP (0.04 % of GDP) and the highest GDP per capita ($78,080). Direct government funding of Business Enterprise Research and Development (BERD), as % of GDP, is the highest for Slovenia (0.28) and the lowest for Poland, Slovakia and Portugal (0.03) while the indirect government support through R&D tax incentives (as % of GDP) is the highest for France (0.26) and the lowest for Slovakia (0.0002) while Germany, Estonia and Sweden do not benefit from any indirect government support through R&D tax incentives. The impact of R&D tax credits may be highly sensitive to their design and organisation, but empirical studies on the effects of design and organisational features are scarce (European Commission, 2014). The R&D tax incentive policies should be assessed regularly in terms of achieving their targets by focusing on R&D eligibility, the criteria for firms that qualify for an R&D tax incentive.

Having an adequate legal framework is essential for the development and adoption of innovation in agriculture. One example is represented by new breeding techniques. Since the 1980s, many new plant-breeding techniques (NPBTs) have been developed. Many of these new approaches deploy biotechnology. Innovation in agriculture and plant breeding can play a key role in responding to challenges such as feeding the growing world population, adapting to climate change and protecting natural resources. These new techniques allow targeted gene modifications to be obtained more precisely and faster than by conventional plant-breeding techniques. Although the applied methodology and changes achieved in the genome of the crops differ from earlier transgenic approaches the question still arises as to whether crops obtained by these techniques should be classified as GMOs (Lusser et al., 2012). The Commission is currently working on a legal interpretation of the regulatory status of products generated by new plant-breeding techniques, which was expected in 2016 but has not been published yet. The Commission points out that its legal interpretation is intended to give guidance to national authorities on the scope of GMO legislation, but that it is the sole prerogative of the European Court of Justice to render a final and binding opinion on the interpretation of EU law. The scientific community remains divided over the issue, and various published legal analyses differ, as do the opinions of other stakeholders. According to a study by the European Commission's Joint Research Centre (JRC), conducted in 2011, Europe's plant-breeding industry and researchers have been very active in the field of new plant-breeding techniques, and have carried out almost 50% of the research done globally (Lusser et al., 2011). The working group set up by the EC completed its work in 2012. The experts all agreed that organisms developed through cisgenesis and intragenesis fell under Directive 2001/18/EC, but remained divided on the regulatory status of most of the other new techniques. Two opinions issued by EFSA[7] concluded that the existing guidelines for risk assessment applicable to GM plants were also appropriate for cisgenic and intragenic plants, and for the ZFN-3 technique.

[7] https://www.efsa.europa.eu/sites/default/files/160621a-p01.pdf

In its statement on new breeding techniques published in July 2015, the European Academies' Science Advisory Council (EASAC)[8], a body of national science academies of the EU Member States, argues that the products of new breeding techniques should not fall under GMO legislation when they do not contain foreign DNA. EASAC notes that in some cases the product cannot be distinguished from one generated by conventional techniques. This, according to EASAC, calls into question the definition of what is meant by genetic modification, and calls for EU regulatory frameworks to be modernised so as to regulate the trait and/or the product rather than the technology. EASAC also argues that the new techniques enable much more precise and targeted changes compared with mutagenesis used in traditional breeding, where changes in the genome are induced by chemicals or radiation, creating multiple, unknown, unintended mutations.

The view that the safety of new crop varieties ought to be assessed according to their characteristics, rather than the method by which they are produced, is shared by a range of bodies, including the UK Biotechnology and Biological Sciences Research Council (BBSRC), the German Academies, the European Plant Science Organisation (EPSO) and the French High Council for Biotechnology (HCB). In its resolution of 25 February 2014 on 'plant breeding: what options to increase quality and yields', Parliament noted that it was important to develop and use new plant-breeding techniques and to be open to the technologies available. Parliament expressed concern at the Commission's delay in assessing new breeding techniques, and called on the Commission to clarify their regulatory status. Parliament stressed that in order to respond to forthcoming challenges, such as future food-supply needs and climate change, it was important to have an effective and competitive plant-breeding sector. It called on the Commission to use the Horizon 2020 Framework Programme to fund research that supported the development of new, innovative plant-breeding techniques such as accelerated breeding. In its resolution of 11 March 2014 on 'the future of Europe's horticulture sector – strategies for growth', Parliament called on the Commission to differentiate between cisgenic and transgenic plants and to create a different approval process for cisgenic plants[9]. Again with its resolution of 7 June 2016 on technological solutions for sustainable agriculture in the EU, Parliament supports the need for continuous progress in innovative breeding; supports the development and use of future technological tools which may allow breeding to successfully address the societal challenges ahead; encourages an open and transparent dialogue among all stakeholders and the public on the responsible development of high-precision, innovative solutions for breeding programmes; calls on the Commission to ensure that consumers and farmers are sufficiently educated in new and emerging breeding techniques so as to ensure that an open and informed public debate can take place[10].

Market-based instruments: They include*, inter alia*, environmentally related taxes, charges and fees, tradable permits and subsidies for reducing pollution. Their role in agriculture is not substantial given the difficulties in identifying pollution sources. Although with the implementation of National Action Plans (NAP) in Europe (Directive 2009/128/EC), **pesticide taxes** are an often discussed instrument in various European countries, few countries in the EU have levied taxes on farm inputs as a way to address environmental issues. One example is Denmark where an ad valorem pesticide tax was first introduced, differentiated by the pesticide's category. In 2013, considering the unsatisfactory results

8 http://www.easac.eu/home/reports-and-statements/detail-view/article/easac-statem-2.html
9 European Parliament resolution of 25 February 2014 on plant breeding: what options to increase quality and yields? (2013/2099(INI)).
10 European Parliament resolution of 7 June 2016 on technological solutions for sustainable agriculture in the EU (2015/2225(INI))

in terms of reduction in pesticide use, the tax scheme was changed into a more differentiated one where each pesticide product receives its specific tax rate that takes into account both pesticide use and pesticide risk. The tax introduction was followed by the implementation of measures to compensate farmers, such as the reduction in property tax on agricultural land. Moreover, tax revenues were used to support organic farming and for administrative services. The purpose was to reduce the total load of pesticides by 40% in the period 2013-2015. The main criticisms regard Danish farmers becoming less competitive and the increase in use of some products that could lead to resistance (Böcker, Finger, 2016). Sweden introduced a special flat tax on pesticides based on the volume sold in 1984. The tax has been continually increased. Until 1995, the tax revenues were used for agri-environmental programmes aimed at reducing pesticide application and at promoting integrated pest management. At the same time, a tax on artificial nitrogen fertiliser and cadmium/phosphorus was introduced. Such taxes potentially contributed to a reduction in pesticides sold and their application.

France introduced a volume tax on pesticides in 2000 ('*taxe générale sur les activités polluantes*' - TGAP), which was in force until 2009. Pesticides were divided into seven taxation categories (based on the eco-toxicological and toxicological properties and the tax had to be paid by the pesticide). In 2009, the TGAP was replaced by a fee on non-point agricultural pollution ('*redevance pour pollutions agricoles diffuses*') and only three different pesticide categories were established. Pesticides allowed in organic agriculture are charged reduced VAT, giving a comparative advantage to organic farming. The new fee has to be paid at the retail level by the customer and the distributors have to state the fee on the invoice in order to create awareness with the aim of reducing environmental or health risks of pesticides. Tax revenues are allocated to water utility and sewage treatment operators according to the regional pesticide contamination in the water and other measures of the NAP (Böcker, Finger, 2016). The French NAP écophyto 2018 lasts from 2008 until 2018 and aims to reduce the total pesticide usage by 50%.

When the reduction objective is well defined and the chosen indicators are well developed, differentiated taxes can be an effective environmental policy instrument in the long term and a contribution to integrated pest management. However, in order to reduce reliance on pesticides significantly, a tax scheme has to go hand in hand with accompanying measures promoting preventive measures of integrated pest management (Böcker, Finger, 2016).

Other non-market instruments: In many MS farmers are involved in voluntary agreements aimed at improving productivity and environmental sustainability. In France the Loi Grenelle, which came into force in 2012, has put in place several measures concerning agricultural green growth. The law has set targets with regard to the organic certified area, the number of farms under high nature value certification, reduction in the use of pesticides and withdrawal from commerce of the most dangerous ones, and support for research. Environmental certification is voluntary, verified by third party bodies, and envisages three levels of environmental progress. In Ireland the government has launched the Origin green Programme. It deals with voluntary sustainability development and concerns the whole Irish food and drink industry. The Danish Green Growth strategy, launched in 2009, has the objective of modernising agriculture in an environmentally sustainable way, preventing farmers leaving the sector. It has introduced shareholding corporations for the ownership of land for farming purposes in order to avoid farm closures. It also removed the mandatory maximum ratio of the number of livestock to hectares per farm.

2.2. Pathways of sustainable intensification

KEY FINDINGS

- Sustainable intensification (SI) comprises manifold approaches to balance economic and environmental goals of agricultural production.
- SI needs locally adapted solutions.
- SI strategies are characterised by where (farm vs. landscape level) and how (land use vs. structural optimisation) they are implemented.
- Four generic SI pathways enable regional decision-makers to choose appropriate SI strategies.
- Implementation of SI needs promotion, communication and knowledge transfer to change intrinsic persuasions and incentivize action.

2.2.1. Introduction: the concept of sustainable intensification

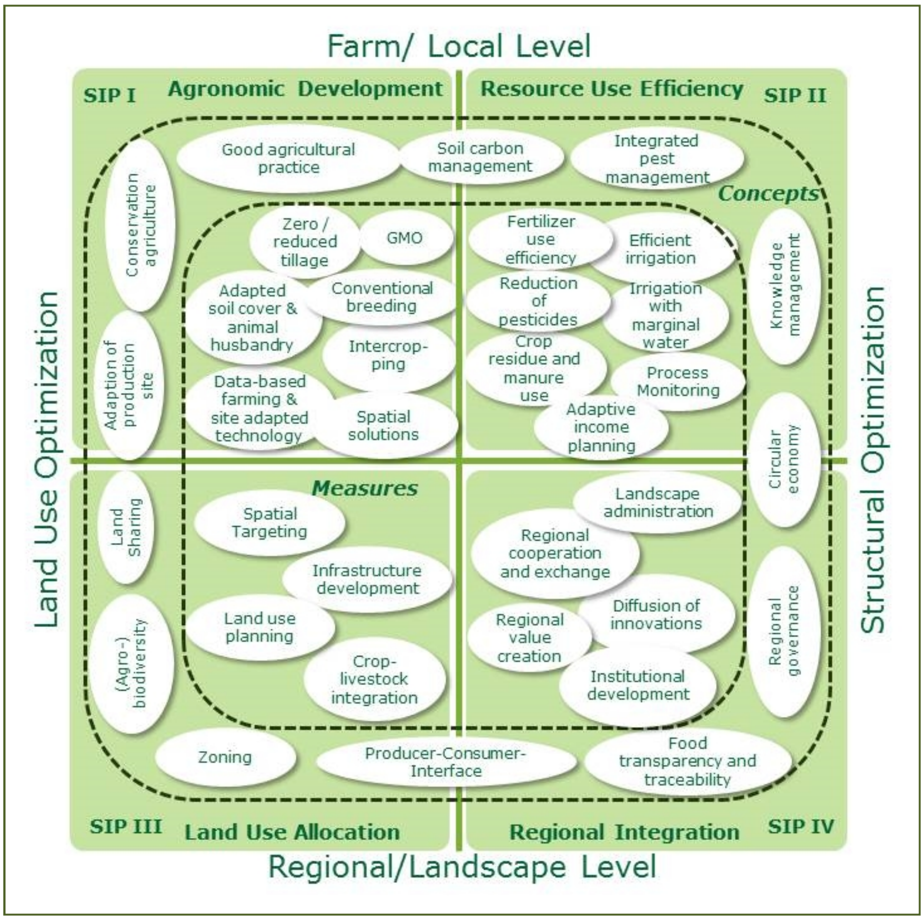
The concept of **sustainable intensification (SI)** was framed by Pretty (1997) in order to demonstrate new output growth paths for smallholder agriculture in developing countries that do not entail the depletion of the natural resource base as experienced in industrialised countries during the '*green revolution*'. The primary aims were to improve the livelihood of rural poor, resilience of the agricultural system and food security. For general understanding of SI, it means *simultaneously increasing or at least maintaining agricultural production per unit of land while environmental pressures generated by the production process are reduced or the services to the ecosystem increased* (Baulcombe et al., 2009; Godfray & Garnett, 2014; Pretty et al., 2011). In Europe with ecosystems coming increasingly under pressure, SI has been discussed as a strategy to integrate the goals of economic production and environmental protection (Baulcombe et al., 2009). Sustainable intensification of European agricultural systems addresses in particular the challenges of preventing the loss of biodiversity, mitigation of climate change and preservation of scarce natural resources.

2.2.2. Sustainable intensification pathways

Going from aspirations to implementation, it has to be distinguished how sustainable intensification can be achieved in practice and which factors are enabling or hindering. According to research into sustainable intensification, it is agreed that it requires **regional solutions** that are adjusted to local framework conditions, such as the biophysical environment, regional infrastructure, peoples' preferences, regulations and the general conditions for innovation (Barnes & Poole, 2012; Caron et al., 2014). Therefore, a whole portfolio of solutions for SI exists. Measures that can be applied on different scales are discussed to achieve a sustainable intensification of agriculture (see e.g. Tscharntke et al., 2005 for an overiew of sustainable intensification solutions). In order to offer farmers, regional stakeholders and decision-makers guidance on the selection from the SI portfolio based on the respective regional characteristics and challenges, these solutions can be assembled in distinct fields of action.

Comparing different SI solutions, it can be demonstrated that they form **clusters** according to two criteria or dimensions: the first is the spatial dimension referring to *where* a solution is applied, either at the farm level or at a larger landscape or regional level. The second addresses the activity dimension of *how* a solution is applied. SI entails either optimisation of land use or of structure, which means organisational or management-related optimisation. Together the two dimensions establish four fields of action that form general **sustainable intensification pathways (SIP)**. The SIPs are generic ways of how a region can make progress towards sustainably intensified land use. The framework of the four SIPs is represented in **Figure 15**. A literature review identified strategies that can be applied in each of the four SIPs. These were distinguished into measures that can be directly applied such as reduced tillage or the establishment of regional networks for cooperation that belong to broader concepts such as soil carbon management or regional governance.

Figure 15: Framework of sustainable intensification pathways (SIP) defined on a farm vs. landscape and land-use vs. structural dimension



Source: Weltin et al. (2016).

By classifying measures and concepts into pathways, the four SIPs can be named and characterised (**Box 2**).

- **SIP I "Agronomic Development"** includes agronomic practices and new production methods and technologies, many of them belonging to good agricultural practice, that make better use of the production side by adapting the treatment, use and cover of land as well as livestock holding. Integrating extensive and intensive production methods on the holding, adapted breeds and varieties as well as own breeding belong to this pathway. The emphasis is on the protection of soils and animals and simultaneously keeping yields prospering due to site-adapted production techniques.
- **SIP II "Resource Use Efficiency"** strives to use the available resources of an agricultural holding, such as natural and non-renewable inputs, but also labour and knowledge, efficiently increasing the output-input relationship. Conventional inputs

such as mineral fertilisers and pesticides are reduced. Resource cycles on farms should be organised to be as closed as possible, which means that residues from the production process are re-used to the maximum extent. To do so, effective knowledge management, monitoring and evaluation systems need to be implemented as well as an income structure that can react comparably flexibly to fluctuations in the market, for example through diversification or payments for landscape conservation activities.

Box 2: Case study examples for sustainable intensification pathways

SIP I: Agronomic Development
Kromme Rijn (Netherlands) is located close to the city of Utrecht and is dominated by dairy and fruit production. Supermarkets have comparatively high sustainability and animal welfare demands. Farmers in the region introduced **milk robots as a technical innovation** on the farm to achieve SI. Cows can decide when to get milked which increases animal welfare and farmers can save on labour costs. The share of grazing for dairy cows is also comparatively high (over 80%) in the region.

SIP II: Resource Use Efficiency
Valencia Region (Spain) is a traditional vineyard production area. The predominantly small farms have to a large degree adopted **integrated farming practices** as an SI strategy. Most of them were already working rather extensively, using limited amounts of fertilisers and pesticides. Farmers can economise on input costs. The extensive model produces higher quality grapes and requires less water. The strategy is an important step for a drought-prone region.

SIP III: Landscape Allocation
In **Rhinluch (Germany)** landscape is built from peatlands which were converted into grassland through drainage to be suitable for agricultural use. Nature protection bodies fear the loss of biodiversity through livestock holdings. In order to enable agricultural use and preserve the natural functions of the ecosystem, **temporary schemes** exist as an SI strategy of **land sharing**. These oblige farmers **to keep their areas under water** for a certain period of time each year. Farmers receive compensation payments or reduced leass for wetland that is partly difficult to cultivate.

SIP IV: Regional Integration
Vaucluse department (France) is characterised by spatial clusters of vegetable and fruit production as well as vineyards. Farms tend to specialise. The region has an established **network for the diffusion of innovations** for regional farming systems. It includes an experimental farm and several pilot farms where measures are tested. The results are distributed through an advice system involving the chamber of agriculture. Innovative farms take up new technologies and spread best practices to their neighbours. Ways to substitute conventional inputs have been made popular in the region in this way.

Source: Personal interviews with regional stakeholders.

- **SIP III "Land Use Allocation"** addresses targeted and planned allocation of land use according to the capacities of the landscape in question in order to enhance landscape functioning and biodiversity. Production should take place at the most suitable places integrated in a holistic spatial plan. Measures of land sparing through designated areas for nature conservation and land sharing integrating nature protection and production on the same area have to be connected to local framework conditions. Infrastructure such as footpaths and water networks is planned with the aim of preventing the depletion of natural resources and mitigating regional climate risk. Access for tourists can be enhanced to broaden the possibilities of income generation.

- **SIP IV "Regional Integration"** encompasses regional exchange of knowledge as well as inputs organised into formal and informal networks of all relevant stakeholders. Consumers are included in this process of cooperation and exchange which is steered by enabling (regional) governance mechanisms. This allows for food and production transparency and helps to generate compromise on the needs and interests of all involved actors. Innovation diffusion steered by advisory and knowledge transfer networks plays a central role for progress towards SI. Coordinated feedback loops on how research results and new technologies can be implemented in practice between science, industry and land users, thus accelerating these processes. (Weltin et al., 2016).

A region chooses from the portfolio of SI strategies depending on the regional problem setting and normally applies a combination of measures in several pathways. In general a trend will be observed for one of the SIPs. Knowing in which direction a region has development potential, the framework of the four SIPs allows matching sustainable intensification strategies to be chosen. The regional diversity of the SIPs is illustrated in box 2, showing a case study for each of the four pathways.

Box 3: SIP framework applied to the Rhinluch case study region

Regional problem setting: the Rhinluch region is dominated by grassland on drained peatlands, a source of greenhouse gas emissions. The drainage and water system lacks systematic planning and maintenance. Semi-intensive livestock and intensive cropping coexist with designated areas for nature protection. The region is home to one of the main migratory crane stopover areas in Europe, an attraction for tourism. However, tourism still lacks coordination, especially outside the crane season. Livestock intensity has reduced in the last two decades and nutrient cycles have become more closed. In parallel, arable production for food (crops, asparagus) and green biomass (energy) has intensified. Short supply chains for quality food have been party established.

Regional image of SI elaborated by regional stakeholders based on the SIP framework[1]:

SIP I "Agronomic development" *- assign extensively and intensively used plots according to economic and ecological criteria* *- side-adapted technology (for wet areas)* *- focus on good agricultural practice*	***SIP II "Resource use efficiency"*** *- adaptive income structure including direct sale, niche products and payments for conservation activities*
SIP III "Land use allocation" *- maintenance of water and drainage infrastructure* *- establish an inclusive water concept* *- land-use according to conservation contracts*	***SIP IV "Regional integration"*** *- establish simplified regulation for farmers to motivate innovation* *- establish a regional supervisory body for water management and collective decision-making* *- foster coordinated tourism promotion initiatives*

The image shows the most important strategies for each pathway according to the frequency of naming and assigned importance (each participant had three votes).

Source: Focus group discussions with regional stakeholders.

A key purpose of the SIP framework is to highlight the scope of action a region has. It should steer discussions on site-specific regional development towards comprehensive SI solutions. This regional applicability was successfully tested in **Rhinluch region** in Germany. In focus group discussions with 20 regional stakeholders who are included in the decision-making regarding land use, promising measures for SI in the region were discussed based on the four SIPs. The group consisted of 7 farmers, 4 representatives of nature protection agencies, 4 representatives of the local environmental administration, 3 scientists with focus on the specificities of the agricultural system, and 2 input providers with regional focus. The stakeholders elaborated a regional image of SI addressing a need for action on all four SIPs but especially highlighting the importance of the two pathways on the landscape level. The outcome is summarised in **Box 3**.

2.2.3. Incentivizing progress on sustainable intensification pathways

In order to direct agricultural systems to SI, agricultural and regional development policy needs to incentivize the uptake of site-adapted strategies. Farmers are often risk-averse to new developments, do not fully include environmental outcomes in their decision-making process or lack the knowledge on favourable management options (Buckwell et al., 2014).

Policy can incentivize change on the **levels of actions, behaviours and investments**. The EU Claim project developed a detailed overview on the policy instruments that can be applied (Zasada et al., 2012). The aim of this section is not to offer a comprehensive analysis of policy instruments but is dedicated to "best practices" and enabling conditions for SI identified in interviews with farmers and regional decision-makers in the regions Kromme Rijn, Rhinluch, Vaucluse and Valencia (**Box 2**).

Market intervention methods can be used to **incentivize action**. That is, to steer the decision-making of farmers and regional actors to engage in SI measures by using (positive and negative) economic incentives such as rewards, grants, fiscal exemptions or facilitative measures (Zasada et al., 2012). An illustrative example for SI is the uptake of integrated farming practices in *Valencia region* supported by agri-environmental measures. Another example relates to the transfer of ownership rights in *Rhinluch*. Nature protection agencies receive pre-emption rights for land areas which they then can lease out to farmers with conservation measures prescribed in the lease contract. Normally, the lease is relatively low. Farmers claim they would be much more willing to engage in such schemes if they offered more flexibility. The first mowing date, for example, is prescribed. Having a more flexible band for this first date would make the schemes more attractive as risk, e.g. from bad weather conditions, would be reduced. Stakeholders also raised the issue that they need in general long-term planning security to engage in newly introduced policy measures.

An important frame around the set of economic incentives should be different measures that address the level of motivations and **incentivize a behavioural change** of regional actors. This can be achieved in a twofold way: on the one hand, a set of rules and regulations need to be set up to restrain unwanted actions through penalties and sanctions. Rules should be transparent and objectives need to be clear in order to achieve a far-reaching consensus on the overall benefits.

The Netherlands are for example currently planning to make grazing obligatory which would affect livestock farming in *Kromme Rijn*. The second, and much more relevant part in order to achieve long-lasting behavioural change, is the role of information instruments that address intrinsic persuasion through communication as well as intellectual and moral appeals (Zasada et al., 2012). In *Kromme Rijn*, a growing network of farm shops and direct sellers increases the contact of farmers and consumers and raises the awareness for each other's perspectives. Stakeholders in *Rhinluch* see the lack of regional cooperation and planning as a key constraint to implement SI in the region. The formation and maintaining of regional networks should be encouraged and supported.

Several SI strategies need larger **investments** in order to be started. On the farm level new investments are needed to adopt new technologies. On the landscape level investments in infrastructure are needed to make progress towards SI. In *Rhinluch*, missing infrastructure prevents the tourism potential from being fully exploited, for example with regard to missing cycling trails. In *Kromme Rijn*, many farmers raise the issue that lacking access to credit prohibits investments in more efficient technologies, e.g. for milk robots. Farmers having the financial means are those who make changes. Investment support schemes, such as in *Vaucluse department* where the intermediary structures of an innovation diffusion network were subsidised by public funding, are promising to foster regional innovativeness. Investment support can thus be a trigger for progress on SIPs.

3. CURRENT INSTRUMENTS IMPLEMENTED BY CAP AND OTHER COMMON POLICIES TO IMPROVE PRODUCTIVITY SUSTAINABLY

3.1. General assessment of CAP instruments linked to green growth

KEY FINDINGS

- The latest CAP reform tried to address the greening of the CAP with specific and targeted measures; however, preliminary results and indicators show that the impact of these measures is relatively low, especially due to the many exceptions and derogations to the rules arising as a compromise for the political acceptance of the reform and to the large flexibility given to the Member States to implement the reform.
- In general, what is evident in the process of CAP reform is a slow but progressive shift from trade-off policies (production vs. environmental impact) to win-win policies, that is policies that can work within the sustainability framework, both maintaining production goals and sustainably managing the natural resources. New technology applied to farming, such as remote sensing and robots, leads in this direction.
- The growing importance of the issue of food security (increasing both quantity and quality of production) and the risk of a progressive abandonment of the primary activity all over the EU territory have progressively led to set a new generation of policies that are based on the search for a synergy among policy goals rather than conflict.

3.1.1. The greening of the CAP

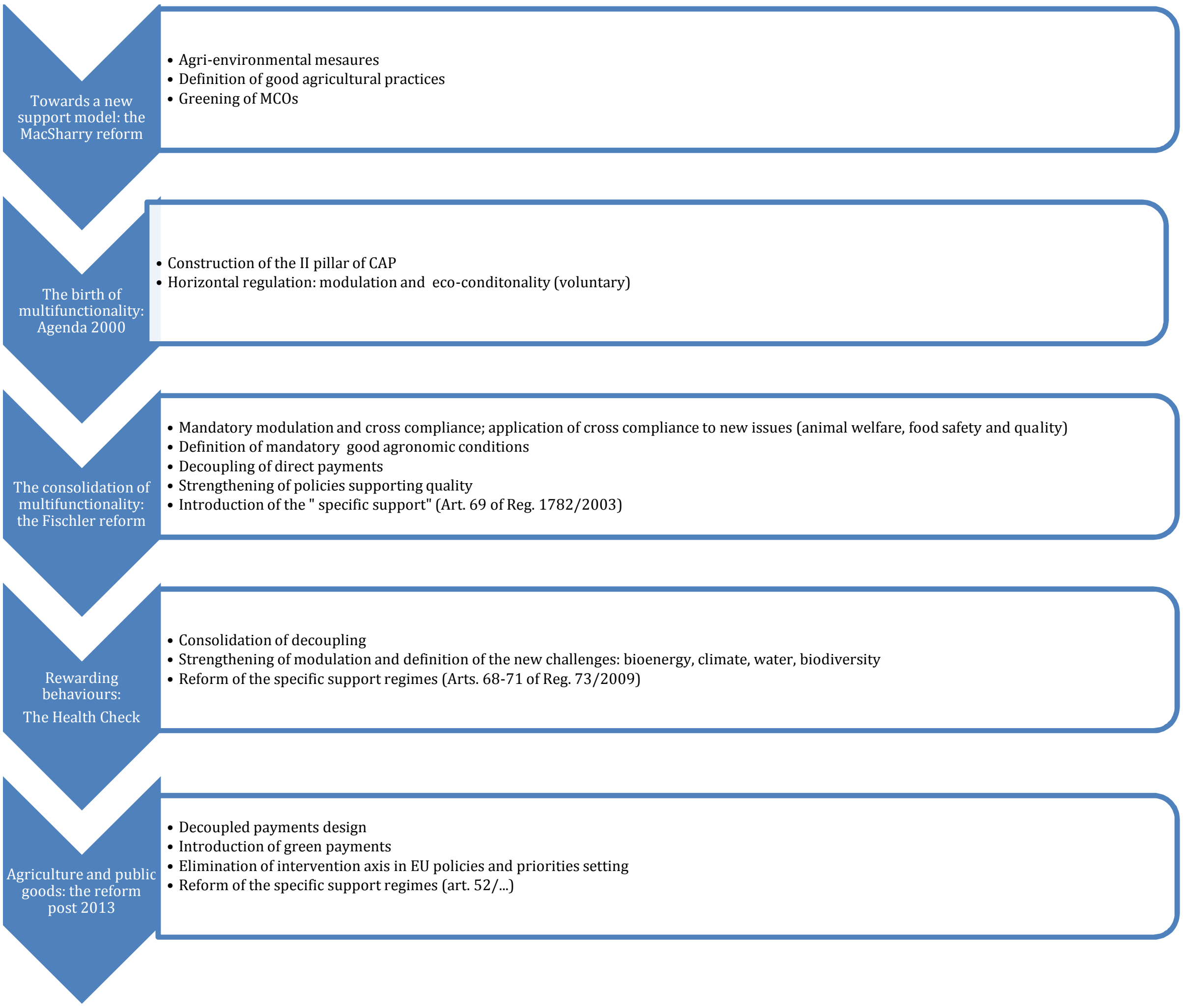
Green growth is a relatively new concept driving the design and implementation of policies in the EU and the rest of the world. However, the greening of policies supporting growth and development is not new for the EU (**Figure 16**). The process of greening has actually developed along a path which, like the rest of the CAP, has followed a path dependency pattern, taking its first steps in the early 1990s, with the MacSharry reform, with the introduction of semi-decoupled direct payments and the agro-environmental programmes among the "*accompanying measures*". This was the first attempt to decouple the level of production from the amount of support, so as to reduce the pressure on intensification to reach higher levels of production and hence higher pressure on production factors, first of all land. At the same time, the agro-environmental measures were widely acknowledged as the first attempt to create a body of measures specifically and explicitly addressing the connections between agriculture and the environment and natural resources. They were conceived to mitigate the effects of the market and pricing policies, introducing a territorial and voluntary approach to more sustainable farming.

That was a first articulate response to the criticism levelled at the CAP as the main cause of the pressure arising from intensive agriculture. As noted by the IEEP (2002), the considerable support offered under the principal CAP regimes was seen as the main driver of intensification, «*while the low-input farming systems, generally more benign environmentally, receive a relatively low share of support under these regimes*» (IEEP, 2002, p. 5).

With the MacSharry reforms, the Common Market Organisations (CMOs) themselves had been "*greened*", introducing measures of extensification and reducing pressure on land

and natural resources (mainly in the sectors of beef and cereals). In the case of beef, direct support had been calibrated on the level of stocking density per hectare of fodder crops, thus encouraging the extensification of herds and penalising intensive livestock. Even the set-aside measure in the arable crop sector, whose main goal was that of a reduction in supply, was often intended as a measure to reduce intensification and pressure on land, even though one of the main flows of the set- aside was its application to marginal less-productive land, so that is was not particularly effective on the supply control. Its environmental effects were highly dependent on specific local management conditions that were beyond the scope of the regulation (IEEP, 2002).

Figure 16: The evolution of the greening of the CAP



Source: Henke and Vanni (2014).

The greening process went on in 1999 with Agenda 2000, with the formal setting of the two pillars and especially with the introduction of the concept of ecological cross-compliance. The whole Agenda 2000 approach grounds on the idea of multifunctional agriculture, which has been a turning point for the policy support of the EU to the primary sector and the rural areas. The new form of support based on multifunctional agriculture featured the decline of automatic horizontal policy tools and the start-up of a process of matching the right policy to each specific aspect of agriculture and to territorial differences. Ecological cross compliance, introduced with Agenda 2000 at a voluntary level, fixed the concepts of "*mandatory requirements*" to follow in agricultural activities in order to gain support and specific requirements connected to the CMOs, thus setting standards for specific sectors. These requirements were set beyond the good practices, so as to set the bar at a higher level than that of the minimum requirements to enjoy support. Although rather weak in its implementation and generating confusion at the institutional level, cross-compliance is a key point in the subsequent measures in favour of sustainability, introducing the principle that support is not due to the status of farmer but it aims to increase sustainable behaviour.

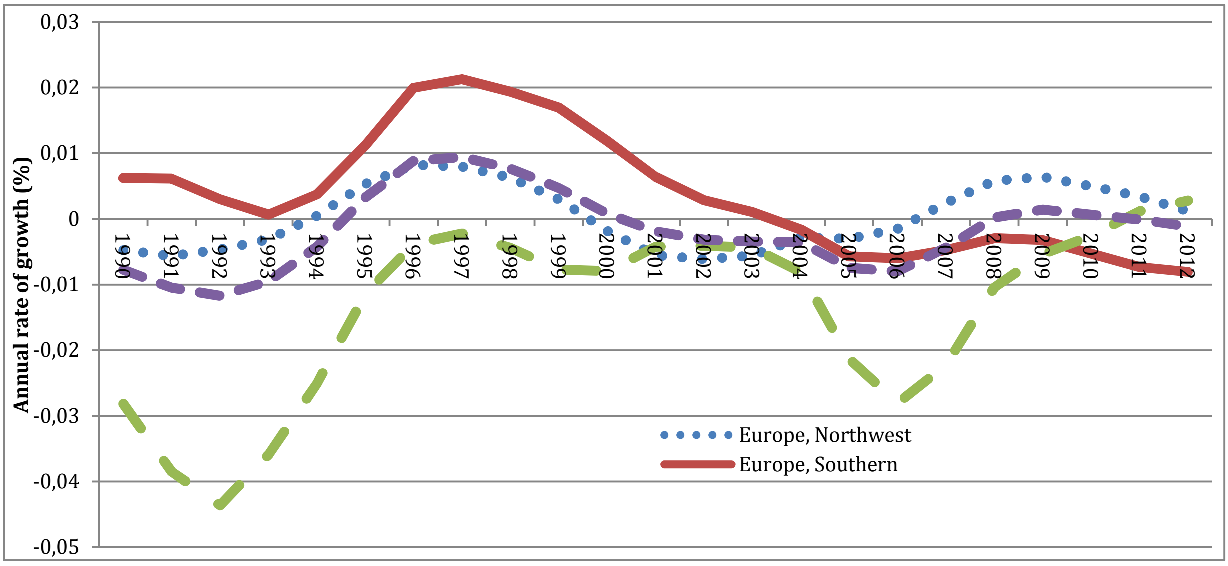
Cross-compliance was enhanced with the next reform of 2003, the so-called Fischler reform. The greening process develops with this reform as follows: a higher level of decoupling, which is considered to generate less pressure on the environment and natural resources (but with pressure also on food security and the level of provisions of raw materials); a mandatory cross-compliance, tied to specific good farming practices; a share of coupled payments addressing specific environmental and food quality systems concerns. Besides, the mandatory modulation ensures a transfer of financial resources from the first pillar to the second, where all the agro-environmental measures and the diversification support for rural areas are appropriately included.

In terms of the debate between sustainability and productivity, it must be recalled that in these years the debate in question has focused especially on the issue of food security in the EU and even more in other contexts, due to the increasing interest towards the practices of extensification, which entail the substitution of food crops with non-food crops, such as energy crops, or even on-farm non-agricultural activities, such as photo-voltaic panels, recreational uses and so on.

With the Fischler Reform, and its health check of 2007, the direct support of the CAP increasingly became an attempt to enhance and improve the production of public goods in agriculture in favour of the whole of society. Part of the new support system is devoted to so-called "*big challenges*", including environmental goals and also introducing the issue of the control and mitigation of climate change.

These major steps in the CAP reform are easily detected when analysing trends in the main indexes related to agricultural production and productivity as in **Figures 17 and 18**. **Figure 17** shows the rate of change in the agricultural output in the last 25 years. The application of the MacSharry Reform puts an end to the increasing trend in agricultural output artificially obtained through coupled support which led, in turn, to sensitive input use intensification. From this moment on, a process of deep change in the organisation of production and in land use has taken European agriculture along a path where the progressive decrease in input use is offset by an increase in **Total Factor Productivity**.

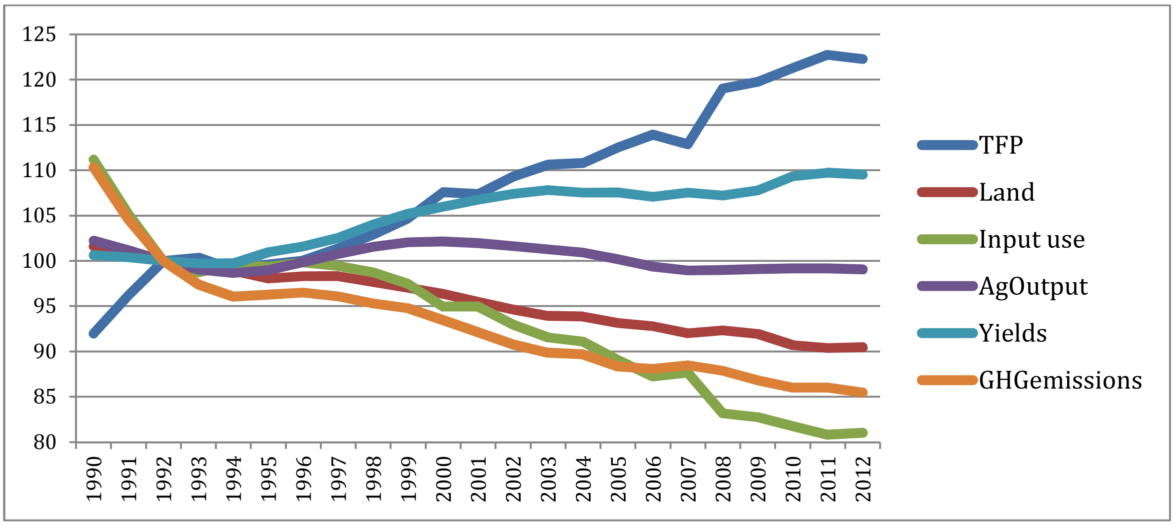
Figure 17: Agricultural output growth in EU regions



Source: Authors' calculations based on http://www.ers.usda.gov/data-products/international-agricultural-productivity.aspx

In **Figure 18**, the growth in agricultural output is decomposed into its determinants (TFP, change in land and input use), and two indicators or resource productivity (yields and GHG emissions) are shown as well. Trends in these variables appear at different levels and intensities in different areas of the EU. While in Northern MSs output trends remained quite stable as well as cropland, in Southern MSs we can depict three different periods: during the first period, from the MacSharry reform to the Fischler reform, the reduction in input use and in land use proceeded at the same rate; during the second, from the Fischler reform to the Health check, there was a stabilization in land use and in TFP growth, a reduction in input consumption and a slight decrease in the agricultural output; finally, a third phase after the Health Check shows a continuing increase in yields and carbon productivity (reduction in GHG per unit of product). It is also very interesting to note that the trends for the NMS (Eastern European New MSs) are rather different from all the others, with much more dramatic changes in the production dynamics.

Figure 18: EU agriculture: productivity and sustainability: index (1992=100)



Source: Authors' calculations based on http://www.ers.usda.gov/data-products/international-agricultural-productivity.aspx

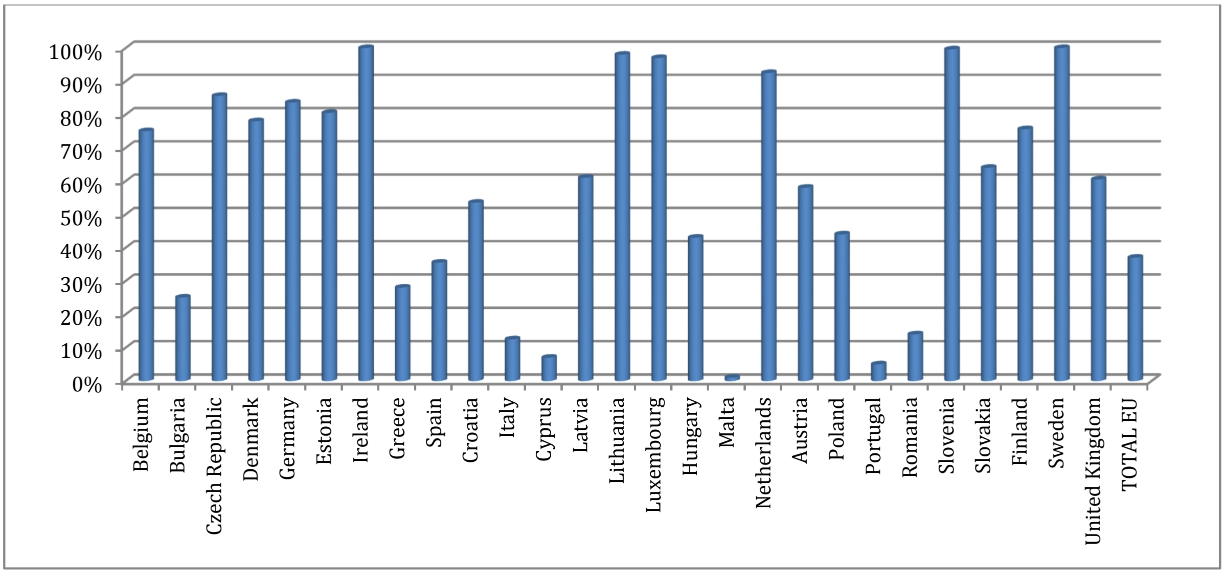
The general trends shown in the graphs are clearly tied to the changes in policies, following quite regularly the main evolution of the CAP in recent decades. However, the diversified response among different European areas may be due to the rather striking differences among the structural conditions of agriculture and farms between Northern, Southern and Eastern MSs, and also to the different land use specialisation and to the uneven level of support granted in the previous decade, which all contributed to a different reaction to the process of decoupling and the increasing environmental constraints.

The latest step in the greening process is the most recent reform set up in 2013. With this **reform (2014-2020)**, for the first time the direct payments are articulated in different shares so as to remunerate specific and selective objectives. One of the shares is devoted to remunerating environmental public goods such as biodiversity and soil regeneration (ecological payments). This share is mandatory: all Member States have to comply with the requirements for this share of direct payments.

In spite of the declared intentions, a large part of the EU agricultural area has been excluded from the requirements of ecological payments (product diversification; pasture maintenance and ecological focus area): permanent crops, organic farming, small farmers, and other cases, are all considered green by definition (Henke and Vanni, 2014). A recent study of the European Commission shows an articulated set of statistics about this issue (European Commission, 2016b). As can be seen from **Figure 19**, the number of farmers under at least one greening obligation as a share of the farmers applying for direct payments ranges from very close to 100% in Ireland and Sweden to around 10% in Italy, Romania, Portugal, Malta and Cyprus. Part of this result is due not only to the average size of the farms in these MSs, but also to the specific land use, with a large predominance of permanent crops in Italy and Portugal that are "green by definition" and are not subject to the obligation of the crop diversification (**Figure 20**). According to Hart and Radley (2016) the greening measures of the First Pillar "*do not appear to be on course to fulfil their potential as an environmental instrument. In most Member States, optimizing the environmental benefits of greening, and of EFA in particular, appears to have been a lower priority than minimizing the impact on farmers and ensuring that measures can be adequately controlled to avoid risks of disallowance*" (p. 53). In the same vein, Hart et al. (2016) suggest that most MSs have not fully used the flexibility offered by the regulations to increase the environmental impact of the reform, merely maximizing the opportunities for farmers to meet their obligations without having to make significant changes, "*for example by permitting crop production in most EFAs, using crops that are not necessarily beneficial to biodiversity, permitting the use of fertilisers and pesticides, and selecting landscape features that are already protected under cross compliance*" (p. 23).

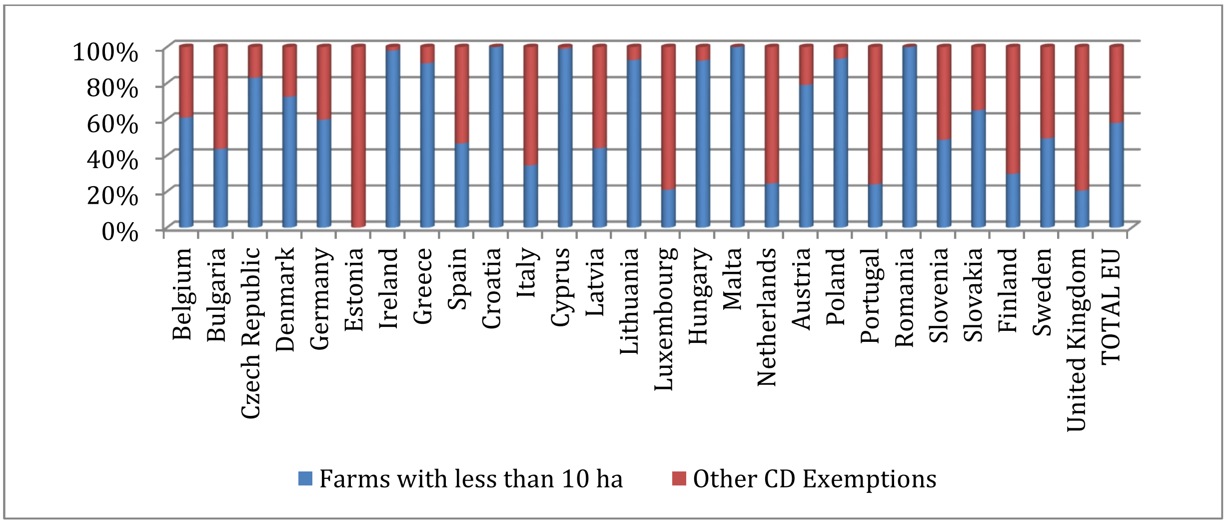
One of the most critical issues in the definition of an "*ecological payment*" as it has been defined in the recent reform is its similarity to conditionality, since it is mandatory, "*horizontal*" and non-selective, since it imposes rules that are applicable in the same way to agricultural land throughout the EU (Matthews, 2012; De Filippis and Frascarelli, 2012). In the same vein, as for conditionality, also for the ecological payment most of the requirements may already be in use, such that in practice the ecological payment is given to many, if not to all. In the end, the principle of remunerating behaviour is only respected in theory, but not in practice, where the status still prevails.

Figure 19: Number of farmers under at least one greening obligation as a share of the farmers applying for direct payments



Source: European Commission, 2016 (France and Scotland data missing at the time).

Figure 20: Reason for arable land to be exempted from crop diversification (greening) per MS



Source: European Commission, 2016b.

Other measures activated with this reform have a more or less direct effect on the greening process: identification of active farmers, the regime for small farmers and the payments for farming in disadvantaged areas, which can all have a direct or indirect effect on the state of soils and on biodiversity. The new coupled payments (Art. 52, Reg. 1307/2013) are also seen as a way to increase the selectiveness of payments and to increase their targeting to specific sustainable farming and reduce the risk of land abandonment (De Filippis and Frascarelli, 2012). Finally, also within the second pillar some of the new features, such as the definition of priority in place of the old intervention axes shed more light on specific environmental and sustainability goals, such as the contrast and mitigation of climate change effects (European Parliament, 2016b).

3.1.2. Trade-offs and win-win strategies

One of the main issues arising from the greening measures of the CAP is their different economic impact on the EU agricultural systems (EurActiv, 2016). This reflects the generally acknowledged drawback of the horizontal standard implementations of the greening measures, which are unable to take into consideration the gradient of vulnerabilities of the different farming systems of the EU. Analysis of the recent literature on the theme of the greening of the CAP shows the complexity of the debate, but also a general dissatisfaction with the EU approach, regarding both the method followed and the merit of the measures (Westhoek et al. 2012; Mahé, 2012; Matthews, 2012 and 2013; Povellato, 2012; Henke and Vanni, 2014). As regards the method, the main issue is the fact that the ecological payment requires rules to be followed that are virtually the same throughout the EU. This component of the overall greening process adds to the other measures in a rather confusing way (conditionality and agri-environmental measures), such that the burden for farmers is definitely disproportionate to the results. As for the merit, the whole package risks being quite ineffective both in economic and environmental terms, given the relatively small amount of farms and land hit by the whole greening, as discussed in many of the works reported here.

However, a change in the approach is quite evident, which can be chronologically established with the Fischler reform: from a **trade-off** approach (where greening was basically opposed to the objectives of productivity growth and intensification) to a **win-win approach** (**sustainable intensification - SI**). The (limited) greening approach before the Fischler reform was basically aimed at reducing intensification through measures of supply control (*set aside*) and extensification (primarily in the beef sector and in arable crops). Indeed, set aside was criticised because it was a supply control tool rather than an extensification tool, on the ground that the area left in production was intensified in order to compensate the (marginal) areas left out of production. Hence the outcome was an increase in intensification and production (Fraser, 2001, Cardwell, 2004).

After the Fischler reform, the approach to greening was heavily influenced by the issues of food security and provision of commodities and raw materials, raised by the growth of alternative uses of agricultural areas for non-food production and also by the instability of the international markets (including the 2007 price spike). . In the new 2014-2020 CAP, the idea of an SI is behind the approach of the new coupled payments and also the greening policy itself, which does not merely reduce the area cropped, but also aims to improve the quality of land and favour soil regeneration.

However, the concept of SI itself lies at the centre of a debate about its political robustness and also its intrinsic coherence ((Garnett et al., 2013); Garnett and Godfray, 2012). The concept of SI is modelled basically on the issue of how to increase food production without generating an uncontrollable pressure on environment and natural resources. It responds mainly to a specific developing country issue, and it is harder to make it spendable in a developed and mature economic system like Europe. With regard to this, one major issue underlined by the critics of the SI concept is that in the developed regions of the word the correct balance between production and environmental pressure should be achieved through a better match of demand and supply rather than increasing supply, especially via waste management and the governance of the resilience of the food system (Garnett et al., 2013). Another major issue is the relationship of SI and animal welfare: since the concept of intensification does not address animal welfare issues as pursued by the EU legislation, it creates serious constraints in livestock production. However, the same concept can be extended to the issue of biodiversity in crop production. These are all cases and caveats where it seems that we are still far away from going beyond trade-offs and moving towards win-win approaches.

3.1.3. Assessment of the new CAP

The assessment of the current CAP greening policies will be developed here following the approach mentioned earlier, according to which the position of each major instrument in the current CAP will be qualitatively assessed. We designed a grid in which the evolution of the main CAP tools is considered and where we show the progressive shift in the policies from a mainly conservative approach generating trade-offs among the objectives of the primary sector, to a **win-win approach**, creating synergies among policy goals. Indeed, it is hard to assess measures in an exclusive way, both because they can respond in different ways to different goals in different regions and also because the effect of a policy is never exclusive but there are several direct and indirect effects according to the context and to the combination with other tools. However, the proposed scheme is helpful in order to set a periodization of the policy and their more predictable effects on both sustainability and productivity (**Table 3**).

At the time of the Gothenburg Council (2001), the EU agreed on the general objective that the CAP should contribute to sustainable development, as launched by the Treaty of Amsterdam, by increasing emphasis on health, high quality products, environmentally friendly production techniques, renewable raw materials and biodiversity (IEEP, 2002). This was, in a few words, the basic structure of the strategy towards the integration of environmental issues with productive ones. What was never really discussed was the level of conflict between these objectives, probably due to the fact that it was taken for granted that the only effective way to achieve fruitful integration was by following a conservative approach.

Underlying this approach was the idea of a polarised system facing on one side the process of intensification on good quality, flat land and, symmetrically, a process of marginalisation of poor quality, sloping land. The cycles of intensification and marginalisation had opposed environmental effects: on one side the main effect was overexploitation of resources and pollution; on the other, the effects were considered not always negative: less pressure on resources with possible abandonment, which could end up in afforestation.

The growing importance in the EU of the issue of food security, together with the risk of a progressive abandonment of the farming all over the EU has progressively steered a new generation of policies that are based on the search for synergy among goals rather than conflicts. The switch over to this set of policies has also been made possible by technological evolution and the diffusion of production techniques that create less conflict between the goals of an increase in production rates and the sustainability issue. At the same time, the concept of sustainability itself has changed in two main respects: the widely shared vision of the multifunctional role of agriculture connected to the production of both public and private goods, and the embodiment of various forms of on-farm diversification in the value of agricultural production, which allows re-distribution of the input among the different types of on-farm, non-agricultural activities.

In **Table 3** two aspects are displayed: the first is the growth of the policy tools that directly or indirectly have an effect of both the goals of sustainability and productivity; the second is that there is actually a consistent shift towards forms of integrated policies, while the trade-off generation policies tend to be superseded.

Table 3: Classification of the main current policies according to the conservation/integration approach

MacSharry (1992)		Agenda 2000 (1999)	
Conservation	**Integration**	**Conservation**	**Integration**
(trade-offs)	*(win-win)*	*(trade-offs)*	*(win-win)*
		First pillar	
		Extensification (CMO)	Partial decoupling
Set aside	Partial decoupling	Set aside	
		Eco-conditionality	
		Second pillar	
Agro-environmental		Agro-environmental	Good agricultural practices
Fishler Reform (2003)		**2014-2020 Reform**	
Conservation	**Integration**	**Conservation**	**Integration**
(trade-offs)	*(win-win)*	*(trade-offs)*	*(win-win)*
First Pillar			**First pillar**
Eco-conditionality			Ecological payment
	Full de-coupling		Payments for young farmers
			Payments for disadvantaged areas
Second pillar			Active farmers
Environmental challenges	Quality package		Small farmers
	RDPs		Cross-compliance
			Specific support (coupled)
			Second pillar
			Removing of axes
		Agri-environmental	Diversification measures
			Risk management

In order to assess the current policies, it is important to bear in mind that the interaction of sustainability and productivity (so-called '*sustainable productivity*') has not been officially adopted by the EU as a policy target (RISE, 2014). Nevertheless, the attempt to reduce trade-offs and work on the win-win approach in order to build a significant body of tools in favour of sustainable productivity is quite openly recognised.

On this matter, the main assessed instruments are direct payments and, specifically, the green component. Direct payments are recognised as being more selective and more "*green*" than in the past. However, the cost of the overall transfer of resources to farmers undoubtedly exceeds the environmental effects. Of course, the instruments also target other objectives, but their main weakness is exactly that, trying to meet too many targets at the same time (Bureau and Mahé, 2008). Coming to the green component, the Commission has announced in many of its official documents that the intention of the green payment was to reinforce the sustainable practices of farming, enhancing the integration of production and sustainability far beyond the agri-environmental scheme (Povellato, 2012). However, many studies show that this integration is effective only in a relatively low share of the overall agricultural area of the EU (not more than 5%) given the many derogations that exclude farmed areas for greening obligations (Westhoeck et al. 2012; Cimino et al. 2015). Moreover, the green payment also fails because it does not consider the specific needs and the local environmental issues of the areas concerned, such that in some cases it over-constrains production and in other cases it is too loose (Jambor and Harvey, 2009; Garrod, 2009). In this case, working by territorial grids, as suggested by Mahé (2012), would have the chance to consider potential local win-win situations-

Many authors also consider the cost of green policies, both in the first and in the second pillar, showing that the cost of such policies would exceed their environmental benefits, considering the control and, in the case of the measures in the second pillar, the administrative and the transaction costs due to the implementation of the voluntary programmes (Matthews, 2012 and 2013; Bureau and Mahé, 2008).

3.2. EIP initiative assessment

KEY FINDINGS

At EU level:

- Enthusiasm in relation to EIP-AGRI implementation. 94 RDPS envisage financing OGs and this approach is implemented in 24 MS.
- Animation and information activities undertaken by the Service Point should be increased, particularly to enhance dissemination of FG results, which are reported to be not extensively used.
- Supporting multi-region OGs. Legislation should envisage cross-border OGs, making their implementation easier in different MS. It would help to avoid duplications of topics addressed but also strengthen links among stakeholders of agricultural and knowledge systems in different EU countries.

At MS level:

- Great importance is given to the bottom-up approach and, in light of this, no specific thematic priorities are usually selected.
- Two main approaches arise from the selection criteria defined: a more scientific-oriented approach versus a more territorial problem-solving approach.
- Simplify administrative procedures: their complexity risks reducing farmers' participation in OGs, particularly small farmers.
- Lack of reimbursement or insufficient reimbursement of farmers' work within the OGs is considered an important element that can hinder farmers' participation.
- Support for the setting-up of OGs is considered to increase quality of project proposals and to strengthen relations among partners.
- The role of innovation brokers is important to support farmers' involvement, translate their needs into project ideas, to ease the preparation of project applications, and to improve the internal coordination of OGs.

The **EIP-AGRI initiative** was officially launched in February 2012 with the EC communication (COM 2012 of 29/02/2012) on the European Innovation Partnership "*Productivity and Sustainability*". The aim is to promote the main goals of the CAP (efficient and competitive agricultural sector, sustainable supply of food, adaptation and mitigation to climate change etc.) while supporting better coordination between research, knowledge, technology and farmers, forest managers, rural communities, businesses, NGOs and advisory services.

The EIP-AGRI is mainly supported by the rural development policy (EC Regulation 1305/2013), through the setting-up of the European EIP-AGRI Network and Operational Groups (OGs) at national/regional level, and the research policy (Horizon 2020), which links research with practitioners via the implementation of multi-actor projects and Thematic Networks.

This new initiative has created much interest across and within Member States and mobilised many actors to establish cooperation partnerships to run OGs, light structures appointed to implement projects that can find innovative solutions and/or develop opportunities for farmers and rural areas.

The analysis presented here was undertaken through desk research and the completion of some case studies. The desk research was mainly related to understanding the state of play of the EIP-AGRI implementation at European level, while case studies gave an overview of the state of the art in four Member States (MS), namely Italy, Germany, Spain and Sweden. Italy, Spain and Germany are characterised by a regionalised programming system: in these three cases, the national situation was taken into consideration as well as that in one federal German State (Schleswig-Holstein), one Spanish region (Cataluña) and in two Italian regions (Emilia-Romagna and Puglia). Collection of information in relation to case studies was based on phone interviews with representatives of Managing Authorities (MA), National Rural Networks (NRN) and other national experts as well as desk research.

It is important to point out that implementation of EIP-AGRI-related activities has reached a different level in different countries, and no operational groups have yet closed down. For this reason, the analysis undertaken focused more on the programming phase and the implementation procedures at national level.

3.2.1. State of play at EU level

In January 2013, the European Commission nominated the high level Steering Board for the EIP AGRI consisting of 42 high level personalities who represent key interests across the agricultural innovation landscape such as Member State representatives, regions, farmers' and forestry organisations, agricultural scientists, environmental and consumer organisations as well as up- and downstream actors. The Steering Board establishes a Strategic Implementation Plan, gives strategic advice to the EIP and provides orientation on its main working areas.

In April 2013, the EIP-AGRI Service Point was set up (following a tendering procedure launched by DG Agriculture). Its main aim is to act as a mediator within the EIP-AGRI network, enhancing communication and cooperation between all those with a keen interest in innovating agriculture. The Service Point provides supporting services to MS and other stakeholders through a helpdesk located in Brussels. In addition, it supports the setting-up and running of ***Focus Groups***, addressing specific challenges in agriculture and forestry, the organisation of events, and the dissemination of information through publications and on-line tools (website, social media, etc.).

To date the EIP AGRI service point has organised 23 focus groups[11] on specific topics relating to needs, problems and opportunities of agriculture and forestry that involve some hundreds of experts from all EU countries. 15 focus groups have already finished their activities and produced technical reports and advisory booklets, while eight focus groups are still operative, three of which just started in October 2016.

Focus group topics are selected based on the main relevant issues identified for the agricultural and forestry sectors across Europe. The relevance of topics is usually discussed in the Subgroup on Innovation for agricultural productivity and sustainability (subgroup of the ENRD General Assembly). Lately, discussions on the identification of relevant topics have also taken into consideration themes tackled by operational groups in different countries.

Results of the focus groups should support the setting-up of operational groups at national level and possibly suggest interesting themes/opportunities/issues to be tackled. Whether focus groups are able to fulfil these expectations, though, is still not entirely clear. According to the analysis undertaken FG results are not extensively used in some countries (e.g. Germany and Italy). In other countries, such as Portugal, Cataluña in Spain and to a certain extent Sweden, it seems that FG results were more relevant to the definition of some issues to be addressed by OGs. The EIP Service Point is at the moment running an internal assessment about the relevance and usefulness of focus groups in this initial implementation phase. It seems clear though that some additional efforts should be made to make their results more effective both at EU and national level. At EU level, dissemination of information and results should be increased, while at national level NRNs could play an important role to enhance the visibility of these results, especially in relation to the setting up of OGs. In Cataluña (Spain) meetings are regularly organised that gather national experts who were selected as members in FGs and potential beneficiaries, representatives of OGs already running and other major stakeholders. This enables to information to be shared and the continued discussion of important themes in the national context.

The EIP Service Point, in cooperation with DG AGRI, organised a number of workshops and seminars (some 12 events organised from 2014 to 2016) addressing both methodological issues and more technical aspects related to the implementation of EIP. These events gathered representatives of NRNs, MAs, organisations and in some cases also farmers and other practitioners. They are considered useful to share information and practical experience (e.g. as pointed out by representatives from Emilia Romagna and Puglia).

3.2.2. Implementation of the EIP Operational Groups: some examples

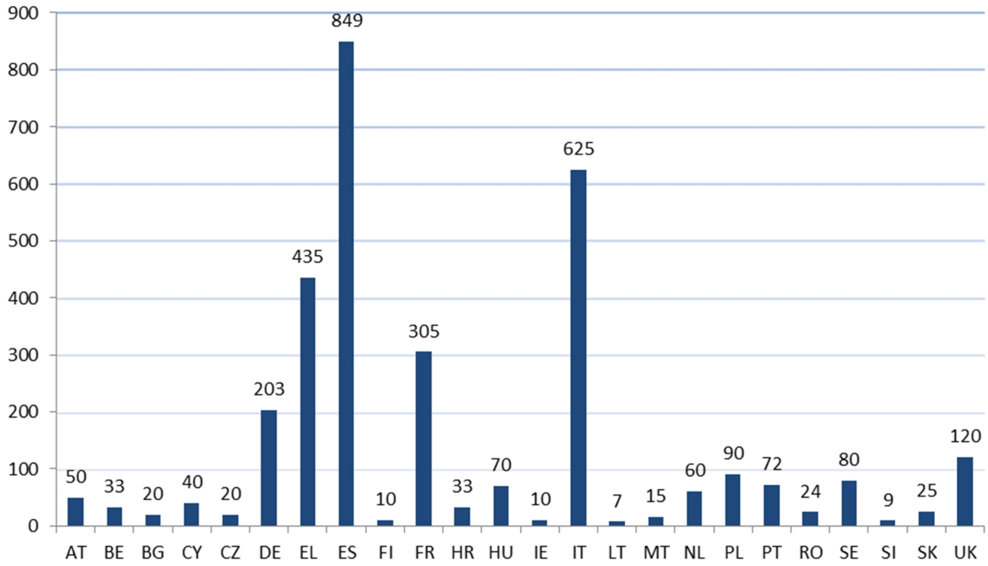
EIP operational groups are envisaged to be activated in 94 of 118 RDPs approved. Four countries will not implement EIP OGs, namely Latvia, Estonia, Denmark and Luxembourg. Some 3,200 OGs are planned in the EU, distributed according to figure 21 below. Spain, Italy and Greece are those with the most numerous groups to be implemented.

Up to May 2016, calls for applications were published in 13 MS (AT, BE, CZ, DE, ES, FI, FR, IT, LT, NL, PT, SE, UK). 200 OGs were approved by October 2016 and there are no projects concluded as yet. These data show that implementation of EIP OGs is still at an initial phase, with less than 10% of planned groups already running. As a consequence, it is difficult to draw specific conclusions on the effectiveness of the EIP-AGRI tool to support

[11] http://ec.europa.eu/eip/agriculture/en/content/focus-groups

viable farms. Nevertheless, some initial considerations can be done, particularly in relation to the setting-up of the EIP-AGRI initiative in different MS.

Figure 21: Number of planned EIP OGs in the 2014-2020 RDPs



Source: European Commission, 19/05/2016.

Programming phase – Three out of the four countries considered have a regionalised programming system when it comes to structural funds, namely Italy, Germany and Spain. This means having multiple Rural Development Programmes (RDPs) and potentially multiple programming, and also implementation, systems to support EIP-AGRI OGs. Among them, Spain has planned to organise EIP-AGRI focus groups and OGs also at national level.

During the *consultation process* most of the countries/regions analysed did not organise actions specifically related to innovation, with the exception of Sweden, where the MA in cooperation with the NRN organised a thorough consultation process that started in September 2014 and went on even after the official approval of the RDP in May 2015. During this process, participants discussed and exchanged views about the implementation approach to be given to the EIP in Sweden. After the approval of the RDP, this consultation process continued and became common practice within the implementation phase.

Negotiations with DG AGRI went on smoothly for most of the countries/regions analysed, with the exception of Puglia, where some specific issues were identified. The implementation procedure in this case, with particular reference to the financial aspects, has become more complicated, following indications given during the negotiation process, and also unique within the country. However, analysis of all other Italian regions highlighted some other particular elements within the implementation procedures that were reported to be a consequence of the negotiation procedures.

No countries/regions analysed when planning the EIP-AGRI initiative established *specific priorities for OGs* to focus on (with the exception of Sweden that excluded the forestry sector, it being considered already a very strong industry). The region of Puglia identified six areas the EIP-AGRI projects should focus on. Identification of these areas was based on the S3 strategy, the Italian Strategic Programme for innovation and research in agriculture and the regional guidelines on innovation needs. However, these areas are rather broad and do not substantially limit potential beneficiaries' proposals. These programming choices were motivated by the fact that EIP-AGRI is considered a bottom-up approach and establishing specific priorities could have hampered the possibility of addressing specific farms' needs.

Implementation phase – Different implementation options are envisaged for the EIP-AGRI measures within the RPD. MAs could choose in terms of administrative procedures between:

a) supporting financially the setting-up of OG partnerships or the implementation of OG projects directly (Emilia-Romagna is the only example analysed which does not fund the setting-up);
b) funding projects through a global amount, that is using only one measure (M16.1), or by using several measures, where 16.1 supports the organisation of the OGs and all other activities envisaged are supported by other relevant measures (all countries/regions analysed use the global amount);
c) organising cross-border(or interregional) OGs (not explicitly envisaged by the EU legislation, but considered as a possibility by Italian regions and German federal states).

In addition to these main choices, it is important to consider all other rules and laws, both at European and national levels, that apply to publicly supported projects, such as eligible costs, control procedures, compliance with state aid regulations. All this considered, most of the countries/regions analysed reported that *administrative procedures set up for the EIP-AGRI measures are extremely complex*. It seems that this complexity might hinder the very aims of the EIP, in particular active participation of farmers, their possibility of finding solutions that can make their farms more viable as well as boosting interactive innovation. The table below shows an example of some administrative requirements in Emilia Romagna (IT) needed to apply for support.

Table 4: Administrative requirements to be respected by OGs in Emilia Romagna in M16.1 call for applications

	Number of annexes to be provided	Number of signatures
Small projects – 5 partners	45	54
Medium projects – 10 partners	70	87
Big projects – 16 partners	100	138

Source: CRPV (Research Centre on plant production) – Presentation delivered in the seminar "*PSR e PEI, nuove opportunità per le imprese agricole e per l'agribusiness che innova*", Bologna 10/11/2016.

An important element that might reduce farmers' participation is the lack of reimbursement or insufficient reimbursement for their work and time spent in the project. In Italy this is considered a big issue, because in none of the regions their work can be reimbursed and this seriously compromises small farmers' participation in particular. A similar issue is also reported in Sweden, where farmers are partially reimbursed for their activities but this reimbursement is not considered sufficient to cover the real costs supported.

Lack of advance payments represents another risk factor in terms of participation of farmers in OGs (Puglia).

The definition of eligibility and selection criteria for calls for applications is also an important element within the implementation phase. In terms of *eligibility criteria*, most countries/regions analysed do not consider the participation of farmers in the OGs compulsory, with the exception of Emilia Romagna. They are just considered among the categories of actors who can be part of an OG partnership.

Some similarities have been identified among the *selection criteria* chosen by countries/regions analysed. Four main areas have been considered by most of them:

a) coherence between project objectives and RDPs and/or EIP-AGRI general goals (Emilia-Romagna-IT, Puglia-IT, Schleswig-Holstein-DE);
b) technical-scientific relevance of projects proposed (Emilia-Romagna-IT, Puglia-IT, Cataluña-ES, Sweden);
c) significance of the partnership composition in relation to the project objectives (Emilia-Romagna-IT, Puglia-IT, Cataluña-ES, Sweden);
d) comprehensiveness of the communication and dissemination plan (Emilia-Romagna-IT, Puglia-IT, Cataluña-ES, Sweden).

Some specificities have been identified within the definition of selection criteria. In Schleswig-Holstein (Germany) additional points are awarded when: i) the OG aims to cooperate with a Horizon 2020 project; ii) the innovative project has potential to create synergies with other projects implemented in the neighbouring regions; iii) more than two farmers are involved in the project.

Most countries/regions analysed gave importance in the selection process to the relevance that innovative projects have for the areas where they are implemented, mainly in terms of increased competitiveness of agricultural holdings. The EIP-AGRI approach in those countries aims to find innovative solutions for issues that companies are experiencing at the local level, solutions that might be considered innovative in specific territorial contexts but not necessarily innovative in other areas. In Sweden, on the contrary, the EIP-AGRI approach has a different rationale, and it is more based on the attempt to identify projects/processes/organisational models that are considered new at national level. In the selection process extra points are awarded to projects that aim to introduce innovations considered to be new in Sweden as well as in other European and/or non-EU countries. This approach, very much geared to identifying innovative solutions, as such entails a very tough selection procedure. Elements of complexity are here related to the content of project proposals rather than to administrative procedures. This approach might, though, facilitate participation of research-related actors instead of farmers and other practitioners.

Content priorities and first results – In four of the five RDPs analysed, M16.1 has already been launched and projects are either selected and running (Emilia-Romagna, Cataluña and Schleswig-Holstein) or soon to be approved (Sweden), while in Puglia the selection process to support setting-up is ongoing. In the case of Emilia-Romagna and Schleswig-Holstein more than half of the planned OGs have already started, and 1/3 of them are running in Cataluña. None of the OG projects are yet concluded. As a consequence, it is still too early to verify whether and to what extent these projects can improve farm competitiveness and viability in Europe. Nevertheless, in all cases analysed, great interest of farmers (as well as other major stakeholders) in participating in OG partnerships has been reported. This can be considered a positive precondition for the success of this initiative and to improve connections between research and practitioners.

This first analysis also showed that most countries/regions preferred to use a bottom-up approach for EIP-AGRI implementation. In fact, no specific content priorities were established by MAs also in the technical documents of calls for applications, consistent with what had already happened at the programming level.

Those countries with a regionalised programming system and multiple RDPs were at risk of overlapping in terms of topics addressed by OGs and also a possible reduced efficient use of financial resources. The EIP-AGRI is, as already pointed out above, at an early stage of implementation to assess such issues. Nevertheless, most of the interviewees excluded this risk or did not consider it so relevant. They had taken into consideration that a certain level of overlapping could happen during the first phase but they considered it more important to promote the bottom-up approach. Most of them, particularly the representatives of Emilia-Romagna, stressed the need to strengthen the role of the EIP Network (both Service Points and NRNs) in the dissemination of information and OG results to overcome these risks.

Support activities for interactive innovation – In all the cases analysed MAs, in cooperation with NRNs, organised a number of activities, such as events, seminars, and dissemination of information through website and social media. These actions were mainly undertaken after the official approval of the RDP and before the definition of calls for applications. Such activities aimed to inform potential beneficiaries about options offered by the EIP-AGRI initiative, to facilitate the creation of partnerships and the preparation of project proposals. In Sweden the NRN, in close cooperation with the MA, organised some 100 seminars and workshops with this purpose.

The role of *innovation brokers* was highlighted during the EIP-AGRI programming phase in the EU. It comes from some northern European experiences (e.g. the Netherlands) and is considered an important element to support the creation of partnerships and the interactivity of projects. In the examples considered, innovation brokerage is more a function undertaken by an institution rather than a specific set of skills of some professional experts. In Sweden, the NRN fulfils this role. Members of the team dedicated to EIP-AGRI within the NRN discuss with potential beneficiaries their innovative ideas (they also sign with them a privacy agreement to ensure that ideas discussed are not disclosed), to better tailor them and facilitate their possible implementation. They discussed until now some 300 ideas. In most of the German federal states, innovation brokers are also reported to be important for the definition and implementation of OG projects. Indeed, they have been important in helping farmers to translate their needs into project ideas.

Advisors are reported to be always involved in the examples considered, albeit with a different level of participation. In Emilia-Romagna they cannot be partners of an OG but extra points are awarded to those projects that envisage their participation as subcontractors. In Cataluña they are usually members of partnerships and they provide technical advice, while in Sweden and Germany they mainly provide partners (particularly farmers) with support for administrative procedures. They also have a high potential to facilitate knowledge sharing and dissemination of project results, considering the direct contacts that they usually have with farmers.

In all cases analysed the *role of the NRN*, in particular the EIP-AGRI related unit, is considered relevant to:

- support implementation of M16.1;
- organise activities;
- link stakeholders and OGs across the country;
- enhance dissemination of results;
- promote exchange of experiences between countries.

Box 4: Case study examples for EIP Implementation

Case study: Puglia – Italy

EIP-AGRI is implemented using M16.1 (setting up of OGs) and M16.2 (OGs projects)
Budget: M16.1 3 million €; M16.2 30 million €
Number of OGs envisaged: 25/30
First call for applications of M16.1 was launched in July 2016. No OGs have been selected yet.
Main focus of the EIP-AGRI approach: territorial problem-solving, to find solutions able to address challenges that farmers are facing in specific areas.
Implementation approach: Projects are supported financially by M16.1 and M16.2 (global amount). The possibility to have interregional OGs is foreseen even though considered difficult to be implemented. In the selection process extra points are awarded to projects whose partnerships includes a higher number of farmers in the area.

Case study: Emilia Romagna – Italy

EIP-AGRI is implemented using M16.1
Budget: 50 million€
Number of OGs envisaged: 100
First call for applications was published in January 2016 and 51 projects were approved in July 2016.

Main focus of the EIP-AGRI approach: to find innovative solutions able to address challenges that farmers are facing in specific areas.
Implementation approach: projects are supported financially only by M16.1 (global amount), but different financial rates per Focus areas apply, namely 70% for competitiveness and from 90% to 100% for environment. Setting up of OGs is not supported and the possibility to have interregional or cross-border OGs is not foreseen. Specific role of innovation brokers and advisors is not foreseen. Nevertheless, additional points are given in the selection process to those projects that include within the partnership companies involved in the organisation of training activities and provision of advice.
First results: 51 projects have been selected on the following topics:

Livestock/dairy	**9**
Crops	**12**
Fruits and vegetables	**19**
Viticulture	**7**
Horizontal aspects	**4**

More information at http://agricoltura.regione.emilia-romagna.it/psr-2014-2020/doc/progetti-partenariato-europeo-per-linnovazione-pei

Case study: Schleswig-Holstein – Germany

EIP-AGRI is implemented within the RDP through M16.1
Number of OGs envisaged: 38
Number of OGs already selected and running: 17

Main focus of the EIP-AGRI approach: territorial problem-solving, to find solutions able to address challenges that farmers are facing in specific areas. **Implementation approach**: Projects are financially supported only through M16.1 (global amount). Financial support is foreseen to the setting-up of OGs partnership, considered important to increase the quality of final projects. Specific role is envisaged for innovation brokers, which are considered of great help to translate farmers' needs into projects ideas (even though the situation is different in other Federal States that did not envisage a strong role of brokers). The NRN organises specific activities to support the role of brokers.

First results: 17 projects selected and on-going, on the following topics

Livestock/dairy	**6**
Crops	**2**
Environment/climate	**2**
Soil quality	**5**
Horizontal aspects	**2**

More information at https://www.netzwerk-laendlicher-raum.de/de/themen/eip-agri/eip-datenbank/.

Case study: Cataluña – Spain

EIP-AGRI is implemented within the regional RDP through M16.1
Number of OGs envisaged: 100
Total budget: 17 million €
Number of OGs already selected: 33 projects (plus 90 groups supported for setting-up). A second call for application was published in 2016, but no additional projects have been approved yet.

Main focus of the EIP-AGRI approach: territorial problem-solving, to find solutions able to address challenges that farmers are facing in specific areas.

Implementation approach: Projects are financially supported through M16.1 (global amount), but financial rate of 70% applies to all projects. Financial support to the setting-up of OGs is also foreseen and considered useful to improve quality of project proposals and facilitate farmers' participation in OGs partnership. In Cataluña research institutes must participate in the OGs as subcontractors and not as main partners. Not specific role is envisaged for innovation brokers, even though it has been recognised the importance to have a project coordinator who can also animate the partnership. The MA in cooperation with the NRN organises periodically workshops grouping Spanish members of the EIP FGs and members of regional OGs as well as other stakeholders with the aim of sharing information and FGs results at national level and avoid duplications in terms of activities.

Case study: Sweden

EIP-AGRI is implemented within the national RDP through M16.1Number of planned OGs: 80

Total budget: 47 million €

45 projects applications were submitted, but no projects have been officially approved yet (November 2016)

Main focus of the EIP-AGRI approach: More scientific-oriented approach. Main goal of EIP-AGRI projects is to introduce within the Swedish agri-food sector innovative products, process and methods, which are not yet used in the country.

Implementation approach: Projects are financially supported by M16.1, with the exceptions of those that need investments supported by M4 to be implemented. In this case, beneficiaries must apply to M4. Projects related to the forestry sector, considered already strong, are not eligible to support under M16.1. OGs are 100% publically supported. This justifies also the strict selection procedures project proposals must go through. Presence of farmers in the partnership is not compulsory. Strong role of the NRN in organising animation activities.

3.3. Specific studies linking good agricultural practices and innovative policy instruments in the framework of CAP

In this section we first explore a selection of **farm practices** that could enhance total resource productivity (**Box 5**). We present some case studies to point out how agricultural practices enhance a sustainable and efficient use of resources, contribute to the production of public goods and increase resilience of production systems, as well as the role of R&I systems and the institutional and policy context.

Box 5: Examples of good farming practices reconciling productivity and sustainability

Soil conservation practices (SCPs): Soil degradation, due to poor management practices, including deforestation and overgrazing, is a common issue at global level and is nowadays increased by climate change. Conservation practices are based upon the simultaneous application of three principles: minimum mechanical soil disturbance, protection of soil through maintenance of permanent soil cover and diversification of rotations. In the EU an integrated soil conservation Directive was proposed in 2006 but it has not progressed since then. However, soil conservation practices are an important element in cross compliance regulations for farmer applying for CAP support while additional requirements are covered under agri-environmental schemes in Rural Development Programmes (RDPs). Many studies indicate positive returns for SCPs (Pannell et al. 2014) and, at the same time, SCPs have been indicated as a means of mitigating climate change by sequestering carbon, although their potential can vary according to local conditions (Luo et al., 2010).

Water management practices (WMPs): These practices are aimed at increasing water use efficiency while protecting water from non-point pollution. The EU Water Directive 2000/60/EC establishes a common framework for integrated water conservation in the EU. Together with the Nitrate Directive it has important implications for farm practices with regard to emissions of nitrogen and phosphates from manure and inorganic fertiliser. Water conservation practices include land management practices and irrigation water use management. Positive outcomes are water saving, improved water quality, management of floods, droughts and drainage, and conservation of ecosystems. While the EU Directives cited above are included in cross compliance requirements, additional measures aimed at increasing water use efficiency and water quality are financed in some regions as part of the agro-environmental measures in RDPs.

Organic agriculture: Organic agriculture aims to develop sustainable agricultural production systems based on the minimum use of external inputs and through the use of renewable resources. In the EU organic farming is provided with financial support in many MS under pillar 2 of CAP while under Pillar 1 it is exempted from the greening requirements. Additional policies are designed in some MSs in the national plans for organic agriculture. These may include – inter alia - additional financial support, measures for research and dissemination, and green public procurement. Several studies have analysed the impact of organic agriculture on yields (Seufert et al., 2012, Ponisio et al. 2014) concluding that although they are generally lower with respect to conventional agriculture they depend on several factors, including the type of crop and diversification practices adopted. Several studies have also analysed market premiums and the overall economic performance including job creation. A study from INRA (Bellon and Penvern, 2014) in France has concluded about the difficulty of drawing unequivocal conclusions. Environmental gains have also been analysed in many studies dealing with resource productivity, soil and water quality, biodiversity conservation and GHG emissions. Another aspect, analysed in the literature and very relevant to the purpose of this study, is the potential of organic farming to trigger innovation.

Biotechnologies: Modern breeding and multiplication techniques or innovations in the field of molecular sciences can accelerate conventional breeding programmes and provide farmers with new varieties that are resistant to pests and diseases, thereby replacing chemical treatments. Such techniques can develop new traits such as drought resistance and nitrogen tolerance, whilst preserving local biodiversity. Positive expectations mainly regard improved yields and reduced costs for chemical treatment, while seeds costs are generally expected to be higher. Potential environmental benefits are normally linked to reduced chemical use while the impact on biodiversity can vary in space and time and according to the trait and the modified cultivar. Concerns on both economic and environmental impacts, as well as on safety issues, are some of the reasons for public controversies that are impeding both research and adoption of new breeding technologies in some MS countries. Changes in the current policy regime - both at EU and at MS level - would be needed in order to increase public acceptance and adoption of these techniques.

Precision agriculture: Precision farming is a relatively new management practice based on the development of information technologies and remote sensing. It aims to optimise yields through systematic gathering and handling of data about crops and fields and it contributes to tailoring input use according to effective needs. Precision agriculture is applied to a wide range of arable and horticultural crops and also to permanent crops such as olives, vines, and fruit trees. Precision livestock farming concerns the optimisation of many aspects of animal rearing such as automatic monitoring of individual animals, early detection of diseases and monitoring of the physical environment. Although adoption of precision farming has grown in recent years, the uptake in the EU remains low and is concentrated in large and more business-oriented farms (Zarco-Tejada, 2012). Adoption happens on the basis of expected higher profitability. The literature on economic and environmental impacts offers a mixed picture, varying according to the specific innovation and also to specific environments. Economic advantages regarding precision weed and pest management are well documented (Knight et al., 2009). Little evidence still exists on the benefits provided to the environment. Critical conditions for adoption in many areas of the EU, especially in southern regions, are represented by farm structural characteristics, required farmer expertise, and high levels of investment required (Aubert et al. 2012).

3.3.1. Case study: Efficient water management

KEY FINDINGS

- Economic and environmental benefits resulting from the application of innovative irrigation support systems are connected with the fact that, for a given yield, applied irrigated water volumes are usually higher than effective crop water demand.
- The three main agro-environmental benefits of using this decision support system are water saving, environmental impact (i.e. ground water quality preservation, soil erosion, etc.) and crop monitoring;
- In order to boost technology adoption in Europe and specifically in Italy, advisory systems need to be connected to specific subsidies or requirements for obtaining certifications of good practice;
- One way to incentivize the use of IRRISAT or similar systems would be to have water authorities such as Regional Authorities, WUAs or other administrations, responsible for environmental protection, buy the service and give it for free to farmers.
- Farmers' participation should be increased in order to have farmers understand the mechanisms under the DSS and boost their trust in the tool.

At EU level, a wide range of policies aims to protect water quantity and quality such as the Water Directive 60/2000 and other initiatives under EU environmental policy, including the Thematic Strategy on Soil Protection, the EU action against climate change, the White Paper on adaptation to climate change, the Communication on water scarcity and droughts, and the 2012 Blueprint document that introduces a new focus in respect of natural resources. The main CAP instruments promoting sustainable water management are some measures in the Rural Development Programmes (RDPs) supporting investments for improving the state of irrigation infrastructures or irrigation techniques, as well as water quality, and the cross-compliance framework that includes statutory requirements related to water protection and management arising from the implementation of the groundwater directive and nitrates directive, as well as GAEC standards.

IRRISAT is an innovative irrigation support system like an "*irrigation advisor*", based on the use of satellite imagery. It has been developed as a follow-up to the FP5 EU project DEMETER and has been improved in other EU projects (FP6 Pleiades, FP7 Sirius and on-going H2020 Fatima)[12].

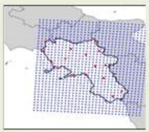
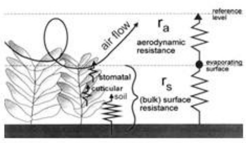
In 2007, Campania adopted IRRISAT technology, activating an experimental irrigation advisory system called "Regional Plan for Irrigation Advisory Service". Since 2011, the service - renamed IRRISAT - has been provided to more than 2500 farmers covering 80,000 ha of irrigated areas in the framework of the Regione Campania Action Plan for Rural Development 2007-2013, in the RDP specific Measure 124 "*Cooperation for the development of new products, processes and technologies in the agrifood sector and forestry*".

[12] ARIESPACE has developed an operative processing chain to estimate crop water requirements and a web-tool dedicated to farmers, water associations and authorities in the context of the IRRISAT project (http://www.irrisat.it). ARIESPACE is a small-sized enterprise, established in 2006 as a spin-off company of the University of Naples Federico II. It provides ready-to-use and user-friendly Decision Support Systems (DSS) based on satellite observations, geospatial data and biophysical models to fill the gap between currently available geospatial tools and information needed for people working in agriculture.

IRRISAT defines the crop status using remote-sensing techniques to better calibrate water irrigation at farm level, with a view to environmental and economic optimisation and sustainable productivity. The service provides farmers with a very intuitive WebGIS App which includes the following information: (i) personalised irrigation advice, based on the calculation of crop evapotranspiration under standard conditions (according to FAO Paper 56) by taking into account the actual canopy development and crop variability obtained from satellite data; (ii) timely delivery of the information, consisting in maps of evapotranspiration, Leaf Area index (LAI) and meteorological data with up to 5 days of forecast. From a technological point of view, the IRRISAT system is based on an innovative procedure which takes into account the near real time canopy development derived from high-resolution multispectral satellite images from a virtual constellation of satellites, namely Landsat 8 (with geometric resolution of 30*30m), Sentinel 2 (10*10m), DEIMOS-1 (22*22m.) and RapidEye (6*6m), coupled with a weather forecasting model[13].

Irrisat started in May 2011 with a partnership of public and private bodies: the Remote Sensing Laboratory for Environmental Hazard Monitoring (RESLEHM) of the University of Salerno, two farms, ARIESPACE s.r.l. (Spin-off company of University of Naples Federico II), GEOSYSTEMS GROUP s.r.l., Istituto Sistemi Agricoli e Forestali del Mediterraneo of National Research Council, 3 Water Users Associations (WUA) and one Farmers association "Coldiretti Campania".

Figure 22: Technology of IRRISAT service

	**Satellite virtual constellation** High-resolution multispectral radiometric images of **Landsat8** (30x30m,every 16 days) , **Sentinel2** (10x10m), **DEIMOS-1** (22x22), **Rapid Eye** (6x6m), **geoeye**, **worldview**, delivered in near real time and processed; **custom selection of resolution and revisit time**
 	**Meteo data and Weather Forecast (5-7 days ahead)** In-situ agro-meteorological variables and meteo data forecasting is provided by selected Numerical Weather Prediction (NWP) Products
	**Standard FAO-56 procedures** Direct calculation of Potential Evapotranspiration by the Penman Monteith equation by combining in-situ agro-meteorological variables, meteo data forecasting, satellite data. Water Balance modelling.

IRRISAT beneficiaries are persons and groups which both use agricultural resources and make decisions about their management:

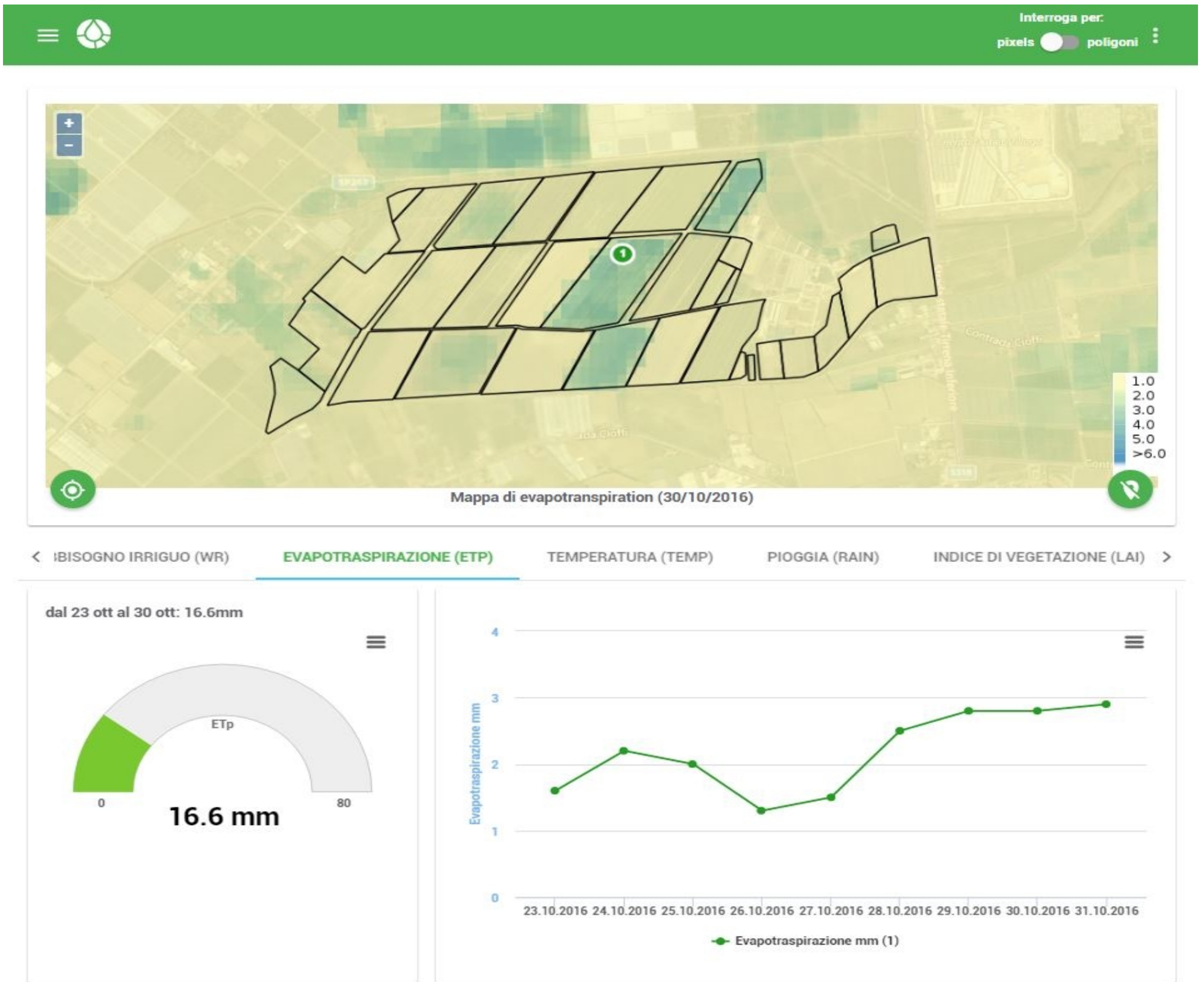
- Farmers, who manage the agricultural production on their own farms. Soil and climate characteristics have always been at the basis of traditional agriculture, but new tools are needed to increase production in an environmentally sustainable way and to improve irrigation practices.

[13] Cosmo Leps from 1 to 5 days of forecast, http://www.cosmo-model.org/content/tasks/operational/leps/).

- Water Users Associations (WUAs), which are responsible for management of water resources of irrigation networks. They need tools to perform day-to-day management tasks and monitor the irrigation water consumption of each farmer and the entire irrigation system, over the season.
- Government authorities, which are responsible for general use and quality of water. In order to control and target agricultural water use properly, providing sustainable food security and rural development, they need tools for monitoring water exploitation plans for irrigation schemes, aquifers or river basins.

Satellite images are elaborated in the 24/48 h following the acquisition of data and produce results such as thematic maps of crop parameters, potential crop evapotranspiration and crop water requirement (CWR). By overlaying satellite images with cadastral data of irrigated plots in irrigated districts, it is possible to determine the total amount of water which is useful for the management of the collective irrigation network. The DSS produces two types of data: maps and alphanumeric data, which indicate the total amount of crop water and the time of single waterings. CWR and satellite maps are visible on the web through a dedicated webGIS, whereas the alphanumeric data are sent directly to the farmer via SMS, so the farmer receives personalised irrigation advice.

Figure 23: IRRISAT dashboard



Benefits - Economic and environmental benefits resulting from the application of the IRRISAT service are connected with the fact that, for a given yield, applied irrigated water volumes are usually higher than effective crop water demand.

A cost-benefit analysis, carried out at European scale, demonstrates that, assuming the application of the services over only 30% of EU irrigated land, the expected net benefit is from around €80 million to €200 million per year, depending on the cost of water services. In the specific context of WUA "*Sannio Alifano*" (Campania), the overall results, obtained comparing the 2012 irrigation season (pre-IRRISAT) and 2013 (post-IRRISAT), demonstrate water savings of about 18%, while a survey on a sample of monitored farms highlights peak saving from about 25 to 30% without loss of production.

Considering a sample of farms growing a maize forage crop in Campania, it was estimated that the average irrigation water applied amounts to 4500 m^3/ha, compared with a crop water requirement of 3500 m^3/ha estimated from satellite data. By applying an irrigation amount of water equal to estimated needs, the reduction in production costs may be significant, both in the case where it is applied to water user association management, or when pumping from groundwater because of the savings achieved in terms of energy for mechanical lifting. In an area of 900 km^2 with 3000 ha of farms, the cost of the service is around 10 euro/ha/irrigated season; if the number of farms increases, the cost decreases and becomes negligible. Nowadays, with the new satellite constellation of the Copernicus programme, data processing costs are still decreasing, making the service even more competitive.

In addition to economic benefits, the three main agro-environmental benefits of using this decision support system are water saving, environmental impact (i.e. ground water quality preservation, soil erosion, etc) and crop monitoring.

Main difficulties and obstacles to new technology adoption - Although an Irrigation Advisory Service has been operating in some WUAs of Campania since 2007, the internalisation of satellite-based procedures and more generally the use of spatial data by farmers and irrigation personnel still seems to be a slow learning process when it comes to direct application to agricultural practices. Software with user-friendly interfaces is currently available to facilitate the task but the average level of computer literacy in the agricultural community is not yet sufficient for rapid diffusion of new technologies. To overcome this barrier, IRRISAT provides a value-added service supplied by ARIESPACE, which acquires data, extracts the information, and makes it easily available to farmers and WUA technicians. However, technology development by itself is not sufficient to spread the use of services like IRRISAT among potential users. For this reason WUAs decided to increase farmers' awareness through regular meetings and training courses. From these discussions, suggestions for improvements as well as constructive criticism often emerge.

More difficult to overcome are issues linked to farm structure. The main problem is that Italian farmers, but also European, are usually unlikely to adopt advisory systems due to mentality (age, education, awareness) and to small farm size. Farmers generally have no perception of direct economic benefits and adopters are normally motivated by the presence of specific economic subsidies, as in the RDPs, or if adoption is required in order to obtain certification attesting virtuous behaviour.

Another reason for not perceiving real benefits is linked to water price distortions: in most Italian WUAs the cost of water is based on the irrigated acreage and not on water volumes. In this way adoption does not generate any effect on farm income.

Finally, the environmental impact is rarely internalised in the farmer's choice unless it has a direct impact on income.

Based on data acquired during the growing season in 2013, our results demonstrate that irrigation based on IRRISAT, all other conditions being equal, produces water savings from 25 to 30%.

In addition to what has already been explained, further economic, social and environmental benefits are represented by:

- Savings in energy consumption and reduction of CO_2 emissions.
- Mitigating the negative impact of climate change on agriculture.
- Preventing excess water in the soil, with subsequent loss of soluble nutrients present in the upper layers, and concomitant pollution of groundwater by fertilisers and other chemical products.
- Increasing farmers' ability to diversify production, according to or anticipating swings in the markets, moving towards less water-demanding and more profitable crop yields.
- Maintaining a consistent presence of agricultural workers in rural areas, avoiding progressive depopulation and impoverishment.

As regards crop monitoring, most Italian farms are less than 10 ha, which is so small that farmers can monitor their crops themselves in the field. There are very few large farms with a business area exceeding 50 ha in Italy and in most cases they have an agronomist as reference, sensors in the field and they are organised with a business management system built specifically for their farm. An irrigation advisory service, such as IRRISAT, would be fine for those with between 10 and 50 hectares of farmland that could receive more benefits for crop monitoring. For example, in South Australia where IRRISAT is now implemented with a similar interface called IRRISCAN[14] (where farms are larger and farmers are more open to new technologies, these decision support systems are better developed and applied directly by farmers.

In order to boost technology adoption in Europe and specifically in Italy, such advisory systems need to be connected to specific subsidies or requirements for obtaining certifications of good practice. Currently, without the incentive of policy tools, IRRISAT, just like other advisory systems based on IT, is more useful for WUAs that manage natural resources in order to boost local knowledge, i.e. the current land cover and land use of their administrative territory where crops change year after year. By not having a precise geolocation of irrigated areas, they are unable to make a detailed estimation of the water use volume in the area of which they are in charge.

One way to incentivize the use of IRRISAT or similar systems would be to have water authorities such as Regional Authorities, WUAs or other administrations, responsible for environmental protection, buy the service and give it for free to farmers. Furthermore, farmers' participation in service development and implementation must be increased. Farmers would thus understand the mechanisms under the DSS, increase their trust in the advice and not consider it as a top-down diktat. For example, farmers can be scared

[14] http://irriscanaustralia.com.au

by the use of satellite images, considering them a form of control. Raising participation and awareness can instead stimulate a proactive behaviour towards innovation.

A win-win policy would be that Ministry, Regions, and WUAs take charge of the service to reduce environmental impacts and monitor crop management while farmers use the tools for sustainable management of water and nutrients, pursuing at the same time collective and private benefits.

The experimental application in Campania has provided important positive feedback on the usage of the information provided by beneficiaries; i.e. farmers are able to recognise without difficulties their plots on the images and they schedule watering by taking into account the information provided. The crop heterogeneity captured by the high-resolution images is considered valuable add-on information to identify the variability of soil texture and fertility, plant nutrition, or different performance of irrigation systems. All farmers have evaluated positively the usefulness of the information provided, and in most cases an increase in irrigation efficiency was achieved, because of the reduction in water volumes.

3.3.2. Case study: context and organic farming development

KEY FINDINGS

- Virtuous circles can arise if all human activities are driven by the same principles, adopting common approaches and emphasizing specific elements, thus creating a positive atmosphere conducive to continuous innovation.
- The development of specific synergies and joint actions with other components of the local context allows the organic supply chain to achieve levels of sustainability over the three pillars that otherwise would be unattainable.
- Inclusive governance, development of an adequate knowledge system and integration and diversification of economic and social activities emerge as the key success elements of local development initiatives.

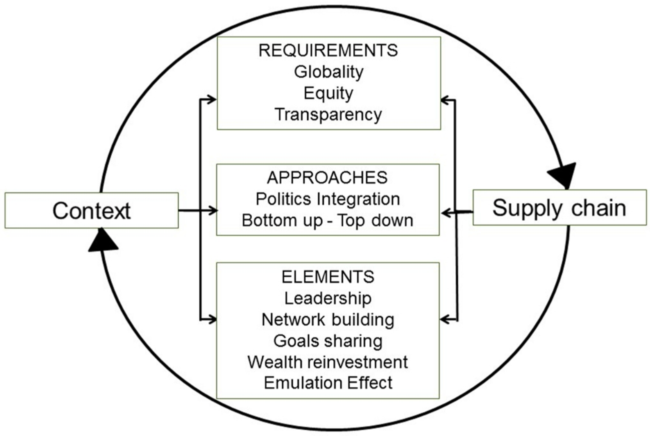
The notion of sustainability is multidimensional and transversal to all human activities and to the policies that regulate it (EC, 2009). Therefore, the context – intended as relations with all the components and variables of a socio-economic-environmental system - is a key element for the sustainability of a food supply chain (Marsden et al., 2000; Marsden, Smith, 2005; Sydorovych, Wossink, 2008; von Wirén-Lehr, 2001). Contextual factors become more articulate and complex the larger the size of the area concerned, while getting influenced by the characteristics of the development processes occurring at lower and specially at higher levels (von Wirén-Lehr, 2001). The influence of the local context over national or even international ones, however, becomes evident when upper levels borrow good practices developed at a local scale, with the aim of disseminating them on a larger scale through appropriate policies and regulations.

In this regard, the area, to which development processes are inextricably tied, is not a mere geographical expression, but a sedimentation of historical and cultural values and productive knowledge (Rullani, 2009), with specific needs that should be met by equally specific solutions and policies. On a temporal perspective, however, development strategies must be adapted to the needs and expectations of the community according to the changes in perception of sustainability over time (von Wirén-Lehr, 2001; Van Calker et al., 2005; Bernués et al., 2011). Sustainability therefore entails a process of continuous improvement, requiring the implementation of a multiplicity of actions and the occurrence of a number of conditions achievable at different times and with various degrees of complexity.

This holds for **organic farming**, which can boost the entire system, thanks to greater awareness of the social and environmental role of organic farming on the part of farmers (Goldberger, 2011) and a higher capacity of social integration in the area, especially in combination with specific production systems such as vegetables (Lobley et al., 2011). There is also evidence that the organic sector is able to promote environmental education of consumers (Seyfang, 2006), while organic farmers can share their values along the supply chain (Marsden and Smith, 2005). However, virtuous circles can arise if all human activities are driven by the same principles, adopting common approaches and emphasising specific elements, thus creating a positive atmosphere conducive to continuous innovation. The development of specific synergies and joint actions with other components of the local context allows the organic supply chain to reach levels of sustainability over the three pillars that otherwise would be unattainable.

Figure 24 shows graphically the principles, approach and elements that facilitate the synergies between context and supply chain. The model takes into account the mutual influence between the local context and the supply chains, without considering relations with outer entities, except for the role of the policies enacted by higher government levels (Regions, State, European Union) or for the contribution that local actors and institutions could make to sustainable development processes in other contexts. The exchange of goods and services, therefore, is left aside, while it is implicit that local institutions, operators and stakeholders must be able to adapt innovations coming from outside to the context in which they operate.

Figure 24: Supply chain and context sustainability requirements, approaches and elements



Source: Sturla & Viganò, 2013.

Sustainable development of an area must then take place in accordance with policies established at hierarchically higher levels, in order to ensure the harmonious development of the regions and countries in which it is located. Policies, therefore, must be defined locally, but in line with the political objectives set at higher decisional levels (integration between top down and bottom up approach). This integrated approach, which requires the coordination of the policies implemented in a specific context by various subjects aimed at the development of synergies, follows from the principle of 'globality' and satisfies a need for rationalization of operations to improve efficiency and effectiveness.

Development processes and supply chains that are part of them can be considered sustainable when two elements, mainly targeting the enhancement of human resources and the development of social capital, are present. The first is leadership that aims to raise awareness and gather local forces around common goals, clarifying the contribution of each actor. Leaders should emphasise interpersonal relations, the formation of networks and the construction of a vision and shared values rather than exercise control and power over the multiple components of the development process (Dooley, Luke, 2008), stimulating a participatory and cooperative behaviour from every actor operating in the area, even from citizens and consumers. The second element, depends on the extent to which leaders manage to encourage the formation of networks, not necessarily formalised, today seen by scholars as a discriminating factor, a competitive advantage to ensure the sustainability of a development process either at a supply chain or territorial level (Baptista et al., 2010; Carbone et al., 2009; Marsden and Smith, 2005; Murdoch, 2000; Renting et al., 2003; Roep and Wiskerke, 2006; Samoggia et al., 2010; Schermer, 2004; Steinlechner and Schermer, 2010; Trauger, 2009).

Governance and local networks define a participatory approach to local development that should lead to goal sharing and to the retention of the wealth produced within the area or by the supply chains, ensuring a balance between the satisfaction of demand needs and maintenance of the investments within them (Marsden and Smith, 2005). An index of the success of the quality of a sustainable development strategy is the existence of emulative actions, which are carried out through attempts to duplicate the same development path in other areas, which, however, require specific adaptive processes.

The case "Varese Ligure"[15]

In the early 1990s, the revival of Varese Ligure was linked to the objective of curbing depopulation together with land abandonment and progressive ageing of the remaining population, pursued by a former Mayor (Maurizio Caranza), aiming above all at improving the level of sustainability from an environmental, economic and, in some respects, social point of view. Such peculiarities make Varese Ligure the ideal test-bench to explore how context, starting from institutions, and the organic supply chains complement each other, developing a synergistic relationship and mutual influence. Furthermore, the case study focuses on a local level, where relations among different actors are simpler and easier to detect than at the regional or national level.

In particular, the municipal administration has spawned a massive renewal of the urban fabric and restructuring of the agricultural sector. The latter was undertaken by promoting the conversion of the existing farms to organic, essentially cattle and dairy farms, so that the number of organic farms increased steadily from 1997 to 2003, when it reached a maximum (75) and then began to drop. In 2013, the most structured organic farms remaining (48 units) in the municipal area owned 51% of the UAA (ISTAT, 2016). The conversion was obtained by means of a 'door to door' work of persuasion carried out by the charismatic mayor, presenting it as the only way to restore revenues to a level fit for making out a living from farming activities, without resorting to a radical change in farming techniques. The process of conversion to organic farming was accompanied by the renovation of the two processing plants, the dairy and the slaughterhouse of the two main

[15] Varese Ligure is an Italian town of 2,059 inhabitants (2015) located in a Less Favoured Area of the North-Western Apennines, in the Province of La Spezia.

cooperatives that, now as then, gather almost all of the farmers operating inside the municipal bounds.

Following urban renewal and the restructuring of the organic sector, the municipal administration has undertaken a series of initiatives, some of them aimed at a greater environmental sustainability: the milestone of the UNI EN ISO 14001 certification for the municipal area (the first town to be awarded this certification in Europe) and the EMAS registration, the development of renewable energy sources (which currently meet 100% of the energetic needs of the municipal area), the implementation of Green Public Procurement procedures, the development of a system of separate collection of waste, and the building of a fully environmentally friendly landfill. Other initiatives targeted the quality of life: the widespread presence of broadband connection throughout the municipal area, the strengthening of public transport services, the construction of a new school (kindergarten and nursery, primary, and secondary schools) and, in 2013, the establishment of an organic district, according to the latter Regional Law on organic farming (L. R. 66/2009). Finally, the opening of an environmental education centre and an organic help desk aimed to increasie the awareness of citizens and farmers.

The development of the two organic supply chains, together with all other initiatives taken in the area, contributes to creating a highly sensitive context to sustainability issues that helps to promote worldwide the image of an unspoilt area and of the high degree of naturalness of the "organic valley. These values, in turn, are reflected by the organic products made there. The restoration of the two organic livestock supply chains, therefore, has become a steady component of the global development of the municipality, perceived since the beginning as the only viable way to ensure the economic feasibility of the agricultural activities, the creation of new jobs and the maintenance and vitality of the rural area. Nevertheless, the potential interactions between the organic sector and some other components of the system, especially the tourism sector, have been neglected, limiting the synergistic effects that would ensue and the overall development of the area.

Ever since the first step of the local renewal process, administrators have initiated a model of governance based on the involvement of local institutions and stakeholders. This strategy has had direct consequences on the equity principle, since it allows an active role to the actors involved in it, thus ensuring that positive effects remain in the local area, with positive externalities (land management, organic farming, clean energy, etc.) benefiting each member of the community.

Thanks to the ISO certification and the EMAS registration, the communication from top (administration) to bottom (citizenry) became a mandatory requirement, contributing to the achievement of an acceptable level of transparency, but restricted to environmental performance. Farmers have been mainly convinced by a “convert or perish” argument and, at the time, the main motive for many initiatives was to raise financial resources to ensure the survival of a dying land.

This initial lack of a strategic vision has led to a failure to take due account of the community as a whole and, despite the efforts made, citizens and stakeholders have never been really engaged in the decision making process.

Nevertheless, local administrators have succeeded in connecting the development objectives for rural areas pursued by the European Union with the peculiarities of their area. The financial support available via the European Structural Funds and other Programmes have been translated into interventions aimed at meeting local needs, following an approach in which policies provided at different levels integrate into a series of different interventions, motivated by the search for greater sustainability. This long series of initiatives concerning organic farming and those needed to meet the requirements for ISO 14001 certification and to enhance public services have allowed the wealth produced to be kept *in situ*, reinvesting profits achieved at both farm and cooperative level and creating new jobs through, for example, the establishment of a public company for the management of energy and water services, previously outsourced.

Such strong guidance, albeit undoubtedly effective in driving local choices toward higher sustainability, failed to create durable networks between local institutions (both private and public), actors and stakeholders. The field survey detected, on the one hand, a lack of networking capability and a disinterest in goal sharing, at least by local administrators, leading sometimes to duplication of efforts, but, on the other hand, a countervailing role for private initiative. For instance, the Consortium "*Valle del biologico*", a spin-off of a farmers' association, with 14 members (12 farmers and two cooperatives), originally established with the goal of promoting the products of its associates and favouring collective action to contain production costs, has recently become the leading partner of an initiative that led to the reactivation of the entire supply chain of a local hen, bred mainly in backyard henhouses, whose genome was virtually extinct in the valley and that the consortium has recovered. Another example is provided by the association 'Biological', a recently constituted cultural association that struggles to create a lively social and economic environment in the Upper Vara Valley without any kind of public subsidy, relying exclusively on the network of actors that orbit around organic agriculture, promptly summoned on occasions such as the 'Biological Festival', attended by more than 5,000 people each year.

The new-born Organic District aims to enhance cohesion among actors and stakeholders and to make organic agriculture the engine of development in the High Vara Valley, "*able to connect diverse economic entities",* as reported by the president of the local branch of AIAB (Italian Association for Organic Farming)[16].

The district is a consequence of the successful attempt to emulate the experience of Varese Ligure by closer towns. There, the number of organic farmers has risen rapidly thanks to the attractiveness of the two cooperatives and to the diligence of local administrators. At the time the regional law became effective, other towns in the Upper Vara Valley had already reached the share of certified UAA that would have made them eligible to join the district. Over time, Varese Ligure has become a model for many Italian towns, which have developed specific strategies for sustainable local development focused on organic farming (e.g. Castel del Giudice (IS), Bienno (BS)).

Organic meat and dairy supply chains

Since the very beginning of the renovation phase, the conversion of the two most important local supply chains (dairy and beef) to organic has been conceived as a milestone in the whole development action. Their presence in the area has been perceived as the only viable way to ensure the economic feasibility of agricultural activities, the creation of new jobs and the maintenance of the rural landscape.

[16] In particular, within the Organic District, AIAB is leading a partnership made of seven municipalities, the two organic cooperatives and two farmers' associations.

The flourishing marketing arising around the reputation of Varese Ligure, identified as the "organic valley" in the public imagination strongly fuelled by the media, undoubtedly testifies to the strong liaisons between the context and the productive sector.

Conversion to organic farming of the two cooperatives prompted a season of innovation that favoured the start-up of new firms strongly related to organic farming which, right from early on, have given life to bottom-up approaches. Such approaches, on the one hand, have replaced the public governance where this failed and, on the other, have acted as a stimulus for corrective action. The consortium "*Valle del Biologico*", the association "*Biological*" and, of course, the organic district would probably have never been born without the possibility of exploiting the image of Varese Ligure and its pristine environment. The strong commitment toward environment convinced Legambiente, a non-profit environmental association, to establish an Environmental Education Centre, in the town centre of Varese, which promotes good practices in agriculture and other sectors, as well responsible consumption and waste recycling.

The joint action of public guidance and private initiative has produced a participatory milieu in which supply chains have been thriving.

Extensive bovine livestock for meat and milk production is a traditional activity in Varese Ligure. Production, already very extensive at the time of conversion, could easily meet certification requirements, with few changes, essentially related to animal welfare and veterinary treatments. The conversion to organic favoured a change in fodder composition and ratio and the renovation of the cowsheds, although the biggest changes have occurred in economic and social terms: certification guarantees a higher price for produce and makes the farmer eligible for public support. Moreover, the consequential better market opportunities enabled younger generations to take over the farm, thus continuing their parents' activity and ensuring the maintenance of rural areas. According to the 6th agricultural census, 19 per cent of farmers are under 40, a percentage well above regional average (11 per cent). Young farmers do not prevent older family members from contributing to farm management but rather absorb their expertise, thus avoiding the loss of traditional knowledge.

Both the organic milk and organic beef supply chains are organised in cooperatives that collect, transform and sell local produce, whose establishment in the area took place thanks to the restoration of the main processing plants, in turn supported with public financial aid coming from different sources. Despite similarities in their structures, the two supply chains show great differences in their organisation, essentially due to the characteristics of the farm members.

The size of dairy farms is very small in terms of livestock units (13 head/farm), while organic beef herds (24 head/farm) are on average larger both than organic milk and conventional meat herds. As a consequence, while the cooperative abattoir processes organic beef raised exclusively in the Upper Vara Valley, two-thirds of the organic milk transformed by the dairy processing plant comes from outside the valley. On the other hand, both cooperatives have shown a constant increase in turnover. According to the Chamber of Commerce, in the span from 2012 to 2015, turnover grew by 13.9% for the milk cooperative and by 2.1% for its beef counterpart, reaching €2,101,568 and €11,118,630, respectively. The results were achieved through an increase in production levels, modernisation of production facilities and strong diversification of sales channels.

In addition to the powerful marketing related to the "*organic valley*" brand, in the last few years both cooperatives, in collaboration with local associations and the new-born District, have further boosted their promotion activities and information, especially targeting the local community. It has resulted in demand for products from the Upper Val di Vara that is exceeding supply. As a consequence, both the cooperatives are processing an increasing amount of raw materials: the organic milk cooperative's demand for raw organic milk increased from 2,580 q in 2011 to 4,200 in 2015, while the organic meat cooperative predicted that, in 2016, the number of animals slaughtered would reach 900 units, 500 of which would be organic, against 445 head in 2012 (+12.4%).

The economic sustainability of the cooperatives allow them to grant farmers a price commensurate with the quality of the products supplied. Organic milk farmers are paid an appreciably higher price than the national average for organic milk (0.56 EUR/l vs 0.50 EUR/l). The organic beef farmers we contacted stated that they were very satisfied with the price paid for their produce as well. Unlike dairy farmers, whose products are required to comply with strict legal requirements to be sold to the cooperative, organic cattle farmers are subject to a probationary period before entering into the cooperative in order to ensure that their meat meets precise quality standards, and are then required to follow an improvement plan. The management of the cooperative motivates its members to pursue collective goals rather than use the leverage of self-interest, thus obtaining significant results at the level of the supply chain and a positive impact at a farm level. This climate of confidence is actively fostered by helping farmers to solve specific problems and steering members' activities towards continuing improvement of their production. Interviewees testified to the beneficial effects on farm management of such strict control. A young female farmer stated that "*the cooperative makes me feel part of a common project whose main objective is the preservation of the countryside and provision of quality food*". The experience of the meat cooperative is a case in point that shows that, whenever stakeholders acknowledge organic agriculture as an integral part of an entrepreneurial strategy, it is possible to create welfare, starting from social and environmental value.

The economic viability of the two supply chains has laid the groundwork for bolstering individual farms and hence for the permanence of agriculture in the Upper Vara Valley. The director of the meat cooperative, emphasizing the good results of the entire supply chain, stated that: "*the economic crisis hasn't even touched us*". The cattle farmers are progressively increasing the size of their herds: the largest organic livestock farms have expanded their herds by up to 15%-20% in the last five years, while in the dairy sector the source of income provided by the cooperative has been helpful to prevent the disappearance of organic dairy farming: the stock is at present constituted by 10 farmers, the "hard core" of the organic milk sector in Varese Ligure. The presence of organic farming has mitigated the abandonment of agricultural activities that has occurred in the rest of mountain areas all over Liguria, where in a decade 75 per cent of the Utilized Agricultural Land has been lost, against 12 per cent in Varese Ligure. Agricultural activities are contributing to the maintenance of the floral composition and hence of the biodiversity of pastureland all over the Upper Vara Valley; they are a defence against forest expansion, thus contributing to the correct hydrological regime of the area.

Policy recommendations

This case study has shown that **organic farming has been the engine of a sustainable development process**, counteracting depopulation and providing a viable economic alternative to young people looking for jobs elsewhere. This has been possible through close collaboration of local actors, on the one hand - the local administration, the two cooperatives, some private organic associations (the consortium Organic Valley and the

Association Biological) -, and the healthy environment, on the other. In particular, the Municipality of Varese Ligure has approached sustainability systemically, ensuring the support and stage direction of the activities undertaken in the different fields and along its three dimensions, through the integration of different European and national policies. The commitment to the principle of globality has especially resulted in a series of positive consequences such that it is possible to single out several other good practices for revitalising rural areas that can be replicated in other areas:

a) Activation of the various components of the socio-economic-environmental system leads to the creation of a context open to innovation, which stimulates the different actors to devise activities, new solutions to local problems and the birth of start-ups to perform specific actions.

b) The *modus operandi* of the institutions and local actors, including civil society, that provides for the development of each activity in all its parts, in order to fully achieve the set objectives.

c) Focus on the organic supply chains and their identification with the area as a privileged means for local development.

d) Many actions, not only in the agricultural sector, aiming at environmental protection contribute to create an image of a pristine area, in turn reflected by agri-food products, which facilitates their market uptake and the integration of different sectors.

e) Encouragement of elements of discontinuity in respect to the "status quo", which are powerful catalysts for private initiatives and drive local processes along unforeseen pathways.

f) The propensity to reinvest in the local area the wealth produced by both public institutions and the private sector, ensuring the adoption of a win-win approach with regard to the three pillars of sustainability.

g) In an intra-generational perspective, the willingness to cooperate to transfer its development model, with the necessary adaptations, to other areas.

Some weaknesses still exist and need to be addressed. They regard governance issues and other relevant aspects related to the development of a local knowledge system, the systematic collaboration among the various actors, and the integration and diversification of the economic and social activities.

The analysis of these key elements of such a pioneering experience allows identification of some features that could be generalised as policy recommendations to the benefit of other local development initiatives.

- ***Adopting tools for inclusive governance***

  Following Jessop (2006), governance implies the establishment of a coordination system where the solution of the problems depends on continuous dialogue between the actors and hence by negotiated consensus, resource sharing and concerted action. At its best, local government should have an accompanying and facilitating role in the development process, a result of the sharing of objectives and participation in its definition by public institutions, economic and social actors, stakeholders, and the citizenry (participatory-deliberative model) rather than establishing a top-down approach. Thus the promotion of sustainable development of an area should start from the boosting of social capital, by mapping the stakeholders, including citizens and consumers, and organizing them, directly or through representatives, into advisory or decision-making bodies, such as committees, partnerships, etc. (Agnoletto et al., 2007). This increases their awareness of the positive effects of sustainable development for each stakeholder, allows the construction of structured networks and ensures their involvement in the decision making process. Furthermore, a local sustainable development process must put in place the tools for the continuing check of the results obtained.

Social reporting can be a suitable instrument for this purpose. It collects information from both institutional and economic actors, which are called upon to demonstrate the value created in the area by their actions. In addition, it communicates results, expectations and failures: it is therefore able to encourage participation. It legitimises the role of the organic district in the eyes of the local community, in structural and above all moral terms. Social reporting, therefore, must be accompanied by an efficient system of monitoring and evaluation, allowing the introductions of corrective elements whenever the development process deviates from the projected path. The methodological framework proposed here could be a valuable starting point.

- ***Development of an adequate knowledge system***

  One of the most deficient aspects found in describing the local development in Varese Ligure is the lack of an appropriate knowledge system. Education and diffusion of innovation are particularly important in the case of organic farming. In a sustainable development process, which also aims to strengthen organic agriculture and its supply chains, one should ensure continuing education, diversified by sector, specific to individual areas, and not only geared to traditional production or supply chains, whose operators often mistakenly assume to possess sufficient know-how to ensure their sustainability.

  Polo Poschiavo (Puschlav, Canton of Grisons, Switzerland) sets an example of what should be done in rural areas, in order to guarantee a wider diffusion of innovation. It is a public centre for continuous training, which also provides vocational retraining, and tutoring for development projects as well. Polo Poschiavo has been able to train skilled people, able to adapt to changes. Its success relies on some very specific elements that could easily be exported outside:

  - the organisation of courses in blended or traditional learning modes, on demand, concerning different themes and covering various economic and socio-cultural sectors;
  - collaboration with the vocational school, which facilitates the identification of innovative solutions to specific needs and their dissemination;
  - the organisation of conferences on various topics;
  - coordination and participation in national and international projects, such as those relating to the European Alps (e.g.: Alpine Space), often alongside universities and research centres, in a perspective of openness, cultural and good practice exchange with other areas and capitalisation of their specific assets;
  - favouring the collaboration between different actors of an area.

  The systematic collaboration between the different actors of an area could be ensured through the permanent establishment of working groups on specific issues, relevant to individual areas (environment, joint acquisition of production inputs, integration of sectors, local production and catering, services for the population, cultural activities, etc.), which will put forward proposals and organise and coordinate related activities, once they have been shared with stakeholders.

- ***Integration and diversification of economic and social activities***

  Integration and diversification of economic and social activities becomes more straightforward whenever participatory governance, alongside continuing and diversified education and the organization of actors around locally relevant themes, creates the basis for enhancing local know-how, sharing and supporting new ideas in different fields, including the procurement of the necessary financial resources.

3.3.3. Case study: arable crops in the Netherlands

KEY FINDINGS

- Many arable crops have shown only relatively small productivity increases in the last decade. The question is whether this is due to increasing sustainability demands.
- Productivity of arable crops in the Netherlands has more or less doubled over the past 60 years.
- Since 2001, the amount of pesticides applied has not decreased, but the environmental impact on soil life and groundwater has strongly decreased
- Since 2006, N-surplus has not significantly decreased, but P-surplus has
- There seems to be no clear trade-off between sustainability and productivity in arable farming in the Netherlands.

Dutch arable farming is an intriguing case of a potential trade-off between sustainability and productivity. Crops like potatoes and wheat have experienced less increase in yields since the mid-1990s than for instance sugar beet. How can this be explained, and what is the role of policy? Some argue that the green revolution has run its course and biotech is not yet delivering. Others follow C.T. de Wit and state that the increases in yields are on average an equal amount of kg (e.g. 100 kg) per year, and should not be shown as percentage growth. But also market and policy factors may play a role: the all-round potato variety Bintje was blamed in the early 1990s for a high use of pesticides, and was replaced by other varieties that in some cases realise higher prices and higher output (in euros). But it is also suggested by some farmers that current pesticides and nitrate regulations put a brake on yields. And then there is the puzzling case of sugar beet, where yields have exploded and the announcement of the end of quotas gives the sugar company and farmers an incentive to raise productivity. As the Dutch FADN contains a unique data set on yields, prices and sustainability indicators, we will provide an up to date data analysis over this period.

Crop production functions, representing marketable output as a function of input (mainly seed, fertilisation and crop protection), have shifted over time. Breeding for better varieties and improved (application of) fertilisers and pesticides have resulted in higher output levels with more or less the same input levels (*Green Revolution*).

In recent decades, sustainability goals in the EU and elsewhere have increased and have been implemented through legislation and additional input restrictions ('soft law' in certified schemes) by processors and retailers. Such restrictions lead to decreased input levels and, along the production curve, to lower output levels. In other words: productivity could decrease due to an increase in sustainability demands. At the same time, plant breeders have continued to improve crop varieties, resulting in shifts in production curves, i.e. in higher productivity with the same input levels. The result appears to be a net stand-still in productivity increase for several crops. For the future, a further shift in the production function is expected through innovations in crop resistance to severe diseases and pests like late blight (*Phytophthora infestans)* in potato. Ideally, a further increase in sustainability could then be combined with an increase in productivity levels due to significantly lower disease incidence and improved plant production processes such as photosynthesis and processing of photosynthetic products into (marketable) starch, proteins and other useful products.

Here, developments in productivity and sustainability for arable crops in the Netherlands are presented and analysed in order to answer the question whether increased sustainability demands have led to decreased productivity for different crops. Sustainability is defined in terms of input levels of fertilisation and crop protection, assuming that lower input levels result in lower emission levels and pollution levels in the environment[17].

For a general picture on productivity, yield data of different arable crops over a relatively long period (from 1954 onwards, representing a period of 60 years) were collected from Statistics Netherlands (CBS). As a second step, Dutch FADN (Farm Accountancy Data Network) data for arable farms were collected to analyse potential trade-offs between productivity and sustainability. Ideally, such an analysis should be carried out for one crop at a time, in order to assess one-to-one relationships between productivity and sustainability levels for the crop in question. However, FADN data were not sufficiently detailed for sustainability indicators for most individual crops, with potatoes as an exception. As an alternative, we estimated those relationships on the cropping plan level. To create a set of comparable farms, a selection was made of farms with a cropping plan containing a minimum proportion of potato, sugar beet and comparable crops. In general, input levels for cereals, rape seed and protein crops are significantly lower than for potatoes, sugar beets, onions and carrots. The selection contained farms with at least 15% ware potato, 10% sugar beet, 25% winter wheat and without animal husbandry. This selection resulted in a dataset of about 35 farms for each of the years since 2001, mostly on clay soils.

The sustainability indicators derived from FADN were expressed relative to 2001:

- Pesticide use (active ingredients) / ha land.
- Environmental impact of pesticides on soil, soil and surface water per ha of land, being the environmental effect of pesticides on soil life and biodiversity in soil and surface waters.
- N surplus and P surplus per ha land, being the inefficiency in nitrogen and phosphate fertilisation from manure and fertiliser.

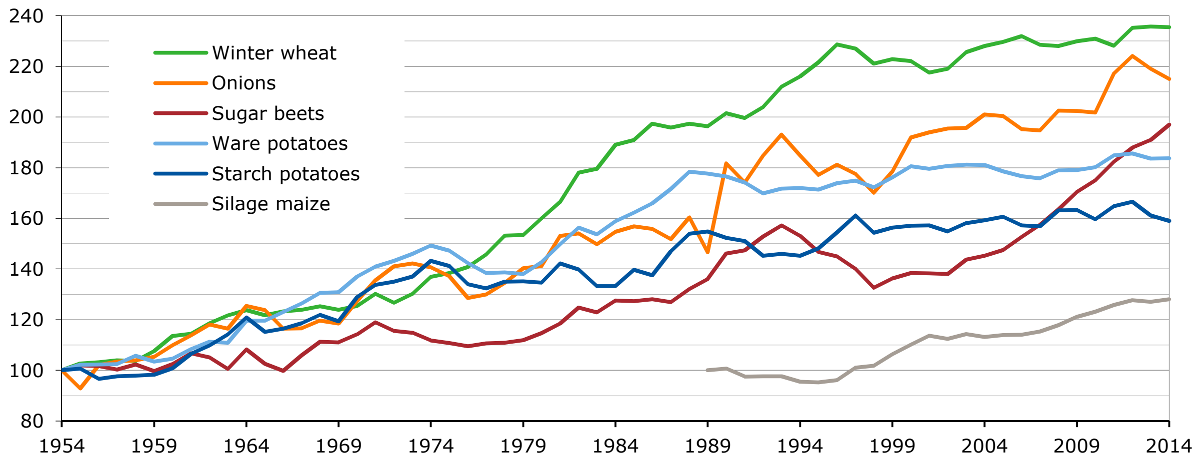
Sustainability data on ware potato were partly available on the crop level, so that a more specific analysis could be carried out for that crop. Moreover, in this case, sustainability indicators could be expressed not only per ha but also per kg product (tuber). In

[17] This is a simplification, since not only are the input levels important, but also the methods, doses and timing of application of fertilisers and pesticides affect to what extent such applications will lead to emissions (and in what form). Sustainability legislation is defined here as a reduction in fertiliser (including manure) and pesticide input levels. Pesticide reduction can also include a ban on *'heavy'* types, having a high risk on environmental damage.

sustainability discussions not only do input and emission levels per ha count (higher input levels have a risk of higher emission levels to soil, water and air), but also the figures per kg product, expressing the production efficiency for the different inputs applied. Thus, the third step was an analysis of potato data. In the Netherlands, three types of potatoes are cultivated: ware potato for direct consumption or processing into e.g. French fries, starch potatoes for processing into very different starch-based products, and seed potatoes as a basis for ware and seed potato growing. In 2015, the areas given over to the three types were about 70,000, 40,000 and 40,000 ha, respectively (CBS, Statistics Netherlands, 2015).

Figure 25 presents the relative yield levels of six major arable crops in the Netherlands. These data are available from 1954 for all crops except for silage maize, which was only introduced in the Netherlands in the 1980s. In a period of 60 years, the yields of most crops have doubled; winter wheat, and onions even more than doubled, and sugar beet, ware and starch potatoes somewhat less. Silage maize shows an increase of 30% over 25 years.

Figure 25: Relative yield levels of six major arable crops in the Netherlands (1954 = 100, except for silage maize, for which 1989 = 100)

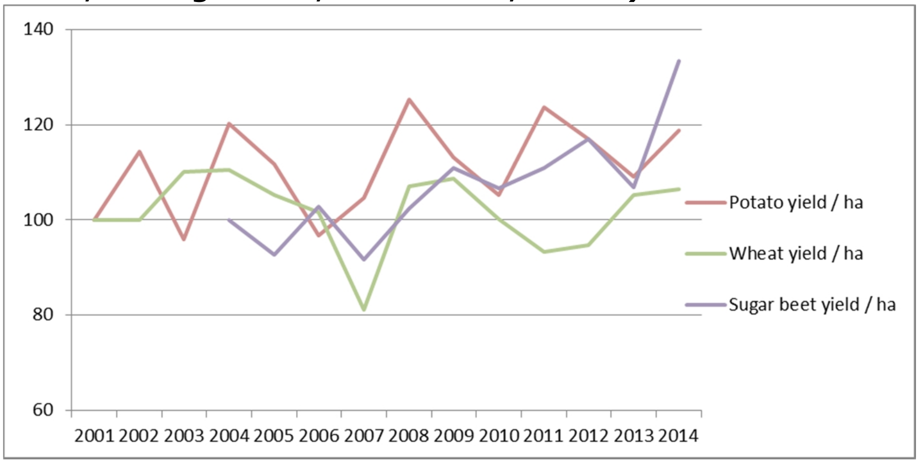


Source: CBS.

The yield increases over 60 or 25 years are partly due to breeding (genetic improvement) and partly due to improved management including technological progress (better equipment). There could even be a climatic effect (longer growing seasons, higher average temperatures, more atmospheric CO_2). However, the increase is not represented by a straight line with a constant slope. Changing weather conditions cause variation between years, with upward peaks in favourable years and downward peaks under unfavourable weather conditions. A more structural high or low slope over a longer period of time is often explained by specific breeding challenges, such as controlling the nematode problems in starch potato and Rhizomania in sugar beet in the 1970s. In general, breeding for resistance and for high productivity at the same time is problematic. As a consequence, periods of breeding for greater resistance alternate with those of productivity increase. The yearly increase in sugar beet yields since 1998 is remarkable. Besides breeding, introduction of leaf disease control has contributed to this effect.

Figure 26 shows the yield development of the three main crops in the Netherlands, but compared with **Figure 25** over a shorter period, since for that period also sustainability indicators were available. The average yield of winter wheat stayed more or less the same over the period 2001 – 2014. Those for ware potato and sugar beet still increased in that period.

Figure 26: Relative yields of ware potato, winter wheat and sugar beet (2001 = 100; for sugar beet, 2004 = 100; n = 35)



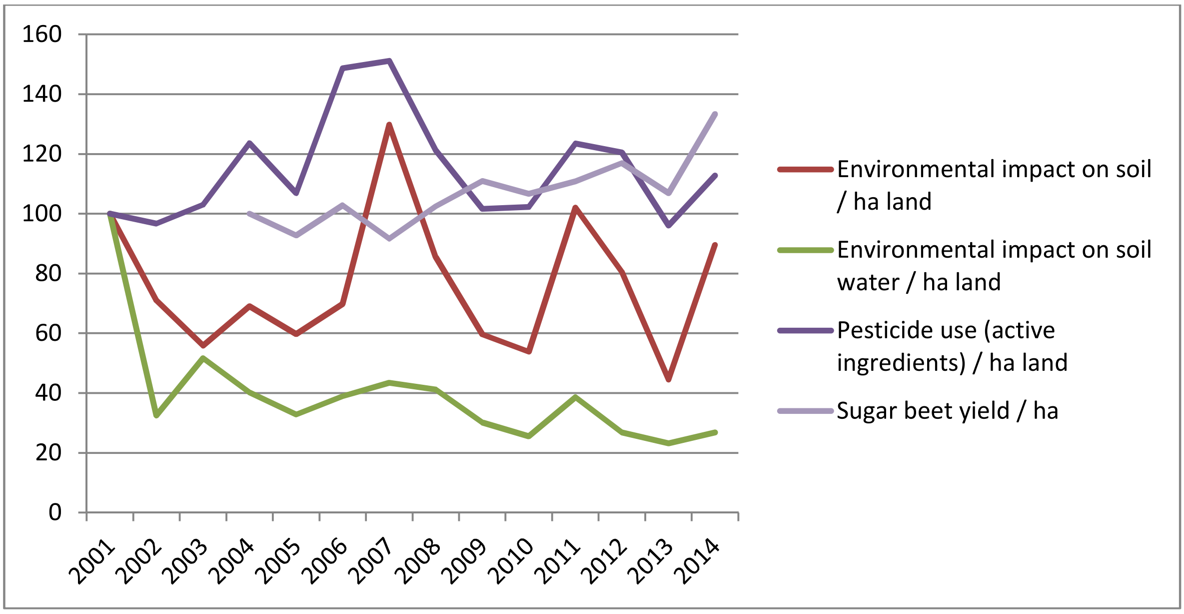
Source: FADN, adapted by Wageningen Economic Research.

Figures 27 and 28 show a number of sustainability indicators for the same period and farms as the productivity data in figure 26, calculated over the total cropping plan. In **Figure 27**, P-surplus has significantly decreased over the last ten years. In 2014, N-surplus was lower than in 2006 but there seems to be no significant progress lately. Since 2001, the amounts of pesticides applied per ha have increased in the beginning and later decreased; however, they tend to stay somewhat higher than 100% (**Figure 28**). At the same time, the environmental impact of the pesticides applied has significantly decreased, especially the effect on groundwater. But the impact on soil life has also decreased, as has the impact on surface water (the latter not presented in the figure).

Figure 27: Relative N- and P-surplus (available from 2006 onwards) and potato yield on arable farms in the Netherlands (2001 = 100; n =35)

Source: FADN, adapted by Wageningen Economic Research.

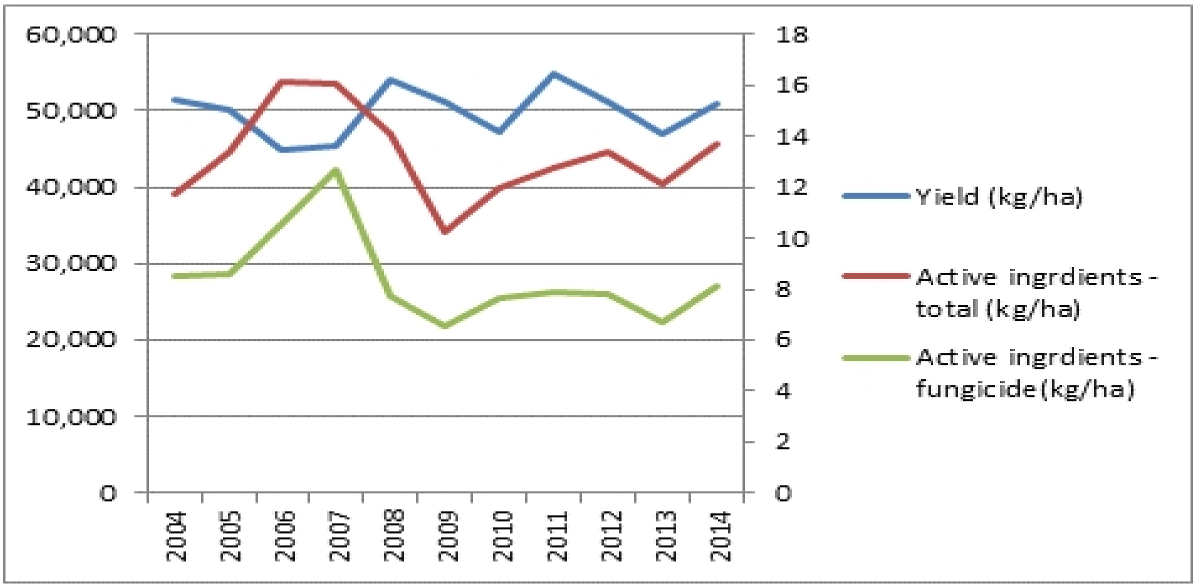
Figure 28: Relative pesticide use and environmental impact (available from 2006 onwards) and sugar beet yield at arable farms in the Netherlands (2001 = 100)



Source: FADN, adapted by Wageningen Economic Research.

Figure 29 presents the development of yields of ware potato on clay soils in the Netherlands and the amounts of active ingredients applied. Since late blight is the greatest epidemiological threat in potato growing, the amount of active ingredients through fungicides, mainly applied to control late blight, is separately presented. The figure shows that the average ware potato yield on Dutch clay soils fluctuates around 50 tonnes/ha. The average yield in the period 2012 – 2014 was only 2% higher than in 2004 – 2006. However, the amount of active ingredients showed a negative trend, for fungicides even more (-18%) than for the total amount (-5%).

Figure 29: Ware potato yield (left hand axis) and active ingredients applied (total amount and fungicides separately, right hand axis) on clay soils in the Netherlands in the period 2004 – 2014

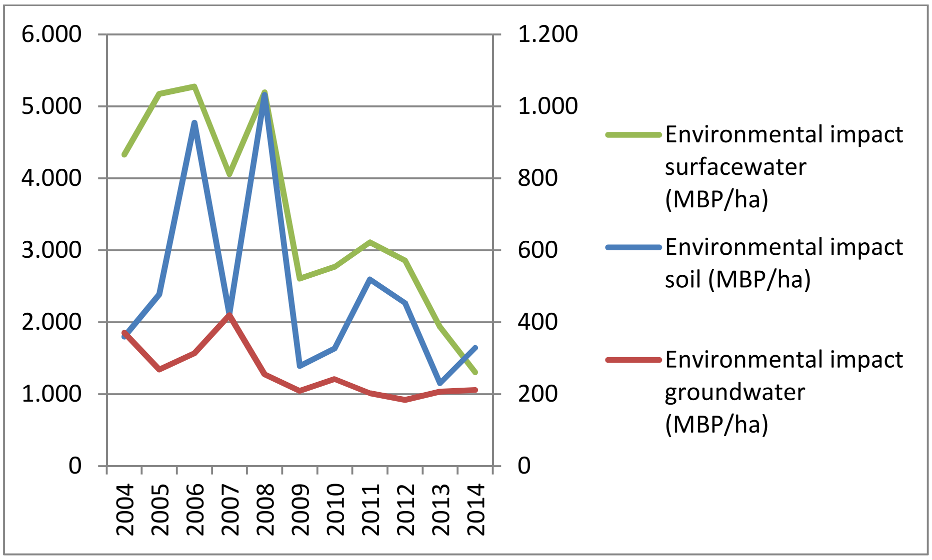


Source: FADN, adapted by Wageningen Economic Research (n = 82).

The environmental impact that pesticides cause in ground- and surface water and in the soil is a better indicator of the sustainability level of potato growing than the amount of active ingredients[18]. Figure 30 shows these data for the same period and in the same crop. Although the differences between years are large, the negative trend for all three indicators is clear. Between 2004 – 2006, on the one hand, and 2012 – 2014, on the other, the environmental impact for surface and groundwater and for the soil decreased by 59, 37 and 44%, respectively (**Table 5**). This is mainly due to the EU and national crop protection policies. Their main effect is that quite a number of 'heavy' pesticides have been banned in the recent decade. Moreover, in the Dutch context with a lot of surface water in the vicinity of agricultural land, the Dutch government has ordered measures for farmers in order to reduce drift of pesticides to surface water, e.g. untreated field margins, better nozzles and limitations for spraying under wet or windy conditions (Ministry of Infrastructure and Environment, 2016).

Comparable developments for seed and starch potatoes are summarised in **Table 5**. Interestingly, where the yield of ware potato only increased by 2% between 2004 – 2006 and 2012 - 2014, the yields of seed and starch potatoes increased by 10 and 8%, respectively. The total input of active ingredients increased in that same period strongly in seed potato, whereas the amount of fungicides strongly decreased. Both indicators stayed more or less the same for starch potato. For all three potato types, the environmental impact has strongly decreased, but the amount of active ingredients has increased in seed potato growing. This indicates that crop protection has become more complicated, but nevertheless the environmental effect per kg ai has decreased. The overall picture is that there is no trade-off between productivity and crop protection limitations for the three potato types.

Figure 30: Environmental impact of pesticides for surface water, groundwater and soil in ware potato growing on clay soils in the Netherlands in the period 2004 – 2014



Source: FADN, adapted by Wageningen Economic Research.
Note: the scaling for groundwater and soil is on the right hand axis of the figure, since these impacts are significantly lower than the impact for surface water, which is scaled on the left hand axis.

[18] This impact is expressed in so-called 'mbp', 'milieubelastingspunten' or 'environmental impact points' (CLM, www.milieumeetlat.nl).

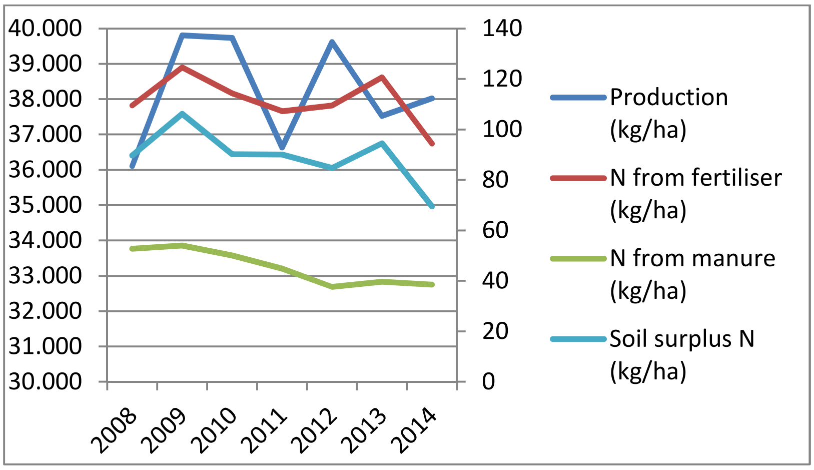
Table 5: Summary of developments in yield and crop protection with three types of potato growing in the Netherlands: ware and seed potatoes on clay soils and starch potato on all soils

Potato type	Period	Yield (kg/ha)	Crop protection				
			Active ingredients (kg/ha)		Environmental burden (MBP/ha)		
			Total	Fungicides	Soil	Groundwater	Surface water
Ware	2004 - 2006	48,854	14	9	597	317	4,927
	2012 - 2014	49,684	13	8	337	201	2,031
	Difference (%)	2	-5	-18	-44	-37	-59
Seed	2004 - 2006	34,888	20	9	916	277	4,764
	2012 - 2014	38,385	28	7	371	155	1,783
	Difference (%)	10	40	-23	-60	-44	-63
Starch	2004 - 2006	41,715	18	14	1,134	701	3,531
	2012 - 2014	44,912	18	14	616	637	2,176
	Difference (%)	8	1	1	-46	-9	-38

Source: FADN, adapted by Wageningen Economic Research (n = 82, 69 and 35, respectively).

Data on fertilisation in potato growing are available from 2008 onwards. Figure 31 presents those data combined with yield data for seed potatoes. N-rates applied from both fertiliser and manure have decreased over time, as has soil surplus. The average seed potato yield has a positive correlation with total N-supply per ha (0.42) and soil N-surplus (0.20), which could indicate that N-rate limitation will reduce both productivity and the risk on N-leaching. **Figure 32** presents the same data but expressed in kg N per ton instead of ha. The level of manure application per ha has stabilised in the last few years. This may be due to the high availability of manure in the Netherlands combined with low manure prices and with attention for the need to ensure sufficient organic matter content of the soil. However, the decrease in N applied and in N surplus per ton tuber indicate that the efficiency of N-application has increased in seed potato growing and, at the same time, the N-loss has decreased. There is no trade-off between productivity and sustainability in this case.

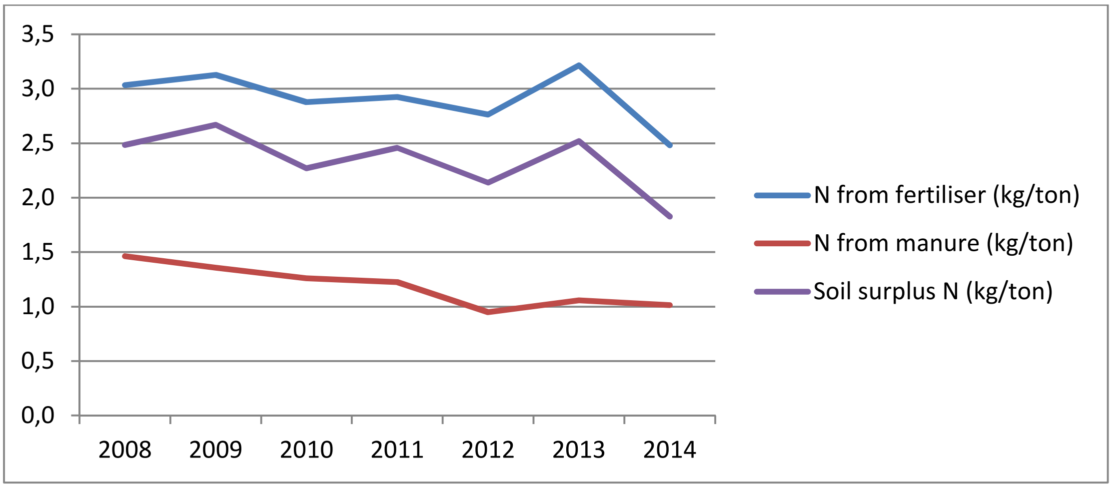
Figure 31: Yield and fertilisation data for seed potato on clay soils in the Netherlands in the period 2008 – 2014. Yield data are given on the left hand axis, fertiliser data on the right hand axis



Source: FADN, adapted by Wageningen Economic Research (n = 69).

Table 6 gives an overview of the N-fertilisation data for the three potato types. Interestingly, in all three types, the N-application from fertiliser and manure has decreased since 2008, but the decrease is much stronger in seed and starch potatoes than in ware potato. The surplus shows the same pattern. This observation holds when these indicators are expressed per ha as well as per ton tuber. The decrease per ton tuber is even stronger than per ha in the case of starch potato, where a yield increase of 5% was observed. In the same period, ware and seed potatoes showed a slight decrease (-2%) or stabilisation in yield, respectively. These figures show that there is no trade-off between productivity and reduced N-fertilisation for starch and seed potatoes. However, there may be a small trade-off for ware potato, where productivity shows some decrease in recent years and at the same time the increase of N-use efficiency is relatively low.

Figure 32: Fertilisation data per ton of seed potato on clay soils in the Netherlands in the period 2008 – 2014



Source: FADN, adapted by Wageningen Economic Research (n = 69).

Table 6: Summary of developments in yield and N-fertilisation with three types of potato growing in the Netherlands: ware and seed potatoes on clay soils and starch potato on all soils

Potato type	Period	Yield (kg/ha)	Fertilisation and surplus (kg/ha)			Fertilisation and surplus (kg/ton)		
			N from fertiliser	N from manure	Soil surplus N	N from fertiliser	N from manure	Soil surplus N
Ware potato	2008 - 2010	50,908	212	88	160	4.2	1.7	3.1
	2012 - 2014	49,684	207	82	152	4.2	1.7	3.1
	Difference (%)	-2	-2	-6	-5	0	-4	-3
Seed potato	2008 - 2010	38,548	116	52	95	3.0	1.4	2.5
	2012 - 2014	38,385	108	39	83	2.8	1.0	2.2
	Difference (%)	0	-7	-26	-13	-6	-26	-13
Starch potato	2008 - 2010	42,925	102	157	133	2.4	3.7	3.1
	2012 - 2014	44,912	91	129	99	2.0	2.9	2.2
	Difference (%)	5	-11	-18	-26	-15	-22	-29

Source: FADN/BIN, adapted by Wageningen Economic Research (n = 82, 69 and 35, respectively).

Rijk et al. (2013) reported for the Netherlands the following results:

- The genetic progress over the past ca. 30 years was largely linear and substantial for winter wheat, spring barley, starch potato and sugar beet.

- Farm yields could not always keep pace with the combined genetic and year effects in variety trials, suggesting a widening yield gap.
- Also, significant year (climate and/or management) effects were found in variety trials.

In the Netherlands, there is some discussion whether yield progress in a number of crops has come to an end or there is still improvement, which however cannot be qualified as 'significant' due to a large variation between years. At the same time, emissions of nutrients and pesticides tend to decrease due to stricter legislation, improved technology and better management. This would imply that stricter legislation does not necessarily lead to a productivity decrease. In other words, there would be no trade-off between productivity and sustainability. On the contrary, through breeding and better crop management productivity has not decreased but in most crops even increased.

However, in theory, the average annual increase in productivity of arable crops could have been higher with a less strict input regime. At the same time, decreasing input levels often stimulate innovation in equipment, management and even breeding. This conclusion is not an open invitation for setting stricter rules for crop protection, fertilisation, water and energy use, etc. Farmers should maintain the flexibility to cope with variation in weather conditions. Moreover, increasing crop yields require at least more nutrients, since crop uptake on average increases with crop yield. Keeping soil fertility high is a prerequisite for such high yields.

Economic effects have not been included in this analysis, but are naturally of great influence on the profitability of arable farming. For example, some crops like potatoes can have an incidental decrease in yields due to high incidence of a disease, but this effect is sometimes offset in the market by higher prices due to less supply to the market.

Produce has become more sustainable (measured per kg / ton) partly due to yield increases but mostly through reduction in input use. However, for environmental effects also the emissions per ha are important. There is an issue of accepting higher emissions per ha in highly productive regions, to save land use (and have more nature) elsewhere. We found no clear trade-off between productivity and sustainability in Dutch arable farming. Specifically in potato, there is no clear trade-off between productivity on the one hand and crop protection and N-fertilisation constraints on the other. There is some indication that limited N-fertilisation reduces productivity of ware potato and productivity increase in other crops too. Even from a theoretical point of view, there are limits to the efficiency improvements that can be achieved.

3.3.4. Case study: Dutch dairy farms

KEY FINDINGS

- Farms with an automatic milking system (robot milking) may have different sustainability and productivity levels than conventional farms. Trade-offs may occur between different triple-P aspects.
- The general trend in the Netherlands is a strong increase in total milk production and a limited increase in milk production per cow.
- In the last decade, robot and conventional dairy farms in the Netherlands have grown in farm areas, number of cows and total milk production with the same rate. However, since the robot farms were already larger at the beginning of the decade, they have grown stronger in absolute numbers.

- Robot milking has different effects on different triple-P indicators of the farm compared to conventional farms.

Over the last 20 years Dutch dairy farming has improved its sustainability performance. Helped by the milk quota regime, the emissions of nitrate and phosphate and CO_2 emissions have been reduced per kg of milk (with lower cost prices at the same time) and per ha of land. After abolishing the dairy quota regime, milk production in the Netherlands has exploded. One of the technologies that helped farmers to raise labour productivity over the last years was the introduction of ICT, especially in dairy farming where the milking robot is used. ICT (precision farming) is often quoted as being positive for the environment. Based on FADN (*Farm Accountancy Data Network*) data that includes a specific data set on sustainability and productivity indicators and the use of a milking robot, we analysed whether farmers with high ICT involvement were more likely to expand production and what this did for the sustainability level.

From the Dutch FADN, data from dairy farms with and without automatic milking were collected to analyse potential trade-offs between productivity and sustainability[19]. Productivity was calculated for the main product, milk, and sustainability indicators were expressed both per ha and per kg milk.

In the data collection, the years 2001 until 2014 were selected in order to follow developments over a longer period. However, FADN contained too few farms with milking robot(s) in the first years in this period for all the indicators on the list. Data collected regard farm size; milking system: automatic (robot) milking or conventional system; number of (efficiently spent) working hours of the farmer, family members and staff (hours), an indicator for labour input; number of grazing days per year (only counted when grazing is applied 6 hours per day or more), in the Netherlands an indicator for animal welfare; energy use (kJ); greenhouse gases (GHG) expressed in CO2-equivalents / ha land available; herbicide use (active ingredients) / ha land available; N surplus / ha land available, being the inefficiency in nitrogen fertilisation from manure and fertiliser; P surplus / ha land available, being the inefficiency in phosphate fertilisation from manure and fertiliser[20]. Besides this specific data analysis from FADN, some other sources and reports were used to feed the discussion on potential trade-offs between sustainability and productivity.

The general trend in the Netherlands is a strong increase in total milk production and a limited increase in milk production per cow

Figure 33 shows the general development of milk production per cow and per farm in the Netherlands. Between 2001 and 2015, the respective quantities increased from 7,400 to 8,100 kg (+10%) and from 460 to 830 ton (+ 80%), respectively. Thanks to better cows (breeding), feed quality and internal climate management, a 10% higher milk production per cow was achieved, which, however, is relatively moderate over a period of 15 years. In the same period, farm size expressed in total milk production almost doubled, which is due to a significant increase in the number of cows per farm (from 62 in 2001 to 95 in

[19] The data collection and analysis did not include meat production.

[20] In this list, 'land available' means that in the calculation the land is included that is used to feed the dairy cows, not only grassland but also other feed crops like silage maize, which is very popular in the Netherlands. On the other hand, the resources for concentrates on Dutch dairy farms mostly originate from outside the farm, mostly even from outside the country. The land used for concentrate resource production (cereals, soy beans) was not included in the analysis.

2014). In table 7, this picture is broken down into farms with conventional and automatic milking systems.

In the last decade, robot and conventional dairy farms in the Netherlands have grown in area, number of cows and total milk production at the same rate. However, since the robot farms were already larger at the beginning of the decade, they have grown stronger in absolute numbers.

Table 7 gives an overview over the differences between the two farm types (farms with and without milking robot(s)) and their development over time. The total number of dairy farms with a conventional milking system decreased between 2004 – 2006 and 2012 – 2014 by more than a third to 11,700. This decrease illustrates the large structural changes in the dairy sector in the past decade. In the same period, the total number of robot dairy farms increased by more than 300% to more than 3,000. The ratio of dairy farms with an automatic milking system increased in this period from 4 to 21%. This sharp increase is reflected in the FADN sample: the sample still includes 250 (specialised) dairy farms, but the number of robot farms in that sample has increased from 12 to 60.

Table 7: Structure and sustainability indicators of dairy farms with and without automatic milking systems (milking robot(s)) in 2012 – 2014 compared to 2004 – 2006

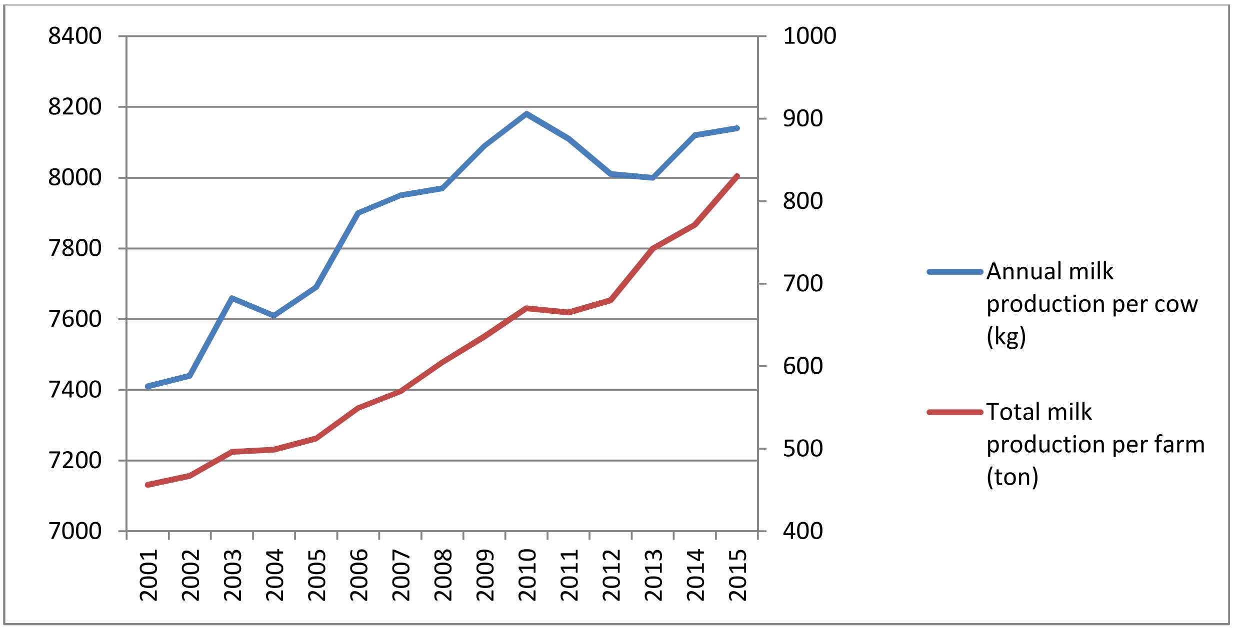
	Conventional			Milking robot		
	2004 - 2006	2012 - 2014	Difference (%)	2004 – 2006	2012 - 2014	Difference (%)
Number of farms in FADN	234	192	-18	12	60	390
Number of farms represented	18,136	11,684	-36	731	3,047	317
Farm area (ha)	42	48	14	52	60	17
Number of dairy cows / farm	67	87	30	85	109	28
Number of dairy cows / ha	1.6	1.8	14	1.6	1.8	10
Total milk production per year (ton)	517	694	34	712	923	30
Milk production per cow (ton)	7.73	7.97	3	8.36	8.46	1
Milk production per ha (ton)	12.2	14.4	18	13.7	15.3	11
Total working hours per year (1,000)	3.76	3.88	3	3.55	4.17	18
Working hours per ha per year	89	80	-10	69	69	1
Working hours per ton milk per year	7.3	5.6	-23	5.0	4.5	-9
Grazing days dairy cows per year	106	152	43	63	96	51
Energy use / ha land (kJ) a)	7,682	7,936	3	10,133	10,21	1
Energy use / kg milk (kJ) a)	630	550	-12	740	670	-9
Concentrate (kg/100 kg milk)	26.8	26.4	-1	26.0	26.5	2
Fertiliser use (kg N/ha)	139	130	-7	115	134	17
Fertiliser use / kg milk (kg N)	1.14	0.88	-23	0.84	0.86	3
Greenhouse gas in ton CO2 equivalent / ha land	n.a.	20.5		n.a.	20.4	
Greenhouse gas kg CO2 equivalent / kg milk		1.42			1.34	
N surplus / ha land (kg) b)	116	150	30	93	157	69
P surplus / ha land (kg) b)	15.4	5.2	-66	7.6	-0.4	-105
Herbicide use in active ingredients / ha (kg)	0.48	0.46	-6	0.52	0.50	-5
Net profit (* 1,000 euro)	- 52.9	- 20.0		- 78.2	- 45.9	
Net profit per 1,000 kg milk (euro)	-102	-30		-110	-51	
Farm income (* 1,000 euro)	52.2	58.0	11	39.2	29.7	-24
Total returns / total costs	80	94	18	78	91	16

Source: FADN, adapted by Wageningen Economic Research.

Notes:

a) All energy used including electricity, gas and all types of oil; electricity sold is not included;
b) The first figure per farm type is the average value for 2006 – 2008 instead of 2004 – 2006.

Figure 33: Average milk production per cow (left hand scale) and per farm (right hand scale) in the Netherlands in the period 2001 – 2015



Source: FADN, adapted by Wageningen Economic Research.

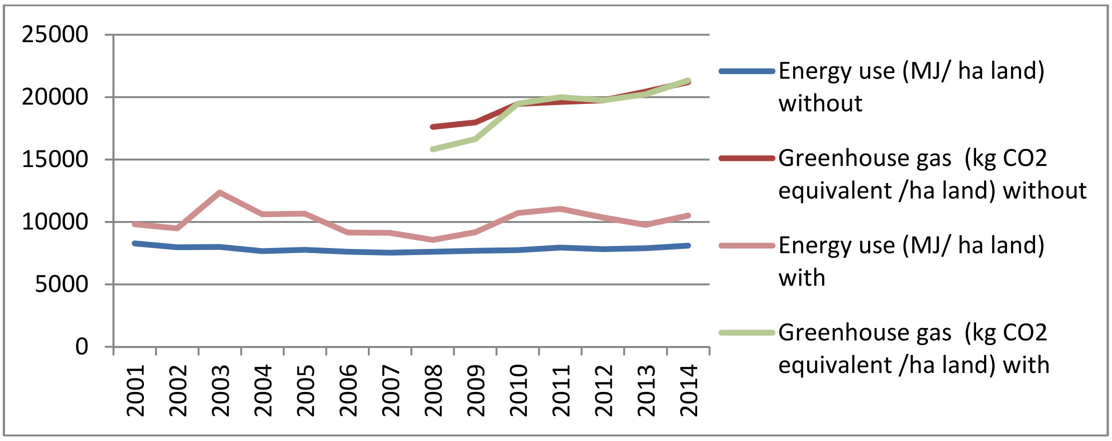
Farms with milking robots are on average larger than those without, i.e. their farm area is larger (60 versus 48 ha), they have more cows (109 versus 87) and a higher annual milk production (923 versus 694 ton; average data over 2012 - 2014). In the last decade, between 2004 – 2006 and 2012 – 2014, their size in area, number of cows and milk production increased at about the same rate in percentage terms, meaning that they grew stronger in absolute (but not in relative) figures. The average number of cows per ha is similar for both farm types and increased in the last decade from 1.6 to 1.8 cows.

The larger size of the robot farms is also expressed in a higher number of working hours per year (4,200 versus 3,900 hours per year). However, expressed per ha, robot farms have a lower labour input (69 versus 80 hours per year). The same is true per ton of milk: 4.5 versus 5.6 hours per year. In the last decade, the total number of working hours has increased on both farm types, but much more strongly on robot farms than on conventional farms (18 versus 3%). In the same period the number of working hours per ha and per ton of milk has decreased more sharply on conventional than on robot farms (-10 versus +1%, and -23 versus -9%). The picture that is given through these data, is that robot farms were already larger and more labour-efficient in the past and partly solved the larger labour demand due to expansion through investments in an automatic milking system instead of more labour input from inside or outside the farmer's family. Conventional farms were on average smaller and less efficient in labour productivity. The opportunities for them to make use of economies of scale were apparently greater, so that the considerable reduction in labour input in the most recent decade can be considered a 'making-up effect' on conventional farms.

Robot milking has different effects on different triple-P indicators of the farm compared to conventional farms. **Table 7** shows that a number of sustainability indicators, GHG-emissions, N- and P-surplus and herbicide use, have, when expressed per ha, comparable levels for conventional and robot farms. Since the milk production per ha is higher on robot farms, the values of these indicators are lower per kg milk. Robot milking takes more energy per kg milk: 670 kJ versus 550 kJ. Energy use per kg milk has decreased in the last decade with both conventional and automatic milking, but with conventional milking a little more than with automatic milking (12 vs. 9%). The greenhouse gas emissions per ha are almost the same for both milking systems, i.e. 20.4 ton CO2 equivalent. However, expressed per kg milk, the GHG-emissions are lower on robot farms (1.34 versus 1.42 CO2 equivalent). Concentrate use is the same for both systems (26.4 kg / 100 kg milk), but, remarkably, has decreased on conventional farms and increased on robot farms. The use of N fertiliser is also comparable for both farm types (130 kg N/ha) and also in this case, there was a decrease on conventional farms and an increase on robot farms. However, expressed per kg milk, robot farms had a somewhat lower and more or less stable level of N-input (0.86 versus 0.88 kg N / kg milk). However, on conventional farms N-use both per ha and per kg milk has clearly decreased in the last decade.

In Dutch dairy farming, the N surplus per ha land has increased in the last decade from about 116 to 150 – 160 kg per ha. In the same period, the P surplus has decreased to 0 – 5 kg per ha. Farm type seems to be of little effect for both. The amount of herbicides applied has decreased by about 5%, but more on conventional than in robot farms. The absolute quantity is somewhat higher on robot farms, which may be caused by a higher share of silage maize in the cropping plan and/or by a higher frequency of grassland renewal. Frequent grazing is better for the grass crop quality than just mowing and silage. The energy use at farms with milking robots is higher than without. Energy use per ha land tended to decrease from 2001 until 2007, but has increased since then, at both farm types. As shown before, the GHG emissions per ha are more or less similar for both milking systems and have increased since 2008 (**Figure 34**). A correlation with the increasing energy use per ha seems logical.

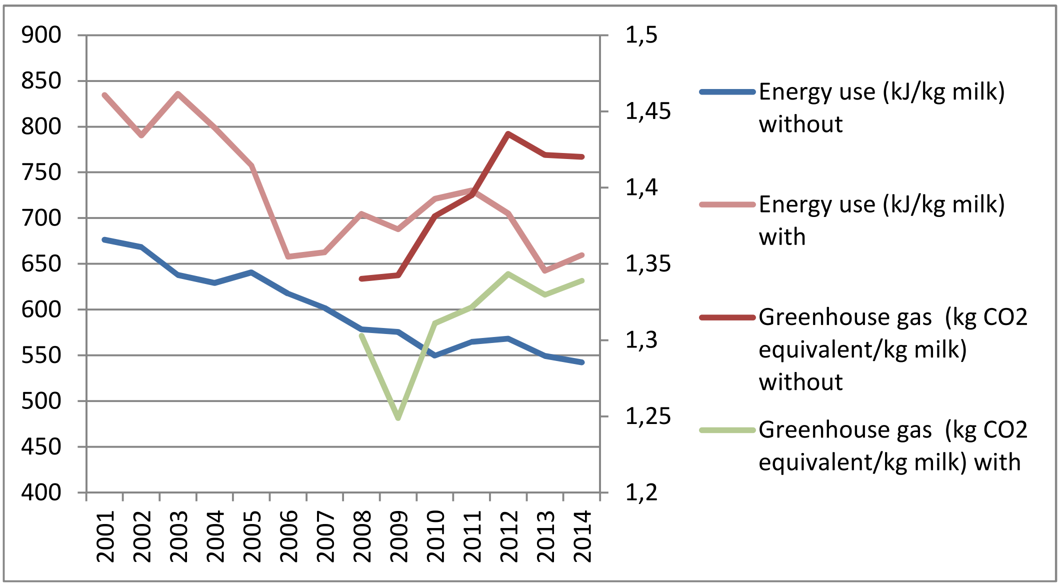
Figure 34: Energy use and greenhouse gas emissions per ha at Dutch dairy farms with and without milking robot(s) in the periods 2001 – 2014 and 2008 - 2014, respectively



Source: FADN, adapted by Wageningen Economic Research.

Since the average intensity i.e. the milk production per ha differs between both farm types, figure 34 is also composed per kg milk (**Figure 35**). This figure shows that the energy use per kg milk is higher for farms with milking robots, but for both types decreasing since 2001. However, robot farms showed an increase between 2006 and 2011, which seems to be a temporary effect. The decrease in energy use at conventional farm shows a more or less stable rate of 10 kJ per kg milk per year. The GHG-emission level per kg milk is higher at farms without milking robots and at both farm types stabilising since 2012 after a period of increase[21].

Figure 35: Energy use and greenhouse gas emissions per kg milk at Dutch dairy farms with and without milking robot(s) in the periods 2001 – 2014 and 2008 - 2014, respectively

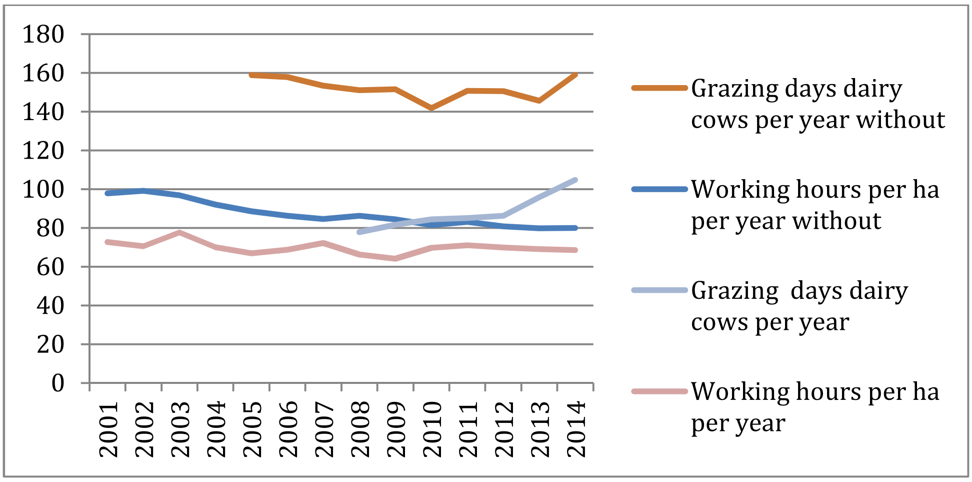


Source: FADN, adapted by Wageningen Economic Research.

Figure 36 shows differences in grazing days and working hours per ha between the two farm types. The number of grazing days is twice as high at farms without milking robots than with robots. At both farm types, the number of grazing days has increased in the past few years. The number of working hours per ha is higher at farms without milking robots and decreasing at both farm types. Robot farms are larger and make more working hours. However, the economic results are on average lower than on conventional farms. The total net profit, the net profit per 1,000 kg milk and the farm income were lower at the beginning of the decade, but have significantly increased since then (Table 7). However, also the conventional farms increased their economic results and the differences with the robot farms are still there at the end of the decade. On the other hand, expressed in total returns / total costs (paid and calculated), the differences are much smaller, almost negligible. Besides, both farm types have increased this ratio of cost-effectiveness considerably over the last decade.

[21] However, these data do not include 2015, in which the milk quota system was abolished and milk production in the Netherlands strongly increased.

Figure 36: Grazing days (minimum of 6 hours per day) per year and working hours per ha at Dutch dairy farms with and without milking robot(s) between 2001 and 2014, between 2006 and 2014 and between 2008 and 2014, respectively



Source: FADN, adapted by Wageningen Economic Research.

The comparison between milking robot-farms and farms with conventional milking equipment shows e.g. that the economic results of robot farms are lower than those of conventional farms. However, the economic development of individual farms which invested in an automatic milking system can be different, i.e. more positive than the group comparison would show. Besides economic reasons, there may be other goals in investing in a milking robot. Working hours become more flexible, creating opportunities for family life or outdoor activities. Farm expansion without hiring (more) personnel can be a personal strategy of farmers who prefer to work with technology than with employees, etc. In other words, there can be a trade-off between economic and personal/social effects (profit versus people aspects) in both milking systems: a higher level of people aspects at the cost of a lower income.

At the same time, when the number of grazing days is considered as a measure relevant to animal-friendliness, then robot milking also has a trade-off for number of working hours against grazing hours: a lower labour input per kg milk but also fewer grazing days per year. Grazing systems in general take more working time compared to mechanical feeding systems[22]. It is partly a matter of personal preferences and partly of logistic opportunities or barriers, especially with large cattle herds, whether a farmer will opt for a lower labour input or for a higher number of grazing days. In this study, we did not take into account effects on milk prices when a minimum number of grazing hours and days is applied at the farm. Neither did we try to quantify the effects of grazing on the 'licence to produce' of dairy farms, which can already be observed in the attitude of dairy companies, administrative bodies and society as a whole.

The number of grazing days is twice as high at farms without milking robots than with robots. The combination of access of the cows to the meadow for grazing[23] and robot milking is only possible when there is sufficient meadow area near the farm buildings. The

[22] However, part of the labour input is often re-allocated outside the farm, i.e. to contract workers who are entrusted with silage harvesting. This may be part of the explanation that the number of working hours per 1,000 kg milk is lower on robot farms. Instead of spending time on grazing management, they hire others to make silage.

[23] For the cows at least 6 hours per day at the meadow for 120 days is required for the 'official' recommendation by the dairy industry and to grant the farmer a bonus for 'meadow milk'.

cows need to be able to reach the robot(s) for milking by themselves and, preferably, at the times they choose themselves. That combination is not always possible, since the physical farm structure is not always optimal in this respect. The meadow area nearby is not always large enough and/or the distance between (some) of the meadows is too great to allow cows in-between visits to the building. Farms with more cows will have this problem sooner than smaller farms. At the same time, larger farms will probably invest sooner in milking robots. This explains why the number of grazing days is much smaller at robot farms: a) giving access of cows to the meadow for grazing is more difficult at farms with milking robots; b) the logistic structure of larger farms is more often not optimal for such access; c) larger farms are more likely to have milking robots than smaller ones.

As hypothesised, robot milking takes more energy per kg milk, but results in a lower GHG-emission per kg milk. However, the higher GHG-emission rate on conventional farms may be partly correlated with a higher number of grazing days. Energy use per kg milk is lower on this farm type, but that is more than outweighed by higher emission rates outside the stable. At conventional farms, the source and composition of the GHG-emissions are different (De Lauwere et al., 2017). Consequently, there is a trade-off between grazing and environmental effects, i.e. between people and planet aspects. Fewer grazing days (which is the case with robot milking) is correlated with lower GHG-emissions from the cows. This effect outweighs the higher energy use in robot milking, which is also correlated with GHG emissions.

Observing the data of both farm types, the impression is that robot farms were already larger and more efficient at the beginning of the last decade than their conventional colleagues. The efficiency increase, e.g. in fertiliser-nitrogen use or P-surplus was lower on robot farms and the efficiency decrease, e.g. in N-surplus, was even stronger. Conventional farms probably had more opportunities to deal with lower efficiency levels, which underlines the recommendation that for more insight in the differences between both farm types, individual farms should be studied before and after their transition period to robot milking.

Conclusions

Farms with a milking robot are larger in terms of hectares, number of cows, and total milk production. Their cows are more productive, although this is not necessarily caused by the fact that cows can be milked more than twice a day in a robot system. Labour productivity (in kg milk per hour worked) is clearly higher on farms with one or more milking robots.

- As a result of the higher yields per cow, milk production per ha is higher on robot milking farms although the stocking rate (number of cows/ha) does not differ.
- The environmental performance does not seem to differ much between the two systems: in terms of GHG-emissions, N- and P- surplus and herbicide use, there are no big differences in levels and trends. Due to the higher yields, the emissions of greenhouse gases per kg of milk are even a little more favourable on dairy farms with milking robots. The exception to this environmental performance is the use of energy. Dairy robot systems are energy-intensive: they use 20% more energy per kg of milk than non-robot farms. However, the net effect on GHG emissions due to this higher energy intensity is more than offset by the lower emissions due to the significantly fewer grazing days.
- Another big difference between the two systems is in the ethical dimension of sustainability. Where working conditions (given the number of hours worked per kg of

milk and the type of work) are more attractive on farms with robots, the cows and the landscape are –in the eyes of many- less well off. On farms with robots, cows are less often grazing, which is their natural behaviour (although they are more flexible in having themselves milked). This means they are also less often seen in the landscape. Both aspects (animal welfare and landscape) are valued by the Dutch (and some consumers).

- Concerning the use of ICT, as in the case of the milking robot, we conclude that this is positive for labour and land productivity. It does not have a clear effect on sustainability, with the exception of the negative effect of a 20% higher use of energy. However, it goes hand in hand with a lower score on social / ethical indicators of sustainability: robot farms have fewer cows in the meadow and/or fewer grazing days. Re-allotment of fields to create larger fields around the buildings might partly solve this issue, and the greater increase in cows in the fields than on conventional farms is an encouraging sign. But for the moment there is a trade-off between this aspect of sustainability and productivity. Where it is often claimed and shown that precision farming is positive for sustainability, the milking robot seems to be a case that is showing that this is not always true if one includes social / ethical aspects in the definition of sustainability.

3.3.5. Case Study: Precision farming for ecosystems services provision

KEY FINDINGS

- Precision agriculture is becoming increasingly popular among farmers in Europe, going beyond a simple tool to increase agricultural output, both in conventional and organic farming systems.
- The full potential of precision agriculture (PA) in regard of ecosystems services is still constrained because of access to information and in the application of regulations.
- Agro-ecosystems managed under PA have the regulation and maintenance of ecosystems services improved.
- Adoption of PA usually has positive impacts on the economic and environmental performance of agriculture.

The combination of efficient agricultural land use with biodiversity protection is a challenge. With the prospect of the global population reaching of nine billion people population in the next four decades, it is expected that the demand for agricultural goods will increase between 70–100% (Godfray et al. 2010). At the same time, the UN declared the current decade (2011–2020) the '*Decade of Biodiversity*' with the European Union setting targets to halt the loss of biodiversity and degradation of ecosystem services as major goals (European Environment Agency, 2010) and setting 2020 as the target for restoring at least 15% of degraded ecosystems (Tscharntke et al. 2012). This is especially important for Europe (EU28), where agriculture, as the prime land use, accounts for about 47% of the land area (European Union, 2014). As land and soil are finite resources, the discussion of land sparing or sharing has gained more relevance. For Phalan et al. (2011) the question is posed whether (or at what scale) farming and conservation land management should be separated; segregating land for nature from land for production (land sparing), or integrated with production and conservation on the same land (land sharing or wildlife-friendly farming). Facing the evident increase in demand for agricultural goods, the option for sharing seems to be the more realistic, at least in a global context.

In order to allow this form of agro-ecosystem management, **precision farming** emerges as an option to improve agricultural output (as providing ecosystem services) and at the same time take account of regulations and maintenance of ecosystem services.

Site–specific management, or precision farming, has the potential to change the way the fields are managed through variable–rate application of inputs such as fertilisers, lime and pesticides (Fraisse et al. 2001), so as specific soil and crop management. Precision farming is understood as a technological package for agronomic management that aims to apply the best practices to single portions of the field. The objective of site-specific management is to: a) increase yield output; b) reduce losses; c) ensure a more efficient use of inputs, amongst other things, bringing about a more sustainable and profitable production (Lana, 2015). The advent of the popularization of global navigation positioning systems (GNPS), together with a wide range of different on-board sensors (yield monitor, soil conductivity, and crop reflectance) and data processing tools allows for continuous improvements on precision farming, including aspects beyond food, fiber and biofuel production, such as nutrient balances.

Contribution of PA to ecosystems services

Precision agriculture can contribute to provision, regulation and maintenance of ecosystem services in different forms. The aspect of cultural ecosystem services is only laterally approached by precision farming, in situations where specific interactions with organisms (such as plant rows or the maintenance of biodiversity fragments within or surrounding fields) are fostered.

The benefits to be obtained are mainly due to increased yields and/or increased profitability of production to the farmer. Other benefits come from better working conditions and the potential to improve various aspects of environmental stewardship. Thus, precision agriculture contributes to the wider goal concerning sustainability of agricultural production (JRC 2014).

A comprehensive list of contributions (**Box 6**) is compiled using different examples for the EU. In the majority of the situations, PA can contribute to the provision of ecosystem services such as production of food, fibre or fuel. However, and what is more important, PA can influence ground and surface water quality by controlling the amount of fertilisers applied (to avoid eutrophication or pollution) or even the quantity of agrochemicals applied. Besides this, the use of PA can encompass compliance with environmental legislation, such as the exclusion of susceptible areas from cultivation, enrichment of biodiversity (**Figure 37**), the reduced application of nutrients on groundwater recharge areas, or the elimination of pesticide application in the surroundings of protected areas or areas with high biodiversity (**Figure 38**). In many situations it is reported that the adoption of PA also reduces production costs, especially by avoiding blanket application of nutrients and agrochemicals over large fields. Equipment such as yield sensors helps to indicate the spatial variability of the yield (as a provision service) and therefore evaluate whether there is room for yield improvement (by applying more fertiliser) or reduce the cultivation density or even exclude this area from cultivation (in situations where factors other than nutrition impact the yield, such as soil compaction, flood, etc.).

Examples of the use of precision agriculture can be found in Spain, where the amount of herbicide applied was lower using patch spraying strategy, instead of a widespread application (Barroso et al. 2003). This management substantially reduced the amount of agrochemicals applied on fields, decreasing the risk of soil and water contamination, thereby reducing economic costs. In terms of mechanical control of weeds in Germany, a higher weed density reduction was observed when the harrowing intensity was adjusted to the weed density (Rueda-Ayala et al. 2013).

In order to provide pollination, for example, initiatives such as the "*Operation Pollinator*"[24] take place in different European countries to create specific habitats, tailored to local conditions and native insects (Bianchi et al. 2013). The main objectives of such action are the protection and increment in overall biodiversity, to improve crop yields and biodiversity and ensure more sustainable farming and an environmental equilibrium. Precision farming in this case contributes by protecting field margins, so as within field strips of biodiversity.

How to promote precision agriculture for ecosystem services provision

Policy provides standards and management prescriptions which have to be transposed into rules and guidelines for technical applications related to soil and water conservation, just as for biodiversity and land use regulations. These rules need to be translated by agricultural consultants, advisors to practitioners and farmers to the industry sector, that will be passed on to farmers with the help of agricultural advisors.

A better dialogue between the scientists, policy makers and the industrial sector should be established in order to develop and produce hardware to equip agricultural machines, such as equipment for variable rate application, auto-guidance/steering systems and sensors for other parameters such as soil moisture, cover, etc.

There is an acute need of knowledge and skills on how to convert data collected by the different on-board sensors and geo-referenced data into geographical information systems (GIS) to provide information useful on crop physiological status and soil condition status. Besides this, capacity building is required to use the large and heterogeneous data sets and information gathered from the sensors. In particular, crop and landscape models are needed in order to understand the interrelations between plant, soil, landscape and climate before inputs can be spatially adjusted.

24 (http://www.operationpollinator.com/).

Box 6: Ecosystem services categories and the intervention of precision agriculture

Category	*Output*	*Group*	*Process*	*Precision agriculture intervention*
Provisioning	Materials	Biomass	Production of fibres and other materials from plants for direct use or processing	*Site specific cultivation of food, fibre and fuel crops*
Regulation & Maintenance	Mediation of waste, toxics and other nuisances	Mediation by ecosystems	Filtration	*Maintenance of buffer areas, no application of agrochemicals on the borders of sensible areas*
			storage/accumulation by ecosystems	*Site specific application of fertilizers and agrochemicals*
			Mediation of smell/noise/visual impacts	*Maintenance of in-field vegetation corridors, protected areas, green barriers*
	Mediation of flows	Mass flows	Mass stabilization and control of erosion rates	*Contour cultivation, localized tillage and plowing, use of automatic guidance systems to reduce soil compaction*
			Buffering and attenuation of mass flows	*Contour cultivation*
		Liquid flows	Hydrological cycle and water flow maintenance	*No tillage on recharge areas, maintenance of green cover, exclusion of flooded areas from cultivation*
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Pollination and seed dispersal	*Selective application of herbicides, delimitation of buffer zones*
		Pest and disease control	Pest control	*Application of insecticides based on localized damage*
			Disease control	*Application of fungicides based on localized damage*
		Soil conditions	Soil management	*Plowing and tillage dependent on soil physical characteristics*
		Water conditions	Chemical condition of freshwaters	*Application of nutrients (mainly N and P) based on soil + crop absorption rates*

Categories, *Output*, *Group* and *Processes* adapted from the Common International Classification of Ecosystem Services (CICES - http://biodiversity.europa.eu/maes/common-international-classification-of-ecosystem-services-cices-classification-version-4.3). *Precision agriculture intervention* adapted from case studies across the EU.

There is a need for more incentives for spatially connected precision agricultural systems due to the functional connectivity of ecosystems services in space (e.g. catchments for water provision). Current precision agriculture systems work mainly within field or farm boundaries. New IT solutions, together with cooperative approaches, have to be developed for larger spatial entities in order to enable integrated land sharing systems. This is why local governance requires decision support for better priority setting between the different ecosystem services.

Figure 37: Site-specific application of herbicides can allow the presence of other species to enrich landscape diversity (right side), providing, within the field, ecosystems services such as habitat maintenance for pollinators, predators and other insects

Source: Institute of land Uses Systems, ZALF, Germany.

Figure 38: Reduced or no application of fertilisers and pesticides around ponds, marsh and swamps reduce the possibilities of eutrophication, pollution and contamination. The ecosystem services provided by such structures are flow of water, recharge of aquifers and maintenance of biodiversity, among others

Source: Institute of Land Use Systems, ZALF, Germany.

Figure 39: Selective application of herbicide on cereal fields. Identification of the presence of weeds triggers the application of the herbicide. This approach considerably reduces the amount of agrochemical inputs on fields, reducing economic costs, the risk of pollution, as well as maintenance of non-targeted biodiversity.

Source: Rometron, Weed it (https://www.youtube.com/watch?v=fjSg0vI5NiE).

3.4. Assessment of the CAP instruments to promote viable food production

KEY FINDINGS

Among various CAP instruments to promote viable food production, POs and their organised system appear to be well focused as a tool to contribute to the improvement in farmers' incomes and in the functioning of the food chain on an environmentally sustainable basis.

The case study of the Italian F&V shows that POs' expenditures on operational programmes are mainly devoted to actions aimed at improving product marketing and environmental concerns, enhancing production planning and improving or maintaining product quality.

The quality regimes (certified organic production, PDO/PGI system, certified integrated production, and private quality certification) taken into account within operational programmes allow the specific objectives of improving competitiveness of the F&V sector to be pursued and achieved, protecting the environment and meeting consumer expectations.

The long-standing experience of POs in the F&V sector suggests some recommendations that could be effective for all agricultural sectors, to which the last CAP reform extended the possibility to build up POs.

Suggestions regard strengthening POs' market-oriented role and supporting PO innovation and internationalisation processes.

Intensification of efforts to tackle unfair trading practices in the food supply chain is suggested.

3.4.1. An overview of CAP instruments to promote "*viable food production*"

Viability is broadly defined, on the basis of the European Commission approach (1991), as the ability of a farm to earn enough income to meet its financial obligations and continue to operate and expand on a profitable basis over a long period (Adelaja and Sullivan, 1998; Argilés, 2001). Another useful definition is that a farm is economically viable as having the capacity to remunerate family labour at the minimum agricultural wage and provide an additional return of 5% on the capital invested in non-land assets (Frawley and Commins, 1996; Kilgarriff et al., 2015). If a farm is not economically viable, but have an off-farm income, earned by either the farmer or the spouse, the household is still considered be economically sustainable.

Maintaining and enhancing farm viability is a relevant goal of every agricultural policy. For the CAP it was an important issue in the past (European Commission, 1994) and still remains a central policy concern (Argilés, 2001; Vrolijk et al., 2010; Barnes et al., 2014; Vassalos et al., 2015), although over the last decades EU policies have broadened their objectives to community-based and environmental concerns.

Because of the recognized importance of farm viability, scholars and policy makers have increased their interest in this issue in order to identify the factors that "may influence whether or not a farm operation will be economically viable" (Vassalos et al., 2015).
For example, Barnes et al. (2014) examined the impact of diversification on farm viability in the Scottish and Swedish agricultural sector, finding that diversified farms are more likely to be viable and that farm location has a role as a financial successful parameter. Argilés (2001) analysed the impact of using financial reports on farm viability in Spain and

observed that "*accounting-based information is an important tool for assessing farm viability*" and for getting greater efficiency and effectiveness in the decision of policymakers and agents involved in agriculture.

The findings from various studies comply with the fact that bigger farms are more likely to be considered as viable.

Other scholars analysed the impact of agricultural policies on farm viability. Coppola et al. (2013) calculate profitability indices in the Italian FADN sample in order to assess farm economic viability, namely whether farm profitability "*holds*" in the absence of public aid. Their findings show that profitability is closely related to physical farm size, land quality and the type of enterprise. Furthermore, they find that a reduction of public aid could be a critical factor for the survival of much of agricultural production. Miceikiene et al. (2015) obtained similar results on examining a sample of Lithuanian farms. Both studies conclude that public support can play an important role in farm viability, particularly for small and medium scale farms and that larger farms may remain viable even without subsidies. Another recent research (Vassalos et al., 2015) examined the relationship of farm economic viability to a series of farm characteristics, as well as policy changes, for a sample of Greek farms. Their results indicate that "*a transition away from field crops towards value added products will increase the probability of economic viability for producers*". Besides, the authors observe that the age of the farmer may have a negative influence on farm profitability, that is older farmers are less likely to be economically viable. Another interesting finding is that single farm payments reduced the probability of farms classified as non-viable.

To promote "*viable food production*", one of the three long-term CAP objectives[25], the 2013 reform aimed to improve the competitiveness of the agricultural sector and enhance its value share in the food chain by strengthening farmers' bargaining power. For this purpose the CAP provides for improving economic tools to place the income of farmers, the functioning of the food chain and market developments on a sound socio-economic and environmentally sustainable basis.

In the context of this general objective, the 2013 CAP reform reinforces the focus on agricultural income, contributing to limiting farm income variability and thus to ensuring a fair standard of living for farmers.

Table 8 shows how Pillar I instruments, and a horizontal measure as well, support the specific objectives into which the overall objective "*viable food production*" is broken down. Also, Pillar II priorities contribute to this CAP objective, in particular through:

> **Priority 2**: enhancing farm viability and competitiveness of all types of agriculture in all regions and promoting innovative farm technologies and sustainable management of forests.
>
> **Priority 3:** promoting food chain organization, including processing and marketing of agricultural products, animal welfare and risk management in agriculture.

[25] The other two general CAP objectives are: "Sustainable management of natural resources and climate change" and "Balanced territorial development" (Article 110(2) Regulation (EU) No 1306 /2013).

Table 8: Viable food production: Pillar I and horizontal instruments

Specific objectives	*Direct payment instruments*	*Single CMO instruments*	*Horizontal and other instruments*
Enhance farm income	Basic payment scheme/SAPS Re-distributive payment Small farmers scheme Voluntary coupled support		
Improve agricultural competitiveness	Payment for young farmers	Producer organisations Wine sector	Promotion policy
Maintain market stability		Market measures	
Meet consumer expectations		School milk and fruit scheme	

Source: our adaptation from: European Commission (2013).

Many instruments contribute to pursue the overall objective of "*viable food production*", above all direct payments, which support and stabilise farmers' income, increasingly also contributing to the provision of environmental public goods. The CAP 2014-2020 provides for a wide range of obligatory and voluntary instruments of direct payments for active farmers, such as basic payment, greening payment, redistributive payment, small farmers scheme, voluntary coupled support, young farmers scheme, and support in areas facing natural constraints. Except for greening payment and support in areas facing natural constraints obviously aiming at the other two broad CAP objectives, all the other types of payment contribute to enhance farm viability.

Some recent studies (Severini et al., 2016; Matthews, 2016) analysed the stabilising effect of direct payments on farm income. Direct payments contribute to stabilise farm income because they represent a less variable part of income than that concerning market income. However, their stabilising effect will differ considerably among different farm types. An investigation on a sample of farms in Italy (Severini et al., 2016) shows that the stabilising role of direct payments rises as the share of direct payments in total farm receipts increase. Nevertheless, there is no guarantee that the contribution of direct payments to risk reduction is the biggest for those farms facing the largest income variability. Therefore, there seems to be "no significant relationships between the share of direct payments in total receipts and overall farm income variability" (Matthews, 2016; Severini et al., 2016). In their study Severini et al. conclude that direct payments are not well targeted as an income stabilisation measure, because the correlation between the variability of market income and the relative importance of direct payments in farm receipts is very low on average and in many farm types.

Another study (Mahé and Bureau, 2016) also confirms the fact that direct payments do not solve the price volatility problem and so do not make income more stable.

As regards the effects of direct payments on competitiveness, they can be positive or negative depending on whether farmers are more or less motivated to perform well, e.g. investing in cost-reducing innovations, with more income due to subsidies. Moreover, in relation to high standards and high-quality, healthy and safe food, Matthews (2016, p.40) argues that the "*competitiveness argument made in support of direct payment […] is not* *a convincing argument*" for a series of elements. Therefore "*there is no link between the payment and food quality*".

Market measures provide a safety net to react efficiently and effectively against threats of market disturbances, and thus maintain market stability and meet consumer expectations. Such measures will be financed through a crisis reserve that will be created through the annual application of the financial discipline on direct payments[26].

The crisis reserve in agriculture is a new financial instrument introduced by the CAP reform 2014-2020 to support the sector in the event of crises affecting production and/or distribution. This fund can be used to finance exceptional measures to deal with market disturbances. However, this tool is considered inadequate and too weak to respond to this purpose (Mahé and Bureau, 2016), because it needs more funds available from a reduction made to direct payments. Furthermore, its role in emergency envelopes should not be singled out with a rescue approach.

Other measures concern the existing systems of public intervention and private storage aid, revised by the last CAP reform to be more responsive and more efficient. The withdrawals from market can be effective in raising prices in the short run, but it is very difficult to have evidences on their economic efficiency in relation to the use of public funds and the functioning of markets (Mahé and Bureau, 2016).

The activities for the common organisation of the markets in agricultural products also include measures to foster the formation of producer organisations (POs) and interbranch organisations (IOs), in order to improve competitiveness of the agricultural sector and enhance its share in the food chain. The measures concerning POs, extended to sectors other than fruit and vegetables where they have long played an important role, and the promotion of the use of written contracts in agriculture aim to strengthen the bargaining power of producers in the food chain.

Other measures regard school milk and fruit schemes, as well as the wine national support programme and other regulatory measures.

3.4.2. Case study: fruit and vegetables sector

Fruit and vegetables (F&V) represent a key sector in the EU agriculture: in 2015 the value of its production was 64.6 billion euros, with a share of 15.8% of the value of total EU-28 agricultural production. Vegetables account for 10.7% (43.7 billion of euros, of which 9.3 are potatoes) and fruit for the remaining 5.1% (20.9 billion of euros, of which 4 are citrus).

The F&V production is highly geographically concentrated in the EU. The first five producing countries (Spain, Italy, Germany, France and Poland) account for about two thirds of the value of total EU-28 F&V production. More specifically, table 9 shows that in the case of vegetables Italy competes with Spain for leadership in the EU. Both these countries highlight a great produce specialization, with a share of 11.7% and 15.1%, respectively, of vegetables on the value of total own agricultural production. For fruit, instead, Spain is the leading producer country, accounting for 20.1%, boasting a strong specialization in citrus, peaches and melons. Italy (16%) ranks first in pears, peaches, apricots and table grapes harvest.

[26] It applies only to direct payments exceeding 2000 euros. For the period 2014-2020, the reserve comprises seven equal annual tranches of 400 euros each, for a total of 2.8 billion euros.

A qualifying perspective of the F&V produce regards organic farming, conducted on 5.3% of the EU area devoted to vegetables and on 10.4% of the EU fruit area. According to the 2013 farm structure survey, over half of the total organic vegetable area (53.6%) was located in three Member States: Poland (19.8%), France (17.3%) and Italy (16.5%). As regards EU organic fruit farming, Spain accounted for 36.4%, followed by Poland (18.8%) and Italy (16.3%) (EUROSTAT, 2016).

Table 9: Share of the value of F&V production in the EU-28 (2015)

	Vegetables %	Fruit %
Spain	19.2	20.1
Italy	18.9	16.0
Germany	9.2	..
France	8.5	15.7
Poland	8.8	7.1
Greece	..	8.0
Other EU countries	35.5	33.1
EU-28	*100.0*	*100.0*

Source: EUROSTAT.

One of the main structural limits of the EU F&V sector is the small size of farms (an average area of only 1.7 ha for vegetables and 1.8 ha for fruit). Among leading producers, only Germany and France show a significantly higher size than the European average, respectively 9.3 hectares (vegetables) and over 5 hectares (vegetables and fruit). Italy and Spain, both characterized by a widespread F&V production, highlight weaker structures, with farms with an average area between 2.2 and 4.0 hectares. This situation causes higher costs for farmers, not being able to reach an efficient level of scale economies, and poses limits on the competitiveness of F&V farms in the world market.

The role of the EU in the world F&V sector remains significant, although declining. The reduction of the share in world production is partly due to the growth of many other producing countries (China first, India, Brazil and Mexico) and mirrors the decreasing dynamic of EU production.

Freshness and perishability of F&V produce, as well as the fairly wide variety of products offered by EU countries, make intra-EU trade a very significant share of the F&V total trade. In 2015 intra-EU trade covered more than 80% of the total value. Fruit accounted for 61.5% of the total value of internal trade while vegetables for 38.5%. The leading countries for intra-EU exports are: Spain (34.9%), ranked first in citrus fruit market (68.9%), melons and watermelons (55.1%), apricots, cherries and peaches (53.5%) as well as lettuce and chicory (53.3%); the Netherlands (22.2%) led the internal trade for tomatoes (42.8%); and Italy dominated the EU grapes (31.7%) and apples (28.2%) market (EUROSTAT, 2016).

3.4.2.1 EU policy for the F&V sector: strengthening POs

EU support for the F&V sector is included in the market instruments provided by the Single CMO scheme, which pursues the following four broad objectives for the sector:

- To enhance competitiveness and market orientation.
- To reduce crisis-related fluctuations in producers' income.
- To increase consumption of fruit and vegetables in the EU.
- To improve the use of eco-friendly cultivation and production techniques.

The 2013 CAP reform confirms the approach adopted by the 2007 F&V CMO reform and based on a viable and sustainable production. The F&V sector was the first in agriculture in which EU policy dealt with the competitiveness and market-orientation objective in an environmentally sustainable view. The principal instruments devoted to achieving EU objectives are POs through their operational programmes, which are jointly financed by the European Agricultural Guarantee Fund (EAFG) and member farmers[27]. POs, introduced by the 1996 fruit and vegetable CMO reform entrusting them with a key role in strengthening the position of farmers in the market, are set up on the producers' own initiative. The 2007 reform strengthened POs with a wider range of tools[28], made available to enable them to prevent and manage market crises. Moreover, mergers between POs, associations of POs (APOs) and transnational cooperation were encouraged through incentives, in order to deal with a greater concentration of demand. Particular emphasis was placed on protecting the environment, the reason why POs were required to include a minimum level of environmental spending in their operational programmes[29]. For the first time, an evaluation process was introduced by the EU for a CMO sector: Member States had to establish a national strategy for sustainable operational programmes in the fruit and vegetable sector, integrating a specific national framework for environmental actions. Furthermore, the 2007 reform removed export refunds in the sector and decoupled aid for fruit and vegetables destined for processing (tomatoes, pears, peaches, prunes and citrus fruit).

The 2013 CAP reform, confirming the EU regime for the F&V sector, has introduced two important innovations, which are the possibility for APOs to set up an operational fund, financed by the associated POs' contribution with EU financial assistance, and the extension of the set of crisis prevention and management instruments. Besides, the EU aid to producer group has been shifted from the first to the second pillar, affecting all Member States.

As a result of all these functions, POs have been able to establish a countervailing power in fruit and vegetable chain relationships (Hendrikse and Bijman, 2002), also contributing to improving producers' margins as well as the adaptation of supply in terms of quality and quantity.

EU support for the F&V sector has focused on other two areas of action, in addition to operational programmes established and implemented by recognised POs: the school fruit and vegetable scheme, which contributes to "the achievement of the objectives of the

[27] The Community financial contribution to POs (50%) remains limited to 4.1% of the total value of marketed produce, but it may rise to 4.6% provided that the excess is used only for crisis prevention and management.

[28] The functions assigned to POs previously consist in the collection and concentration of supplies, the marketing of farm products, the collective purchasing of inputs, and technical assistance.

[29] POs are required to devote at least 10% of expenditure in their operational programmes to environmental actions going beyond the same minimum and mandatory requirements (baseline) applicable for the agrienvironment measures. In alternative, an operational programme must include at least two environmental actions. This in addition to the fact that the inclusion of F&V in the SPS entails that cross compliance is compulsory for all F&V producers receiving direct payments.

CAP, in particular stabilising markets and ensuring the availability of both current and future supplies"; recognition plan of producer groups[30].
As regards the school fruit and vegetable scheme, positive cooperation takes place with the PO organised system, which is the main agent of the implementation of this programme.

3.4.3 The National Strategy for sustainable operational programmes and the "*Intervention logic*" scheme for evaluation

In order to make PO activities carried out through the operational programmes more effective, as mentioned above, Single CMO introduced the possibility for Member States to develop a National Strategy for sustainable operational programmes in the fruit and vegetable market. The strategy must include the following elements: an analysis of the initial situation in terms of strengths and weaknesses and the potential for development; justification of the priorities chosen; the objectives of operational programmes and instruments, and performance indicators; assessments of operational programmes; reporting obligations for POs. The analysis of the initial situation must be aimed at identifying and assessing "the needs to be met, the ranking of the needs in terms of priorities, the goal to be achieved through the operational programmes to meet those priority needs, the result expected and the quantified targets to be attained in relation to the initial situation, and lay down the most appropriate instruments and actions for attaining those objectives"[31].

The European Commission has provided for the obligation to monitor and evaluate the effectiveness of the national environmental framework and the national strategy. Therefore Member States are required to ensure the monitoring and evaluation of the National Strategy and its implementation through operational programmes. For this purpose provision has been made for the use of relevant indicators among a common set of performance indicators, relating to the baseline situation, as well as financial execution, outputs, results and impact of the operational programmes implemented. The monitoring and evaluation must be aimed at examining "the degree of utilisation of financial resources, the degree of implementation of the operational programmes, the efficiency and effectiveness of the operational programmes implemented, and assess the effects and impact of those programmes, in relation to the objectives, targets and goals set by the strategy"[32]. In other words, the evaluation procedures based on the above-mentioned common set of indicators aims to emphasise policy effects on markets (e.g., selling prices, new varieties) and on the environment. However, the CMO for fruit and vegetables involves not only POs, but also farmers. This makes it often difficult to understand and measure whether and to what extent the benefits provided by CMO policy are transferred to farmers.

The evaluation process is based on an "*intervention logic*" model that illustrates the conceptual links between the proposed measures and the stated objectives as well as the internal breakdown of the objectives. As highlighted in the Report "Evaluation of the National Strategy for sustainable operational programmes in the Italian F&V sector" (ISMEA, 2012), "'intervention logic' plays a crucial role within a strategy that envisages the development of instruments designed to pursue and optimise an objective function".

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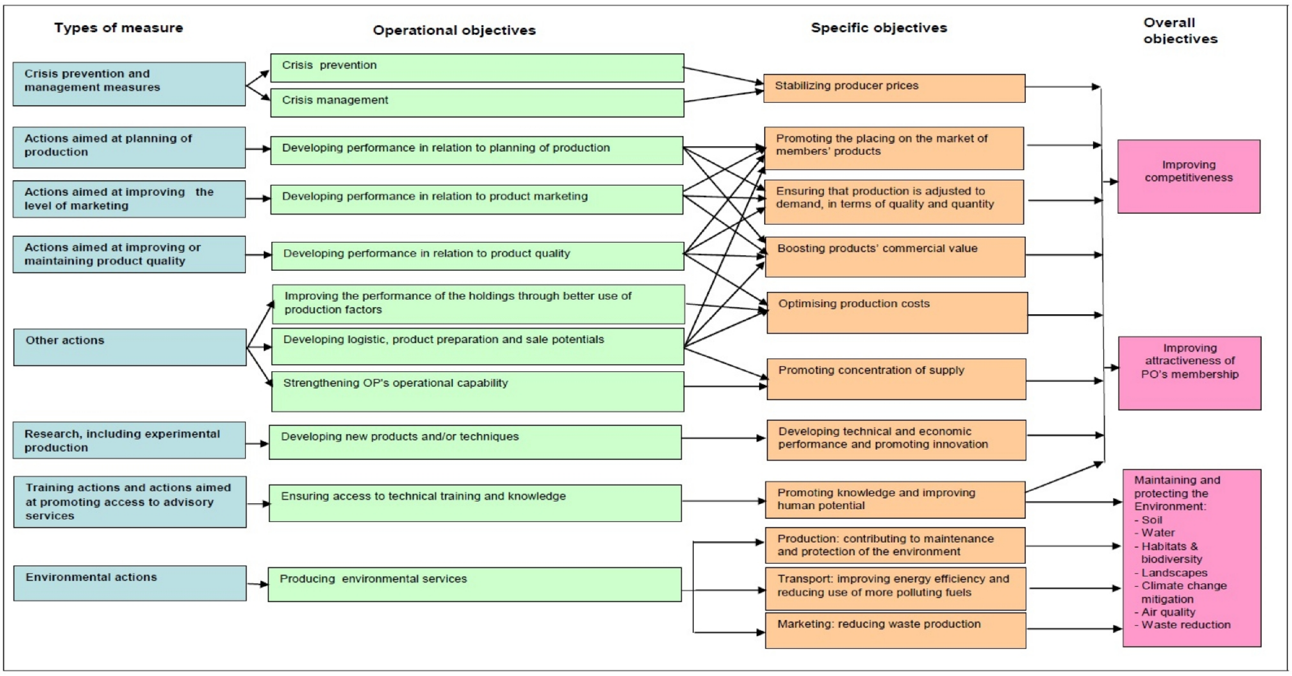
30 For producer groups the EU aid has been limited to Member States which joined the EU on 1 May 2004 or thereafter, the outermost regions, and the smaller Aegean Islands.
31 Commission Implementing Regulation (EU) No 543/2011 (art. 55 (3)).
32 Commission Implementing Regulation (EU) No 543/2011 (art. 127 (4)).

We report below (see **Figure 40**) the "*intervention logic*" diagram adopted by the Italian F&V Strategy. Even if it takes account of the specificities of the Italian case, it is as consistent as possible with the "common intervention logic model" contained in the European Commission Guidance Note (ISMEA, 2012).

A factor of crucial importance in the management of the operational programmes is represented by the relationship between the CMO support scheme and the rural development scheme. This is because both schemes can support the same types of expenditures, more specifically, investments[33] and agri-environmental actions (integrated production and organic production). In order to follow the general principle of "no double funding" a demarcation between the different commitments is required.

Figure 40: '*Intervention logic'* diagram adopted for evaluation of the National Strategy in the Italian F&V sector



Source: ISMEA (2012), p. 38.

3.4.4 An assessment of the EU support to the F&V sector

Thanks to the various reforms of the CMO, the European F&V sector has been the subject of an extended process of growth and reorganisation of the production system, involving Member States in different ways in terms of dynamics and characteristics. Nonetheless, empirical evidence shows that the path undertaken to encourage F&V POs has proven to be anything but straightforward.

In 2014 the European Commission drew up a "*Report on the fruit and vegetables regime*" (COM (2014) 112 final), based on evaluation of the National Strategies for operational programmes, as provided by the 2007 reform. The rate of organisation, which is the share of the total value of EU fruit and vegetable production marketed by 1,599 POs recognised in the European Union in 2010, on average was approximately 43%, a relatively low level

[33] Under the National Strategy, investments may be made specifically through the actions "purchase of fixed assets" under the measures "actions aimed at planning of production", "actions aimed at improving or maintaining product quality" and "'actions aimed at improving marketing". Under the rural development scheme, investments can be made specifically by using measures 121 (modernisation of agricultural holdings) and 123 (increasing the added value of agricultural and forestry products) of axis 1.

and, however, far from the objective of 60% established by the CMO. It is clear that this rate highlights a high degree of heterogeneity among regions (European Commission, 2014b). Moreover, only 16.5% of the EU F&V producers join POs, confirming the relatively low participation rate of farmers in the PO system already observed by previous studies (European Parliament, 2011; Camanzi *et al*., 2011; Agrosynergie, 2008). Despite the fact that the benefits of joining POs are generally recognised (first by European institutional bodies), empirical evidence suggests that many fruit and vegetable producers do not enjoy the benefits of being PO members and therefore do not directly take advantage of the EU regime. This means that these producers, usually the smallest, continue to be the weaker subjects within the supply chain because of their very low bargaining power. This makes them "more exposed to the risks linked to market globalisation and climate change" (European Commission, 2014b).

Slightly better, though still inadequate, is the situation in Italy where the rate of organisation, on average, was approximately 47.3% (European Commission, 2014c) and the degree of producer participation in POs was approximately 20.5%.

Several factors can explain the reasons underlying farmers' decisions as to whether or not to join POs. These factors may be of a social, cultural or historical nature (institutional environment) and they can constitute barriers to the development of POs. Farmers' individualism, lack of trust in collective forms of economic organisations, and "free rider" behaviour may influence farmers' decisions to participate in POs (European Commission, 2014b; Bijman *et al*., 2012; Ouabouch *et al.*, 2011). Furthermore, a lack of tradition in cooperation or joint marketing organisations can prevent or make the development of POs difficult in some areas (European Parliament, 2015; Petriccione, Solazzo, 2012). More specifically, with respect to the fruit and vegetable sector, another obstacle may be the "complexity of the procedures" required to recognise POs, approve operational programmes and gain access to financial support of the EU financial. Similarly, the perception "by producers of very high risks of losing the public financial aid" provided by rural development policies may represent a further obstacle (European Commission, 2014b).

According to the Report of the European Commission, European POs' expenditures on operational programmes (1,252 million euros, on average, between 2008 and 2010) were mainly devoted to improving product marketing and environmental actions, enhancing production planning and improving or maintaining product quality.

On the other hand, crisis prevention and management instruments introduced by the 2007 CMO reform to support the fruit and vegetable sector have been only minimally accessed by the European POs. This is likely because of the complexity of the procedures and the widespread small size of POs (European Commission, 2014b).

The European Commission also stresses that priority measures, such as research and experimental production, continue to be negligible. This means that these measures, that are strategic for having a stronger impact on competitiveness, income stability and market demand, need reinforcement of the application of the resources available.

3.4.5 Evaluation of the Italian F&V case study

For the evaluation of the Italian F&V case study, we carried out an analysis based on the Italian annual reports concerning the implementation of operational programmes during the period 2010-2014.

In 2014[34], there were 292 Italian POs in the F&V sector, with a marketed production value (MPV) of almost €6.2 billion. In all, 70,654 fruit and vegetable producers belong to POs, with production covering more than 340,000 hectares (table 2).

The southern area (South and Islands) shows the highest share of POs, accounting for almost 54% of all producer organisations. North-East accounts for 20% of POs, while Central and North-western areas have, respectively, 17% and 10% of POs.

Highly different is the distribution among the areas of the other variables (number of associated producers and MPV) taken into account. In this case the North-Eastern area concentrates more than half the national F&V MPVs and almost two thirds of producers belonging to POs. In the southern area the corresponding percentages amount to about 25% each.

These findings reflect the differences existing between the production and organised systems: in the southern area in the F&V system there is a limited tendency to join associations and the area also appears to be generally more fragmented than other areas and mainly made up of small and micro enterprises. In the Northern area, instead, cultural and historical factors, as well as a long tradition of cooperation, have influenced farmers' behaviour and their decisions to join POs, favouring the development of POs in this areas. These results confirm what was shown by previous studies on this subject (ISMEA, 2012; Bertazzoli and Petriccione, 2006).

To evaluate the overall objectives of the EU CMO for the Italian fruit and vegetable sector (see Table 7) we used the impact indicators calculated in annual reports. These indicators, compared to the baseline ones (**Table 10**), highlight an increase in the F&V area cultivated by PO members and, above all, of the production value, against a decline in the number of PO members. This positive dynamic of MPV affects all analysed areas, while the increase in the cultivated area mainly concerns the South of Italy. The trend in the number of associated producers instead is differentiated at the local level: North and South show a decrease in producers belonging to the POs while in the central and island areas they increase by more than 4%.

Other indicators taken in account concern the investment, based on the total expenditure incurred for actions within operational programmes (**Table 11**).

The total expenditure incurred by Italian POs in 2014 was about 415 million euros. The North-eastern area concentrates 58% of expenditure while the South and the islands account for less than 25%. Interestingly, the measure covering actions aimed at improving or maintaining product quality shows the greatest value of expenditure, totalling more than 130 million euros in 2014 (almost 32% of overall PO expenditure). Other major measures, by level of expenditure, comprise environmental measures and those to improve marketing and plan production. In 2014 more than 90% of total PO spending at national level is allocated to these four measures, with a major increase in the

[34] Latest available year of the annual reports.

expenditures concerned, except for environmental measures, during the period 2010–2014.

With regard to environmental measures (table 12), it is worth pointing out that all the geographical areas spent much more than the minimum threshold established by the Regulation (10%). POs of various regions (Lombardy, Sardinia, Puglia and Molise) show a strong tendency to invest in such actions at a much higher proportion than the national average (ISMEA, 2012). Expenditure on environmental measures is mainly accounted for by the integrated production measure, amounting to more than 38% of the total. These are considerable resources, which help members of POs to align with integrated production standards. The spread of these production methods helps to improve the environmental impact of activities and to enhance production value. Indeed, the environmental sustainability of production becomes increasingly frequently a criterion of consumer choice of fruit and vegetable products (Nomisma, Unaproa, 2016). In recent years the expenditure on this measure, as well as on the purchase of fixed assets, dropped while spending on action to conserve soil and, above all, favour energy saving, increased significantly between 2010 and 2014.

Table 10: Structure of POs (2014) and impact/baseline indicators

Area	Variables	2014	Var. % Impact indicator/ baseline indicator[1]
North-West	Number of POs	28	
	Marketed production value of the POs (EUR M)	848.5	26.8%
	Number of fruit and vegetable producers belonging to the POs	4,345.0	-15.4%
	Fruit and vegetable area cultivated by PO members (*ha*)	32,268.3	0.8%
North-East	Number of POs	58	
	Marketed production value of the POs (EUR M)	3,360.6	9.0%
	Number of fruit and vegetable producers belonging to the POs	44,106.0	-3.3%
	Fruit and vegetable area cultivated by PO members (*ha*)	162,470.2	-0.2%
Centre	Number of POs	49	
	Marketed production value of the POs (EUR M)	453.3	11.5%
	Number of fruit and vegetable producers belonging to the POs	5,391.0	8.5%
	fruit and vegetable area cultivated by PO members (*ha*)	35,595.7	4.5%
South	Number of POs	98	
	Marketed production value of the POs (EUR M)	1,038.0	37.3%
	Number of fruit and vegetable producers belonging to the POs	11,757.0	-9.7%
	Fruit and vegetable area cultivated by PO members (*ha*)	78,629.2	2.7%
Islands	Number of POs	59	
	Marketed production value of the POs (EUR M)	475.4	41.2%
	Number of fruit and vegetable producers belonging to the POs	5,055.0	13.7%
	fruit and vegetable area cultivated by PO members (*ha*)	35,160.2	4.7%
ITALY	Number of POs	292	
	Marketed production value of the POs (EUR M)	6,175.8	16.1%
	Number of fruit and vegetable producers belonging to the POs	70,654.0	-3.1%
	Fruit and vegetable area cultivated by PO members (*ha*)	344,123.5	2.3%

[1] The baseline indicators are three-year averages and reflect the situation at the beginning of each Operational Programme. For the calculation of the baseline/impact indicators, only the products (a) marketed by the PO / APO, (b) for which the OP / APO is recognized and (c) which are produced by members of PO, are taken into account.

Source: Authors' calculations from Italian Annual Reports on POs and operational programmes.

Table 11: Total expenditure incurred by operational programme measure/action (investment indicators) (euro)

		2014 (Euro)	%	var. % 2014/2010	Percentage of MPV
Nord-West	Actions aimed at planning production	5,817,102	1.4%	-21.9%	0.7%
	Actions aimed at improving or maintaining product quality	18,162,778	4.4%	12.7%	2.1%
	Actions aimed at improving marketing	10,052,099	2.4%	146.4%	1.2%
	Research and experimental production	2,906	0.001%	-83.2%	0.0%
	Training activities[1]	21,300	0.01%	-93.4%	0.0%
	Crisis prevention and management instruments	3,706,372	0.9%	218.3%	0.4%
	Environmental actions	7,533,599	1.8%	-32.3%	0.9%
	Other actions	800,720	0.2%	0.5%	0.1%
	Total expenditure incurred	**46,096,877**	**11%**	**12.2%**	**5.4%**
Nord-East	Actions aimed at planning production	42,975,236	10.4%	42.8%	1.3%
	Actions aimed at improving or maintaining product quality	67,450,934	16.3%	0.3%	2.0%
	Actions aimed at improving marketing	60,881,453	14.7%	12.5%	1.8%
	Research and experimental production	278,790	0.1%	-1.5%	0.0%
	Training activities[1]	567,722	0.1%	1262.7%	0.0%
	Crisis prevention and management instruments	19,193,933	4.6%	-15.1%	0.6%
	Environmental actions	48,325,867	11.7%	-28.0%	1.4%
	Other actions	2,569,451	0.6%	8.9%	0.1%
	Total expenditure incurred	**242,243,385**	**58%**	**-0.7%**	**7.2%**
Centre	Actions aimed at planning production	4,201,377	1.0%	77.4%	0.9%
	Actions aimed at improving or maintaining product quality	11,393,115	2.7%	24.2%	2.5%
	Actions aimed at improving marketing	4,896,886	1.2%	17.2%	1.1%
	Research and experimental production	-	0.0%	-	0.0%
	Training activities[1]	704,944	0.2%	3677.2%	0.2%
	Crisis prevention and management instruments	1,092,745	0.3%	241.0%	0.2%
	Environmental actions	5,129,344	1.2%	-18.9%	1.1%
	Other actions	523,637	0.1%	22.6%	0.1%
	Total expenditure incurred	**27,942,049**	**7%**	**22.5%**	**6.2%**
South	Actions aimed at planning production	14,349,849	3.5%	10.3%	1.4%
	Actions aimed at improving or maintaining product quality	21,787,747	5.3%	-12.5%	2.1%
	Actions aimed at improving marketing	12,030,214	2.9%	17.8%	1.2%
	Research and experimental production	-	0.0%	-100.0%	0.0%
	Training activities[1]	191,470	0.05%	75.3%	0.0%
	Crisis prevention and management instruments	3,455,323	0.8%	33.0%	0.3%
	Environmental actions	14,531,823	3.5%	-34.9%	1.4%
	Other actions	1,251,583	0.3%	-17.1%	0.1%
	Total expenditure incurred	**67,598,009**	**16%**	**-9.5%**	**6.5%**
Islands	Actions aimed at planning production	2,526,012	0.6%	54.9%	0.5%
	Actions aimed at improving or maintaining product quality	12,945,294	3.1%	70.2%	2.7%
	Actions aimed at improving marketing	5,857,540	1.4%	2.7%	1.2%
	Research and experimental production	27,000	0.01%	-	0.0%
	Training activities[1]	471,893	0.1%	4481.5%	0.1%
	Crisis prevention and management instruments	1,615,386	0.4%	91.0%	0.3%
	Environmental actions	6,773,730	1.6%	-11.3%	1.4%
	Other actions	531,614	0.1%	8.6%	0.1%
	Total expenditure incurred	**30,748,469**	**7%**	**28.6%**	**6.5%**
ITALY	Actions aimed at planning production	69,869,576	16.9%	28.1%	1.1%
	Actions aimed at improving or maintaining product quality	131,739,868	31.8%	5.3%	2.1%
	Actions aimed at improving marketing	93,718,193	22.6%	19.7%	1.5%
	Research and experimental production	308,696	0.1%	-12.9%	0.0%
	Training activities[1]	1,957,329	0.5%	291.3%	0.0%
	Crisis prevention and management instruments	29,063,758	7.0%	5.6%	0.5%
	Environmental actions	82,294,364	19.8%	-28.1%	1.3%
	Other actions	5,677,005	1.4%	1.7%	0.1%
	Total expenditure incurred	**414,628,789**	**100%**	**2.0%**	**6.7%**

[1] Other than in relation to crisis prevention and management.

Source: Authors' calculation from Italian Annual Reports on POs and operational programmes.

Table 12: Total expenditure incurred by environmental action (investment indicators) (euro)

Environmental actions			2014 (Euro)	Var. % 2014/2013	Var. % 2014/2010
a) Purchase of fixed assets			2,025,128	-45%	-60%
b) Other forms of acquisition of fixed assets			6,396,057	1296%	118%
c) Other actions	(1) Production	i) Organic production	419,056	-58%	-42%
		ii) Integrated production	31,766,440	-11%	-22%
		iii) Improved use and/or management of	3,714,338	5%	-52%
		iv) Actions to conserve soil	3,993,133	56%	51%
		v) Actions to maintain habitats favourable for biodiversity or to maintain the landscape, including conservation of historical features	979,759	-57%	7%
		vi) Actions favouring energy saving	3,119,571	867%	1213%
		vii) Actions related to reduction of waste production and improvement of waste	345,540	-43%	-98%
		viii) Other actions	25,594,226	2%	28%
	(2) Transport		3,798,433	-5%	112%
	(3) Marketing		142,682	-	-99%
Total e xpenditure incurred			**82,294,364**	**4%**	**-28%**

Source: Authors' calculations based on Italian Annual Reports on POs and operational programmes.

Furthermore, we used result indicators to evaluate the actions aimed at improving or maintaining product quality and responding to various specific objectives, as shown in **Figure 39**. These indicators have been calculated with regard to four different quality systems: certified organic production; PDO/PGI system; certified integrated production; and other quality certification.

The assessment analysis highlights, during the period 2010-2014, substantial percentage increases in F&V quantities produced under quality regimes (between +22.8% for certified organic produce and +36.8% for the PDO/PGI system), set against a very low growth of total MPV (only +0.8% at national level) (Table 13). These results are due to the high value of expenditures supporting this type of measure as shown above. Thanks to these performances in 2014 F&V products under quality regimes accounted for almost 50% of total production marketed by POs, against about 37% in 2010. Among the different regimes, certified integrated production ranks first with a share of 26.5%, thanks also to the national integrated production discipline. This is a major result because it complies with a viable and sustainable production vision. Generally, all quality regimes allow to pursue and satisfy the specific aims of improving competitiveness of the F&V sector to be pursued and met, protecting the environment and meeting consumer expectation.

A focus on geographical areas allows very different behaviours to be observed. The southern area shows the highest increase in certified integrated production marketed by POs, which doubled in the analyzed period, and other considerable percentages related to other quality measures. Islands, instead, experienced the highest increase in certified organic production (+52.7%), almost entirely citrus fruit, and a considerable percentage increase for certified integrated production (+41.6%). The North-Eastern area reveals the highest increases in other quality certifications, that is private certifications (+43.2%), and of the PDO/PGI system (+46.6%). At the same time in 2014 this area ranked top for certified integrated production in Italy (62% of the total), maintaining the Italian record already observed in 2010. F&V production grown with the integrated method in the North-east is not only the most extensive in Italy, but it also accounts for about 37% of the total production marketed by POs in this area. Moreover, it is worth noting that F&V production under the four quality regimes is about 72% of the entire F&V production marketed by POs in the North-east and that more than 60% of the national F&V quality production managed by POs comes from this area.

Table 13: Marketed fruit and vegetable production (total and by quality schemes) in baseline and result indicators (2014)

Area	Variables	baseline indicator[1] (tonnes)	Var. % result indicator/ baseline indicator
North-West	Total marketed production	1,071,746	-0.4%
	Certified organic production	27,510	-15.3%
	PDO/PGI system	33,267	0.0%
	Certified integrated production	398,246	5.8%
	Other quality certifications	192,281	15.7%
North-East	Total marketed production	5,143,816	-0.2%
	Certified organic production	157,615	20.9%
	PDO/PGI system	269,022	46.6%
	Certified integrated production	1,477,024	29.1%
	Other quality certifications	829,727	43.2%
Centre	Total marketed production	642,268	-18.5%
	Certified organic production	11,758	0.0%
	PDO/PGI system	17,819	0.0%
	Certified integrated production	197,432	0.0%
	Other quality certifications	36,551	6.1%
South	Total marketed production	2,652,622	4.5%
	Certified organic production	53,662	31.9%
	PDO/PGI system	20,022	29.3%
	Certified integrated production	236,634	119.2%
	Other quality certifications	196,326	22.4%
Islands	Total marketed production	1,998,216	5.1%
	Certified organic production	37,416	52.7%
	PDO/PGI system	29,798	16.6%
	Certified integrated production	21,933	41.6%

	Other quality certifications	30,299	5.4%
TOTAL ITALY	Total marketed production	11,508,668	0.8%
	Certified organic production	287,961	22.8%
	PDO/PGI system	369,929	36.8%
	Certified integrated production	2,331,268	31.9%
	Other quality certifications	1,285,184	34.0%

Source: Authors' calculations from Italian Annual Reports on POs and operational programmes.

These findings allow some considerations to be made. POs and their organised system play an important role in improving and enhancing product quality, as well as in pursuing the environmental sustainability of F&V production. They prove to be the most suitable subjects for these purposes, thanks to their action coordinating a plurality of different subjects (associated farmers) towards common objectives and strategies aimed at product enhancement and improving eco-friendly cultivation techniques. Their function requires sharing codified and formalized rules. POs aim to strengthen the competitiveness of the sector by pooling F&V output, sharing their interest in pursuing product quality and making it recognizable on the market, supporting innovation, increasing productivity and improving the bargaining position of farmers in the F&V supply chain. Nevertheless, POs also contribute to the integration of environmental concerns in F&V production and marketing. Moreover, it seems that long-standing cooperation areas, as some North-eastern empirical evidence demonstrates (e.g., the Apple Production System in the Region of Trentino-Alto Adige, and the Tomato Processing District in Northern Italy), best address the combined issues of quality and eco-friendly production. This means that POs and their organised system could be a suitable tool to match competitive aims with environmentally sustainable goals, and then enhance farm viability and sustainability.

3.4.6 Conclusions and recommendations

Pillar I instruments and other measures from Pillar II and Horizontal Regulation contribute to pursuing the CAP objective "***viable food production***", in order to enhance farm viability.

Among them it seems that POs and their organised system are well targeted as tools to steer the income of farmers and the functioning of the food chain towards an environmentally sustainable basis. In order to evaluate this kind of instrument we have chosen to analyse, as a case study, fruit and vegetables, the most long-standing experienced sector in POs. The 2007 CAP reform for fruit and vegetables provided essential elements, confirmed by the CAP 2014-2020, to reinforce POs, giving them strategic functions to improve competitive capacity in the sector.

Through operational programmes, co-financed by EU funding, POs take on a strategic role in coordinating actions aimed at planning production, improving product quality and marketing as well, and environmental actions. In particular, product quality, private standards and other certifications are strategies aiming at increasing the economic value of products. This "*may lead to gain a position of advantage in the market, which means that POs have to take the behaviour of buyers into account*" (European Parliament, 2011). Environmental concerns are also focused by CAP provisions for the F&V sector, the reason why POs are required to include a minimum level of environmental spending in their operational programmes.

F&V was the first sector in agriculture where EU policy dealt with the competitiveness and market-orientation objectives in an environmentally sustainable way.
Our evaluation of the Italian F&V case study shows that PO expenditures on operational programmes are mainly devoted to actions aimed at improving product marketing and environmental concerns, enhancing production planning and improving or maintaining product quality. These findings confirm what was already observed by the European Commission in its Report on the EU F&V regime (2014b). More specifically, the four quality regimes (certified organic production, PDO/PGI system, certified integrated production, and private quality certification) taken into account within operational programmes allow the specific objectives of improving competitiveness of the F&V sector to be pursued and fulfilled, protecting the environment and meeting consumer expectation.

Thanks to their coordination action also in relation to common strategies towards merging farmers' interests, POs and their organised system prove to be the subjects best suited to achieving the purposes of enhancing product quality and improving environmental sustainability of F&V production.

The long-standing experience of POs in the F&V sector suggests some recommendations in order to reinforce their strategic role in contributing to enhance farm viability and sustainability. This regards all agricultural sectors to which the last CAP reform extended the possibility to build up POs.

Some suggestions could involve strengthening the market-oriented role of POs and supporting the innovation and internationalisation processes in which they are involved.

Furthermore, in order to promote a qualitative development of POs, it could be necessary to support investments in training measures for PO managers, also in order to acquire "the necessary skills for carrying out commercial activities in the competitive environment" (Melo, 2015). Nevertheless, we also agree with the suggestion of calling on the European Commission "to intensify efforts to tackle unfair trading practices in the food supply chain which negatively impact producer returns, depress incomes and threaten the viability and sustainability" of the agricultural sector (Melo, 2015). In our opinion this is a key point, because clear principles of good practices in the food supply chain enable POs to really carry out their role in establishing a countervailing power in food chain relationships and strengthening the position of farmers in the market.

CONCLUSIONS

Improvements in agriculture productivity growth are required to meet the growing demand for food, feed, fuel and fibre, and must be achieved sustainably through the more efficient use of natural and human resources. This concept - known as '**sustainable intensification' - SI** - entails improving resource efficiency in agriculture i.e. improving productivity whilst reducing the negative environmental impacts of agriculture (leakage of nutrients, emissions, soil erosion, loss of biodiversity) and improving the provision of public goods.

Productivity analysis based on an accurate measurement of agricultural **total factor productivity (TFP)** is critical to identify areas for improving agricultural policies that have potential to influence agricultural productivity growth in the long term. These include building capabilities, such as investing in R&D (to increase the supply of innovations), education and training (to increase farmers' capacity to innovate and adopt innovations) and provision of farm extension and financial services (to encourage adoption of innovations). Most existing metrics of agricultural productivity, however, do not fully account for the use of environmental goods and services in agricultural production, thus providing only limited means for assessing the long-term sustainability of agricultural productivity growth. The approach that we have adopted for monitoring progress towards sustainability relies on the concept of resource productivity i.e. the effectiveness with which a production process uses natural resources. A first group of countries (Netherlands, Germany, Denmark) have had a positive trend in agricultural output, explained by gains in agricultural area and in TFP and, at the same time, have reduced their unit GHG emissions and nitrogen surplus per hectare. Still, the indicators used to monitor the natural asset base (bird population and presence of permanent pastures) have a negative trend. The analysis of some policy drivers at the national level can provide useful insights: in particular, the higher investment in R&D, the lower average age of farmers, the use of economic instruments as pollution taxes on environmentally-damaging inputs. In most cases, the aging of agricultural managers and the lower rate of expenditure in R&D can in part explain these trends and help identify main areas for policy response.

The extent to which farmers will adopt sustainable farm practices strongly depends on the policy framework that is in place. **Policy coherence, at EU level as well at local level, appears to be a key factor in inducing sustainable growth strategies. Policy regimes, besides CAP implementation, differ to a large extent across MS.** Fiscal regimes for R&D show a strong heterogeneity in MS legislation and evidence about their real impact is controversial. Few MS have levied taxes on farm input as an instrument to address environmental issues.

The efficient use of resources is a key priority for sustainable growth strategies. **Farm practice and adoption of new technologies that increase productivity, sustainability and resilience of agricultural systems should be encouraged**. The same applies to research and policy developments aiming at the same goals. Besides, how much diverse policy and a technology approach will deliver needs to be tested and assessed, taking biophysical and social contexts into account (Garnett et al., 2013).

Policies for improving productivity and resource efficiency involve **quite** a **large range of instruments** that are consistent with the objective of increasing productivity sustainably and that go from traditional regulatory approaches to a much wider set of tools including information and education, R&D cooperation, technology and innovation. Because the intensity and sustainability of agricultural systems vary from site to site depending upon location, farming system and individual farms, in order to steer agricultural systems towards SI, **agricultural and regional development policy needs to incentivize the uptake of site-adapted strategies.** Farmers are often risk-averse to new developments, do not fully include environmental outcomes in their decision-making process or lack knowledge on favourable management options (Buckwell et al., 2014). Policy can incentivize change in the **levels of actions, behaviours and investments**. An important framework around the set of economic incentives should be different measures that address the level of motivations and **incentivize a behavioural change** in regional actors. This can be achieved in two ways: on the one hand, a set of rules and regulations need to be set up to restrain unwanted actions through penalties and sanctions. Rules should be transparent and objectives need to be clear in order to achieve a far-reaching consensus on the overall benefits. The second, and much more relevant part to achieving long-lasting behavioural change, is the **role of information instruments that aim at intrinsic persuasion** through communication as well as intellectual and moral appeals (Zasada et al., 2012). Implementation of SI needs promotion, communication and knowledge transfer to change intrinsic persuasions and incentivize action. Several SI strategies need larger **investments** in order to be started. On the farm level this often involves new technologies. On the landscape level investments in infrastructure are needed to make progress towards SI.

Having an adequate legal framework is essential to the development of new technologies: though Europe’s plant breeding industry and research have been very active, carrying out more than 50% of world research, the EU regulatory framework appears to be inadequate with regard to new breeding techniques.

The CAP has changed in the last few years, shifting from product support to targeting producer behaviour. In this process, greening has been a specific objective fulfilled along a long path from the MacSharry reform to the most recent 2014-2020 CAP reform. The latest CAP reform tried to address the greening of the CAP with specific targeted measures. However, preliminary results and indicators show that **the impact of such measures is relatively low, especially due to the many exceptions and exemptions to the rules occurring as a compromise for the political acceptance of the reform and to the great flexibility given to Member States to implement the reform.** In general, a slow but progressive shift is evident in the process of CAP reform from trade-off policies (production vs. environmental impact) to win-win policies, which can work within the sustainability framework, retaining both production goals and ensuring sustainable management of natural resources. In spite of the declared intentions, a large part of the EU agricultural area has been excluded from the requirements of ecological payments (product diversification; pasture maintenance and ecological focus areas): permanent crops, organic farming, small farmers, and other cases, are all considered green by definition (Henke and Vanni, 2014). Most MSs have not fully used the flexibility offered by the regulations to increase the environmental impact of the reform (Hart, 2016).

Research and innovation are considered key factors in fostering green growth in agriculture as in the whole economy, as stated in the EU’s growth strategy for 2020. The new technologies applied to farming, such as remote sensing and robots, go in this direction. The rationale for policy actions to foster eco-innovation rests on well-known market failures that concern underinvestment from the private sector and weak market signals to internalise/avoid environmental externalities. Within this context agriculture presents a sectoral specificity due to factors such as, among others, adequate farmer level of education and training, and access to credit in the case of high initial investment required. The **‘European Innovation Partnership’ (EIP)** is the approach proposed by the EU with the objective of accelerating the adoption of research findings together with the development of research and innovations. The assessment pursued in this study found that legislation, both at European and national level, should address **some financial issues that have been identified as elements that can discourage farmers' participation**, namely lack of advance funding, lack or difficult reimbursement of farmers' work (identified in some countries) within the OGs. The importance of having **cross-border OGs** has been strongly highlighted in a number of countries. They would help avoid duplications of topics addressed but also strengthen links among actors of agricultural and knowledge systems in different EU countries as well as within countries. When planning EIP OG implementation rules and procedures, particular effort should be made to reduce the **complexity of administrative procedures**. This complexity was identified as one of the main issues that discourage farmers' participation. Other recommendations regard the strategic **role of advisors and innovation brokers** together with the **role of networking that** should be strengthened. Better interactions between the EU and national levels can improve links among actors of national AKI systems, dissemination of innovative solutions and knowledge exchange.

In the **assessment of CAP instruments to promote viable food** production it emerges that POs and their organised system are well-focused as a tool to contribute to the improvement of farmers' income and of the functioning of the food chain on an environmentally sustainable basis. The case study of the Italian F&V shows that POs' expenditures on operational programmes are mainly devoted to actions aimed at improving product marketing and environmental concerns, enhancing production planning and improving or maintaining product quality. The quality regimes (certified organic production, PDO/PGI system, certified integrated production, and private quality certification) taken into account within operational programmes allow the specific objectives of improving competitiveness of the F&V sector to be pursued and fulfilled, protecting the environment and meeting consumer expectations. The assessment analysis highlights, during the period 2010-2014, **major percentage increases in F&V quantities produced under quality regimes** (between +22.8% for certified organic produce and +36.8% for PDO/PGI system), against a very low growth of total MPV (only +0.8% at national level). F&V products under quality regimes account for almost 50% of total production marketed by POs, against about 37% in 2010. The long-standing experience of POs in the F&V sector suggests some recommendations that could be effective for all agricultural sectors, to which the last CAP reform has extended the possibility to build up POs. These regard the **strengthening of the market-oriented role of POs and supporting POs innovation and internationalisation processes**.

Moving the EU agenda towards the circular economy[35] can boost sustainable growth in agriculture and forestry, by placing resource-efficiency at the centre of economic decision making and practice, ensuring added value and making sure that resources are maintained as long as possible so that they can be re-used. A more circular approach to the economy would help reduce waste and costs, preserving and enhancing natural capital by balancing renewable resource flows, and optimising natural resource yields.
Moving towards a circular (bio)-economy could help create new and diverse incomes and jobs by using new resources and opening up new markets, reducing exposure to risk from commodity prices or changes in policy, reducing costs through more sustainable resource use and making more of waste resources. And, thus, in the end, building a more resilient agriculture.

[35] Closing the loop - An EU action plan for the Circular Economy COM/2015/0614 final.

This calls for increased linkages and dialogue between people and sectors together with higher coherence at the policy level. But it also requires investments, at financial level to support the development of new ideas and the creation of new markets.

Future policy reforms will need to move along three main directions:

1. **Better targeting and qualification of the whole process of greening**: this has probably been the most criticized component of the latest reform so far. At the moment greening has been designed and implemented mainly as a form of legitimization of the status quo rather than as a strategy to make public intervention more sustainable. In the next round of reforms, better integration among the agro-environmental components of both pillar is to be pursued, at the same time enhancing a territorial and systemic approach rather than establishing horizontal rules applying to single farms.
2. **Enhancing the integration among objectives and tools, in the framework of win-win policies**. As admitted by the same Commission, the direct and indirect effects among objectives and tools of the CAP currently create a complex net of relationships that often end up increasing the trade-offs rather than focusing on how they might be superseded. A fuzzy hierarchy of objectives and a stratification of mandatory and voluntary instruments, some of which come from far in the past history of the CAP and others added more recently, increase the conflicts and reduce the synergies in favour of an SI.
3. **Moving effectively towards simplification and better communication**: simplification of tools and access to resources for farmers, and communication about the real and concrete advantages of being part of a "system", going from research and innovation labs to the fields and involving the whole supply chain. At the moment, in spite of the fact that the CAP is one of the most generous public policies, it is perceived by both farmers and citizens as a burden rather than a resource: by the farmers because they have internalized the support in their income expectations and do not see it as a participatory negotiating process; by the citizens, because they often see it as a huge flow of resources in favour of a marginal component of the economy, not addressing the real problems of contemporary society. Much more work needs to be done in this direction in spite of the efforts of the EU institutions. Farmers need to feel more involved and that they form an essential part of an economic, social and environmental system, with rights and duties, while citizens need to feel reassured with practical evidence that green growth is not just a theoretical justification of the status quo, but rather a new and better way to plan the future.

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ANNEX I: TOTAL FACTOR PRODUCTIVITY MEASUREMENT

Agricultural productivity measures the ability of a production unit (i.e. field, farm, or industry) to convert economic and natural inputs into outputs. In absolute terms TFP represents the status of technology and efficiency in production. When it is expressed as change, it measures technological progress (Jorgenson et al. 2005).

Both TFP levels and its growth are useful indicators. Approaches for measuring TFP fall into two main classes: parametric and non-parametric (Griliches, 1996). The parametric approach involves econometric modelling of production functions and often uses regression techniques to estimate the relationships between total output and major types of inputs, like land, labour, capital, and intermediate inputs. Once the output that can be attributed to the inputs is determined, the residual (unexplained) output from these regressions can be used as a measure of TFP. One of the major non-parametric approaches is "growth accounting", in which output and input prices are used to aggregate quantities to form a ratio of total output to total input, which is defined as TFP (Fuglie et al., 2016). This is the basis for constructing *Toȑnqvist-Theil (or simply "Toȑnqvist")* and Fisher Indices described below.

Conceptually, TFP is the ratio of gross output to total inputs while TFP growth is the difference between the rate of change in gross output and the rate of change in total input .

$$\text{TFPt} = Yt\ /Xt \qquad (1)$$

$$\Delta T\text{FP}t/\ T\text{FP}t = \Delta Yt/Yt - \Delta Xt/Xt \qquad (2)$$

where $T\text{FP}t$ represents the level of total factor productivity, Yt measures the total quantity of output, and Xt measures all inputs used at time t.

The terms $\Delta T\text{FP}t$, ΔYt, and ΔXt represent the rates of change of these measures over time. Using Equations (1) and (2) to estimate agricultural TFP level and growth, one needs to aggregate various outputs and inputs in a consistent way. A common practice is to sum over outputs and inputs using the corresponding prices (or revenue/cost shares) as weights based on an index formula (Diewert, 1992). Ball et al. (1997b, 2001, 2010, 2015) and Sheng et al. (2013) attempt to provide harmonised cross-country agricultural TFP levels using national account data from the U.S. and other OECD countries. Fuglie (2010a, 2012, 2015) used a version of the growth accounting method applied to FAO data to compare agricultural TFP growth among 172 countries between 1961 and 2012. To obtain price weights for aggregating outputs, he used the FAO estimate of average global prices for agricultural commodities from 2004-2006. For input prices, he drew from country-level case studies, where available, to construct cost shares for major input categories like land, labour, capital and materials. Where unavailable, he used country-level evidence to construct regional average cost shares or econometrically estimated input elasticities for the cost shares (Fuglie et al., 2016). TFP indices were also constructed for global regions and the world average. Annual updates of these indices are available on the USDA's Economic Research Service's website (Fuglie et al.2015). This database has been used in this report.

Average annual output growth

Country	1961-70	1971-80	1981-90	1991-00	2001-10	2003-12
Austria	0.012	0.012	0.000	0.008	0.006	0.005
Belgium-Luxembourg	0.021	0.004	0.017	0.017	-0.009	-0.003
Denmark	-0.003	0.018	0.012	0.010	0.004	0.003
Finland	0.009	0.008	-0.006	-0.003	0.000	-0.004
France	0.015	0.012	0.004	0.007	-0.007	-0.003
Germany	0.019	0.009	0.002	0.002	0.005	0.007
Ireland	0.019	0.032	0.016	0.007	-0.004	-0.002
Netherlands	0.032	0.033	0.014	-0.002	0.010	0.016
Sweden	-0.007	0.016	-0.010	0.005	-0.009	-0.007
United Kingdom	0.014	0.015	0.005	-0.004	0.001	0.002
Cyprus	0.072	-0.017	0.018	0.011	-0.030	-0.030
Greece	0.027	0.030	0.008	0.008	-0.019	-0.021
Italy	0.020	0.015	-0.003	0.003	-0.002	-0.006
Malta	0.025	0.011	0.022	0.035	-0.009	-0.010
Portugal	0.002	-0.004	0.020	0.007	0.001	0.004
Spain	0.024	0.028	0.017	0.027	-0.001	-0.001
Bulgaria	0.039	0.013	-0.009	-0.038	-0.011	0.008
Czechoslovakia, former	0.027	0.013	0.011	-0.030	-0.008	-0.010
Hungary	0.027	0.028	-0.001	-0.015	-0.012	-0.017
Poland	0.021	0.003	0.010	-0.011	0.002	0.006
Romania	0.034	0.040	-0.019	-0.006	-0.002	-0.006

Average annual TFP growth

Country	1961-70	1971-80	1981-90	1991-00	2001-10	2003-12
Austria	0.004	0.015	0.012	0.024	0.022	0.015
Belgium-Luxembourg	0.010	0.022	0.018	0.024	0.002	0.006
Denmark	-0.007	0.021	0.020	0.032	0.022	0.023
Finland	-0.010	0.018	0.017	-0.014	0.018	0.016
France	0.001	0.014	0.010	0.018	0.015	0.017
Germany	0.017	0.008	0.023	0.015	0.019	0.019
Ireland	-0.002	0.017	0.027	0.001	0.001	-0.002
Netherlands	0.027	0.014	0.010	0.015	0.020	0.028
Sweden	-0.012	0.019	0.013	0.012	0.009	0.006
United Kingdom	0.017	0.009	0.008	0.000	0.009	0.007
Cyprus	0.045	0.011	0.024	0.029	-0.007	-0.003
Greece	0.006	0.020	0.009	0.012	0.000	0.000
Italy	0.025	0.017	0.008	0.021	0.032	0.026
Malta	0.031	-0.019	0.046	0.027	0.011	0.000
Portugal	-0.004	-0.036	0.027	0.012	0.027	0.024
Spain	0.005	0.036	0.014	0.025	0.017	0.020
Bulgaria	0.002	0.002	0.002	0.004	0.015	0.028
Czechoslovakia, former	0.006	0.002	0.020	-0.001	0.018	0.008
Hungary	-0.001	0.017	0.013	-0.010	0.010	0.003
Poland	-0.011	-0.007	0.015	0.001	0.004	0.013
Romania	-0.013	0.009	-0.013	0.010	0.009	0.005

Fuglie (2015) provides a decomposition of growth in output into the relative contribution of TFP and inputs. Using g(Z) to signify the annual rate of growth in a variable, the growth in output is simply the growth in TFP plus the growth rates of the inputs times their respective cost shares (S): ☐

$$g(Y) = g(TFP) + \sum S_j \, g(X_j) \quad (3)$$

Focusing on a particular input, i.e. land (designated as X_1), it is possible to decompose growth into the component due to expansion in land area and the change in yields:

$$gY = g(X_1) + g(Y/X_1) \quad (4)$$

This decomposition corresponds to what is commonly referred to as extensification (land expansion) and intensification (land yield growth). Yield growth can be further decomposed into the share due to TFP and the share due to using other inputs more intensively per unit of land:

$$gY = g(X_1) + g(TFP) + \sum_j g(X_j/X) \quad (5)$$

2003-12 Growth Partition I

Country	Output	Labour	Land	Livestock	Machinery	Fertiliser	Feed	TFP	Total Inputs
Austria	0.005	-0.034	-0.002	-0.002	0.000	-0.011	0.003	0.015	-0.010
Belgium-Luxembourg	-0.003	-0.025	-0.003	-0.004	0.000	-0.016	0.004	0.006	-0.009
Denmark	0.003	-0.036	0.006	-0.007	0.002	-0.034	-0.011	0.023	-0.019
Finland	-0.004	-0.037	0.000	-0.009	0.005	-0.041	-0.005	0.016	-0.020
France	-0.003	-0.046	-0.002	-0.006	-0.002	-0.031	-0.004	0.017	-0.021
Germany	0.007	-0.043	0.001	-0.002	-0.004	-0.013	0.010	0.019	-0.011
Ireland	-0.002	-0.014	-0.007	-0.008	0.005	-0.020	0.031	-0.002	0.000
Netherlands	0.016	-0.024	0.009	0.010	0.000	-0.050	0.022	0.028	-0.012
Sweden	0.002	-0.019	-0.012	-0.009	0.000	-0.034	-0.004	0.018	-0.015
United Kingdom	-0.007	-0.022	-0.004	-0.011	0.000	-0.020	-0.010	0.006	-0.013
Cyprus	0.002	-0.011	0.004	-0.012	-0.001	-0.022	-0.001	0.007	-0.006
Greece	-0.030	-0.031	-0.029	-0.016	-0.001	-0.086	0.010	-0.003	-0.027
Italy	-0.021	-0.030	-0.003	0.003	0.018	-0.045	-0.018	0.000	-0.021
Malta	-0.006	-0.040	-0.009	0.004	-0.017	-0.071	-0.008	0.026	-0.032
Portugal	-0.010	0.000	0.021	-0.032	0.019	-0.045	-0.043	0.000	-0.011
Spain	0.004	-0.029	-0.025	-0.003	0.002	-0.046	0.004	0.024	-0.020
Bulgaria	-0.001	-0.033	-0.006	-0.009	0.021	-0.038	-0.015	0.020	-0.021
Czechoslovakia. former	0.008	-0.090	-0.004	-0.045	0.096	0.080	-0.032	0.028	-0.020
Hungary	-0.010	-0.059	-0.005	-0.028	-0.001	0.000	-0.004	0.008	-0.019
Poland	-0.017	-0.034	-0.007	-0.027	0.026	-0.030	-0.032	0.003	-0.020
Romania	0.006	-0.023	-0.015	-0.017	0.022	0.016	0.006	0.013	-0.007

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