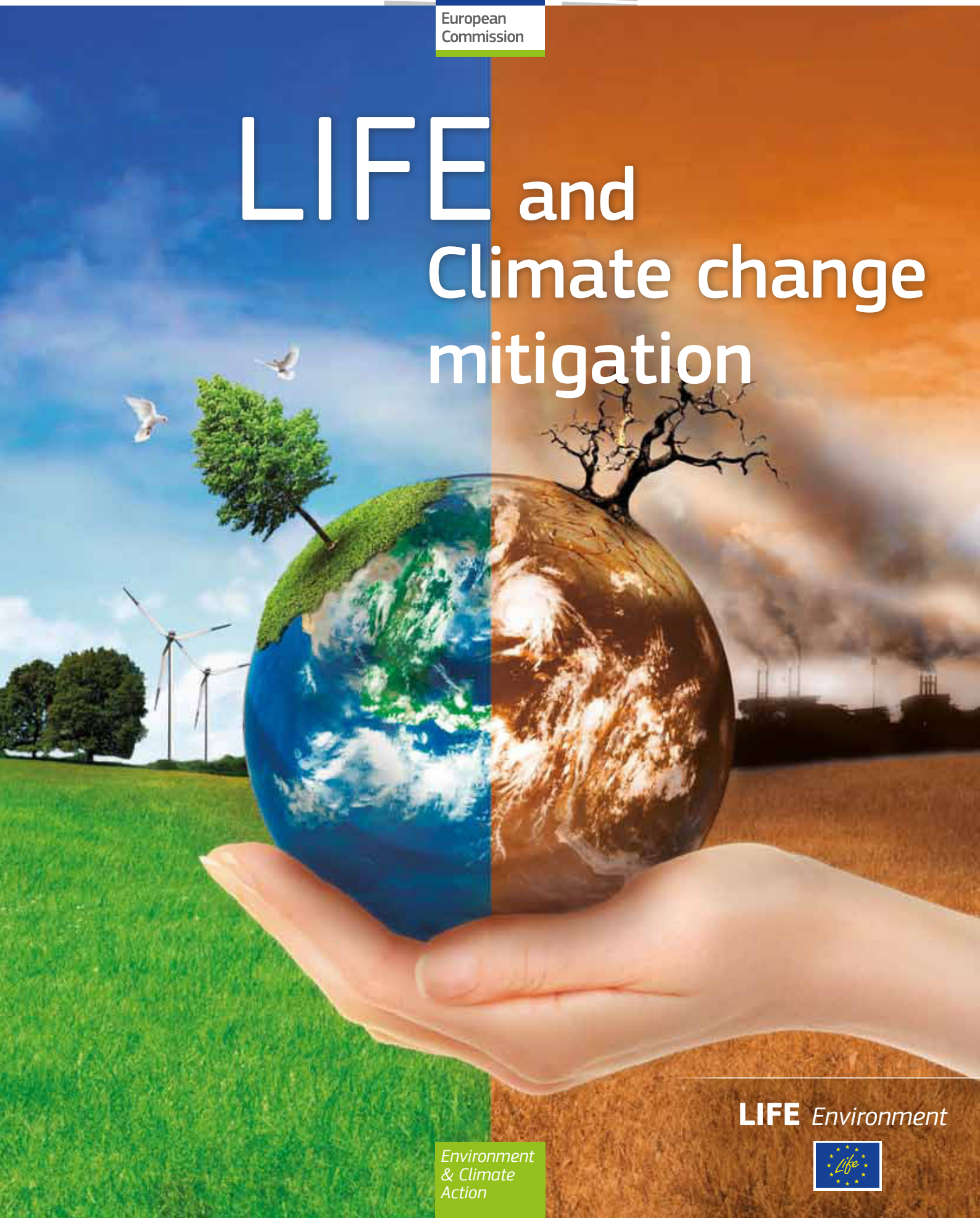
European Commission

LIFE and Climate change mitigation



LIFE *Environment*

Environment & Climate Action

AGRICULTURE & FORESTRY

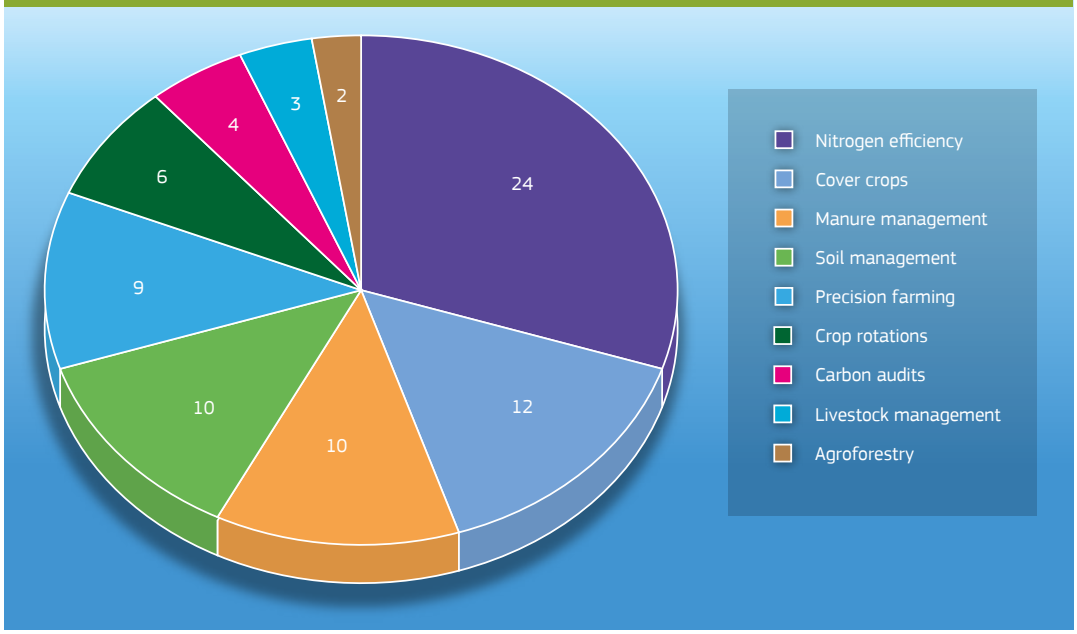
LIFE and **farm-based climate action**

Agriculture holds many opportunities to be a major force for mitigating climate change and LIFE co-funding has been used well by Member States to demonstrate this.

More of the EU's land is used for agriculture than for any other purpose. Europe's farmlands act as highly important carbon pools. Farms can therefore be a significant source of greenhouse gas (GHG) emissions and so all Member States recognise the long-term value of adopting sustainable approaches to the production of our food, fibre, and energy from farmland.

Data from the European Environment Agency highlight that in 2012, CH_4 and N_2O emissions on EU farms accounted for 469 $MtCO_2e$, or approximately

Fig. 1: **Agriculture & Foresty projects (1999-2012)**



Source: LIFE database

10% of total EU28 GHG emissions. Farms therefore are a high priority for climate action and Figure 1 illustrates the breakdown by source in order of importance.

Agri-climate challenges

The challenge for the agriculture sector is how to reduce GHG emissions - and overall environmental performance - at the same time as meeting the need for increased production in order to keep pace with growing global food and energy demand.

Agriculture is, however, one of the few sectors that can both contribute to mitigation and sequestration of carbon emissions. It also can contribute indirectly to emission reductions in other sectors through the supply of biomass for the production of bioenergy and renewable materials. However, it is hard to quantify GHG emissions from agricultural activities: the atomistic nature of production (many individual farmers) in a wide range of geographic and climatic conditions means that emissions are not only highly variable but also difficult and costly to measure precisely.

National and EU support is available to help meet the challenges outlined above and, in particular, to facilitate on-farm investment in climate action. One of the largest support sources is the Common Agricultural Policy (CAP), which combines EU funds with national co-finance and includes scope to encourage more sustainable agricultural practice. So-called 'direct payments' through Pillar 1 of the CAP for instance, have recently increased their emphasis on mandatory environmental standards that assist mitigation. Rural Development Programme (RDP) aid, through Pillar 2 of the CAP, has also put in place strong new priorities (including compulsory elements) for tackling climate challenges.

Agri-climate opportunities

There are a number of farming practices that have the potential to reduce GHG emissions below current levels. Methane and nitrous oxide emissions can be cut by optimising nitrogen application or precision farming, as well through livestock management and improving manure management (storage and production of biogas). Carbon losses can be reduced by maintaining and optimising carbon levels. Ways to achieve this include proper soil management (conservation agriculture, no tillage, maintenance of soil cover, protection of organic matter in carbon-rich soils, restoration of peatlands, grasslands and degraded soil) and land management (diversifying crop rotations, conversion of arable land to grasslands, organic farming, afforestation).

The mitigation potential of soil and land management practices varies considerably, but overall they have the advantage of being readily available and low-cost (no advanced technology). Other ways in which agriculture can contribute to CO_2 emission reductions include: modernising farms to use more energy-efficient equipment and buildings; providing support for the production and use of renewable energy; and offering compensation for extra costs incurred by farmers who voluntarily help protect the environment (agri-environment climate schemes).

Climate mitigation in EU agri-climate policies

Mitigating GHG emissions is a core objective of EU agri-climate policies, which focus on three main GHGs:

- Methane (CH_4) – this gas is created by ruminant livestock (mainly cattle, sheep, and goats) and methane is also released as farm manure decomposes.
- Nitrous oxide (N_2O) – these emissions occur when manure and synthetic fertilisers are applied to land. Livestock urine is another source of agricultural N_2O.
- Carbon dioxide (CO_2) – agri-energy use is a key driver of CO_2 emissions from farms but land use change (ploughing, crop choice etc.) also affects the ability of agrarian areas to fix and store carbon.

Monitoring the use of natural zeolites that reduce ammonia release from fertilisers

Photo: LIFE10/ENV/IT/000321/Massimo Coltorti

Training, knowledge exchange and advisory services play vital roles in implementing such actions. These should be further promoted by (and between) Member States in ways that help reduce GHG emissions. Awareness needs to be raised amongst food producers and land managers about how they can help themselves and others to reduce emissions and increase carbon storage.

Farmers should also be made more aware of the economic advantages that such mitigation opportunities offer for them – particularly from savings in costs, management, and/or maintenance inputs, as this is another incentive for change towards climate-friendly agricultural practices.

LIFE's role

LIFE co-financing has been used by Member States to test and demonstrate a valuable collection of new climate-action methods and mitigation techniques in the aforementioned areas. Many useful lessons have been learnt across rural Europe and successful project outcomes continue to be incorporated into today's climate-friendly farm practices.

LIFE projects dating back to the 1990s have produced helpful reductions in GHG emissions even if, in most cases, this has been an indirect consequence of actions aimed at implementing the Water Framework Directive or other environmental policies.

The AGRICARBON project showed how precision and conservation agriculture techniques can contribute to GHG emission reductions

Photo: LIFE08/ENV/E/000129

Increasing nitrogen efficiency

LIFE has funded over 20 projects targeting nitrogen efficiency in agriculture that have produced multi-purpose environmental outcomes. In the Petrigano project for example, a programme of work was launched in 2000 demonstrating agronomic techniques where nitrogenous fertilisers were adapted to specific cultivation objectives, soil types and type of crop. A farm-by-farm and crop-by-crop calculation achieved a reduction of 50%, without reducing the yield. Such findings remain relevant for Europe's air, water, biodiversity, and climate simultaneously The use of zeolites that significantly reduce the release of unused nitrates from fertilisers are being shown by two LIFE projects (ZeoLIFE, UNIZEO).

Other examples of multifunctional outcomes from earlier LIFE projects include AGRI-PERON's satellite techniques for helping farmers to adopt tailored practices, and thereby reduce their nitrogen inputs. LIFE has highlighted the value of applying real-time monitoring data to establish a farm's ideal nitrogen requirements (OptiMaN). This approach has attracted the interest of policy-makers, since LIFE project results showed that nitrate usage levels on EU farms may be overestimated (and thereby reduced) by as much as 30%.

When climate issues became a strategic priority for LIFE in 2007, agricultural projects started to be aimed more directly at climate matters. Nitrogen management continued to be pivotal for much of LIFE's agricultural portfolio, as it moved from profiling general good practices to more targeted methods for minimising N_2O emissions from specific types of farms, crops, and soils.

This can be seen in modern-day projects such as IPNOA, which is demonstrating new opportunities for measuring N_2O fluxes in farm soils. The IPNOA team is testing a portable tool to identify emission levels from different soils at farm level, and a complementary technology is increasing knowledge about emission variability across wider-scale agri-ecosystems. Project results due in 2016 are predicted to help reduce emissions by as much as 20% from their baseline position.

Improving agriculture's ability to quantify emission levels, carbon storage, and mitigation impacts is highly important for agri-climate projects, programmes, and policies. One of LIFE's most promising sets of results in this area has been achieved

by the AgriClimateChange project (see p.65). This project's toolkit can measure an individual farm's carbon footprint and monitor and quantify emission effects from mitigation measures, as well as incorporating a much-welcomed cost-benefit analysis of the mitigation options for individual farms.

Livestock management

Rising methane (CH_4) emissions are caused by the expansion of livestock farming as a reaction to growing global demand for meat and dairy products. The bacteria that help cattle and sheep digest their food produces CH_4, a powerful greenhouse gas which returns to the atmosphere, contributing to global warming. Alongside extensive forms of pasture management in livestock rearing, breeding and the use of additives to reduce methane emissions, one possible solution to this problem is to change the nutrition patterns of livestock – diet and the timing of food intake influence methane release from ruminants and manure.

LIFE could help identify methods (LIFE Carbon Dairy), support and advisory needs to fill this knowledge gap through more work with farmers and livestock nutrition experts. Importantly, the programme could improve awareness-raising campaigns to advise farming communities of changes that they will be expected to help deliver, such as the need to make use of low-protein feeding strategies for livestock.

Managing manure

Many of LIFE's agricultural projects in the livestock sector address emissions from manure. These waste products have an important role to play in mitigating climate impacts because using manure instead of synthetic fertilisers can decrease N_2O emissions from farms, as well as from fertiliser manufacturing.

On the other hand, manure emits ammonia (NH_3), which breaks down to become GHG. LIFE projects have therefore not just concentrated on highlighting how manure can be used as a cost-effective organic fertiliser, but also how it can be used more reliably through techniques such as 'precision farming'. LIFE projects in this area often have the co-benefit of improving air quality. Indeed, LIFE's manure management knowledge-base represents a mutually useful reference resource for both climate action, and informing the codes or standards proposed by the EU's National Emission Ceilings Directive.

LIFE09 ENV/IT/000214

GAS-OFF

This LIFE project developed good practices for reducing methane from Italian dairy farms by calculating emissions associated with particular diets and specific husbandry methods. Different parts of dairy farms (feeding alleys and resting areas) were shown to produce different GHG emissions and a practical set of mitigation solutions were demonstrated through relatively easy-to-apply husbandry changes.

"We found that the cows' resting areas have major emissions of GHG so it is important to remove frequently the straw and also to clean the floor surfaces," explains Frederica Borgonovo from the GAS-OFF team.

Using rubber floor matting in cattle barns was shown to help reduce emissions because farmyard scrapers can clean a matted floor better than a concrete surface.

Additionally the project team successfully confirmed that nutritional strategies could be applied to reduce emissions. "Tuning of the cows' diet, by acting on starch and protein content, can diminish methane emissions and lead to more cost-efficient milk production," says Gianni Matteo Crovetto, who supervised this aspect of the project.

Similar analysis of livestock diets by the Ammonia LIFE project in Sweden also showed how feeding routines and lactation husbandry could be managed to promote milk production systems that are more climate sensitive.

Photo: LIFE09 ENV/IT/000214

The LIFE programme has funded more than 20 recent projects involving new and proven methods for reducing manure emissions in ways that retain nutrient content. One such case is ECOFILTER, a project that showed how a combination of bio-washers and bio-filters can reduce NH_3 emissions from manure by some 95%.

Pig manure is more polluting than most other animal wastes and so it has been targeted to good effect by projects including ES-WAMAR's low-emission

spreading work. Here, LIFE co-finance helped prepare new approaches for treating piggery waste through coordinating nutrient balances over a network of participating farms – and results created 16 sustainable jobs for the green economy.

The MIX FERTILIZER project is another piggery venture and this combines swine manure with other ingredients to create a new type of fertiliser containing a special inhibitor (3-4 dimethyl pyrazole phosphate). The project plans to achieve 45-50% reductions of N_2O emissions from wheat plots, as well as a reduction in chemical fertiliser use of 30%.

Good commercial interest in, and thus replication of, these results is anticipated because the slow release means only one application of fertiliser may be needed (saving on operational costs) and increased yields are also expected (by around 10%).

Soil emissions

Organic and precision farming methods have been trialled by LIFE in numerous soil circumstances. Projects involved with advancing these techniques (for example, Sinergia, Crops for better soil, AgriClimateChange, SOLMACC and AGRICARBON) have studied parameters for reducing soil emissions in a host of crop types ranging from wheat and viticulture, to citruses and leguminous plants.

All these projects share nitrogen reduction goals. Between them they have all also furthered our intelligence about soil emission factors linked to crop protection and rotation, tillage, irrigation, and fertilisation (including use of traditional nitrogen fixing crops that need less fertiliser).

LIFE projects continue to contribute to the development of precision agriculture as a farm management concept based on observing and responding to intra-field variations. This may involve use of satellite imagery and geo-positioning systems to help farmers optimise fertiliser rates and use of plant protection products when spraying (AGRICARBON). Reduced use of agri-chemicals and energy delivers multiple benefits for the soil and groundwater - and thus the entire crop cycle - as well as in terms of cost savings and lower N_2O emissions.

LIFE's focus on resource–efficient approaches to precision agriculture can be seen in the real-time monitoring data systems developed by projects such as OptiMaN. These have attracted the interest of authorities dealing with nitrogen regulations, since project results have shown objectively that current nitrate usage levels on EU farms can be over-estimated (and thereby reduced) by as much as 30%. LIFE has demonstrated a decision-support tool for agri-businesses that helps farmers achieve the correct balance of manure inputs and thus avoid GHG emissions (DEMETER). Another acclaimed LIFE project in this field is SOWAP, which carried out successful cost-benefit analysis in a cross-section of Member States for precision farming techniques, including conservation tillage and nutrient management.

ES-WAMAR developed low-emission solutions for spreading pig waste

Photo: LIFE06 ENV/E/000044/SODEMASA

Useful projects like these thus help to provide farmers with the management information they need to make climate-related business decisions, and they also help to improve farmer confidence in climate-mitigation measures. Increased emphasis on cost-benefit analysis in future LIFE projects will add more credibility to their results. New LIFE projects in this area should aim to report on the cost of their climate solutions against a conventional 'control' cost, and new projects could aim to better estimate the cost of commercialising prototypes, or of adapting them to different climates or agricultural sectors.

Soil storage

Agriculture and forestry are the two main sectors of Europe's economy with the ability to remove CO_2 from the atmosphere and store it (in crops, trees, hedgerows, and soil). Soil management practices are therefore important influences on global carbon stocks, and soil management remains a crucial tool for tackling climate change.

The Nature, Environment and Information strands of LIFE have all been used to support sustainable soil management, testing and confirming the suitability of strategies for a diversity of land use categories and soil situations. The utility of the Information & Communication strand in particular is demonstrated by the success of the CHANGING THE CHANGE project (see pp. 66-67).

A sizeable number of LIFE Nature projects also fund soil sustainability actions through their work with extensification of land use and conversion of arable land. Outcomes from such nature conservation activities help to increase pan-European soil carbon stocks through sensitive land management methods that are tailored to the long-term needs of local soil conditions. One of the very many examples of this type of LIFE Nature project is the Egyek-Pusztákocs initiative from Hungary's steppic grasslands.

LIFE Environment projects supporting soil management improvements acknowledge that a soil's ability to store carbon is dependent on the state of its functionality. Effective soil functions are an absolute prerequisite for agricultural productivity. Projects have therefore targeted assistance to help farmers take good care of their soils in order to maintain overall soil functionality and farm profitability.

These actions have been promoted through holistic approaches such as organic production systems or

Photo: LIFE11 ENV/ES/000535

OPERATIONCO$_2$ is transforming two naturally degraded areas into complete agroforest ecosystems

EMAS certification. Once again these projects have targeted other environmental impacts (soil water pollution, air quality) rather than climate mitigation directly; however, they use the same techniques as are needed to promote soil carbon storage.

One of the most effective techniques for soil carbon storage is reduced tillage, which involves less or no soil disturbance (i.e. ploughing, drilling, etc.). Decreasing tillage can reduce farm GHG emissions both by increasing fields' carbon stocks and reducing the use of fossil fuel energy for tillage work.

LIFE12 ENV/IT/000578

LIFE HelpSoil

This ongoing project is testing conservation agriculture and sustainable soil management techniques and is a good example of how farmers can learn through LIFE about options for improving the ecological functions of soil. LIFE HelpSoil is being carried out within the context of promoting healthier soils that better fix GHGs and sequester organic carbon.

"Our project uses monitoring indicators to measure soil ecosystem functions and assess the capacity of conservation agriculture techniques to restore agro-ecosystems to a more sustainable and productive state," explains Alberto Lugoboni. The project team will compare new management techniques with conventional practices at 20 demonstration farms in northern Italy, working closely with farmers and other stakeholders. Results will inform technical guidelines for farmers adapted to the different local agro-ecological conditions and cropping systems occurring in the region." All the Italian regions in which the project is working have conservation agriculture measures in their Rural Development Programmes for 2014-2020, and so our results should help implement these measures," adds Mr Lugoboni.

A host of LIFE projects (including Sinergia, Crops for better soil, AgriClimateChange, Petrignano, SOLMACC, LIFE HelpSoil, and RegaDIOX) have monitored and demonstrated the potential of reduced tillage, with projects such as SOLMACC going further and combining reduced tillage with non-use of herbicides on organic farms.

Soil monitoring is a common component of these and other LIFE projects that provide climate benefits from European farms. Member States have used an assortment of different soil monitoring techniques. The EU also has funded soil monitoring in 2009 and 2015 through its LUCAS programme, which could help redress this gap in the agri-climate policy apparatus.

Crop contributions

Farmers' crop choices affect farm incomes and GHG emissions. Intensification trends over recent decades encouraged the installation of monocultures, but evidence indicates that these highly – mechanised systems have negative impacts on many environmental factors – including climate matters.

LIFE project actions have reflected this fact and worked with farmers to identify cost-effective alternatives to monoculture cropping. Such projects (which include Crops for better soil, AgriClimateChange, AGRI-CARBON and LIFE HelpSoil) have successfully rotated crops (avoiding planting the same crop on the same land each year) as a GHG reduction method. The amount of nutrients that the different crops can provide to the soil is being tested and measured according to the type of soil and climatic conditions.

Photo: Gabriella Camarsa

Leguminous plants fix atmospheric nitrogen into the soil and improve soil quality

The SOLMACC project, for instance, is investigating optimal crop rotations between grass and legumes. This creates both environmental and economic advantages: the legume increases nitrogen fixation in soil (reducing the amount of fertiliser used) and the grass biomass becomes a feedstock to produce biogas for on-farm use.

The Crops for better soil project is also testing leguminous crops and first trials have demonstrated that they have the effect of fixating nitrogen to the roots of the plant. This is then released to the soil, cutting both the need for fertilisers and N_2O emissions. Farmers have already expanded legume cultivation beyond the project's pilot plots. This suggests LIFE has succeeded in its efforts to change the behaviour of farms that previously disregarded such nitrogen-fixing crops on the grounds of poor profitably. The programme's involvement has helped to dispel such myths by proving that the yields and economic

LIFE08 ENV/E/000129

AGRICARBON

The project worked closely with Spanish farmers to help clarify the best ways of boosting soil sustainability, without impinging on agri-profitability. "Our intention has been to promote certain techniques that have proven to be environmentally, socially and economically sustainable. What we are looking for within this broad sustainability framework is to focus on what climate change actually is, and on how to mitigate harmful effects of greenhouse gases through conservation agriculture and precision agriculture," explains project coordinator Emilio Jesús González Sánchez.

Conservation agriculture (CA) principles were applied to reduce tillage, slow the decomposition of plant matter, and thereby promote the storage of fixed CO_2.

Increased understanding by farmers about the dynamics of soil carbon stocks was another useful outcome. "We have been able to prove at a larger plot scale that we are able to mitigate climate change due to an increase in soil carbon by improving the sink effect of these techniques. We have also been able to reduce emissions derived from the use of inputs in farming activities," adds Mr González. He identifies the involvement of farmers and ongoing use of CA techniques after LIFE as one of project's key achievements: "We have witnessed an increase of double the surface area in lands under conservation agriculture in herbaceous crops."

savings from climate-friendly leguminous crops can make commercial sense for farmers.

Another solution that is being tested is the reduction of annual pastures and the introduction of perennial crops. Compared with annual crops, perennials (especially grasses) tend to allocate a relatively high proportion of carbon underground and have a greater number of days per year of active plant primary productivity, resulting in more potential biomass production and carbon storage. LIFE RegaDIOX will test perennial crops, crop rotation, leguminous and permanent pastures using mulches in order to increase carbon capture in soil.

Cover crops

Cover crops have a significant impact on increasing the carbon stock at farm level. A number of LIFE projects are demonstrating this positive mitigation effect, including AGRICARBON, AgriClimateChange, SOLMACC, LIFE HelpSoil and oLIVE-CLIMA.[1]

AgriClimateChange experimented with the use of cover crops. Farmers have now established annual small-scale field trials to test and select the cover crops (mixed species) that satisfy their objectives. The choice of such crops is not predetermined, the farmer's decisions are instead guided by climatic conditions in a given year. The biomass produced by cover crops enhances soil fertility, with a recycling of nutrients of some 20 kg N/ha for the following crop, thus reducing the amount of mineral nitrogen fertilisers purchased.

Retaining crop residues

Agricultural crop residues returned to the soil can help mitigate climate change by increasing carbon sequestration, reducing direct emissions from nitrogen fertilisers and reducing the amount of such fertiliser that needs to be applied to the following crop.

The oLIVE-CLIMA project is sampling and analysing the different material (pruned wood, olive-mill sludge and leaves and other composted material) to determine the amount of carbon returned to the soil. Another project (SOLMACC) is teaching farmers about controlled composting. Techniques include the collection of manure and/or plant residues; how to favour the microbial processes in the compost heap; how to form the compost heaps that facilitate microbiological transformation processes; and regular turning of manure piles using either standard or specialist farm machinery.

1 Cover crops can help to mitigate GHG emissions in four main ways: increase soil organic carbon content, decrease soil erosion during the fallow period, reduce nitrate leaching, and reduce the amount of nitrates that need to be applied to the following crop

oLIVE-CLIMA is demonstrating a range of climate-friendly olive crop management practices, such as the use of cover crops

Photo: LIFE11 ENV/GR/000942

Agricultural carbon audits

Although there is no current EU requirement for farmers to report GHG emissions at farm level, there are many voluntary initiatives to evaluate emissions from agricultural activities and to implement mitigation actions. New RDP measures in Pillar 2 of the CAP can now finance carbon auditing as a contribution to mitigating climate change and the audits can be extended to cover a full lifecycle analysis of farm production, examining factors beyond the farm gate that contribute to GHG emissions in agri-food chains (i.e. in processing, packaging, waste management and haulage).

Carrying out a farm carbon audit can help an agribusiness to identify GHG emissions and benchmark these in order to identify cost savings through improved use of inputs or energy-efficiency. LIFE projects such as AgriClimateChange and ClimatechangE-R represent some of Europe's pioneers in farm-based carbon audits, and their results have been recognised at the highest levels of EU policy (see the feature article on p.65).

Energy use is a key part of carbon audits and an informative collection of energy-efficient approaches has been taken forward by LIFE projects involved in cutting fuel consumption on farms. Reduced tillage, limited frequency of agri-chemical applications, and more efficient irrigation have all been objectively appraised by LIFE as viable tools for making farms less energy dependent. Increased use of renewable energy sources - by projects including Adapt2Change and BIOAGRO - further contribute to the LIFE knowledge-base in this sector. Also, OZERISE is developing an innovative rural development to farmers increase production of renewable energy and to reduce overall energy consumption on farm holdings.

The AGRICLIMATECHANGE project team did much to transfer knowledge about soil conservation techniques

Photo: Tim Hudson

Agroforestry

Forests play an important role in the global carbon balance. As both carbon sources and sinks, they have the potential to form an important component in efforts to mitigate climate change. Accounting for the carbon within forest ecosystems and changes in carbon stocks resulting from human activities is a necessary first step towards the better representation of forests in climate change policy at regional, national and global scales.

Few LIFE projects have targeted agroforestry. SOLMACC is encouraging farmers to combine trees, crops and livestock in one agricultural system and to plant new trees. The project also intends to conduct close scientific monitoring to show how these practices can assist farmers to mitigate climate change, as well as highlighting their economic feasibility and technical requirements. OPERATION CO_2 will demonstrate the economic viability and environmental validity of agroforestry carbon sequestering projects in Europe. It aims to promote active nature conservation and carbon management in forests over an area of 4 500 ha. To this end, it will demonstrate a series of targeted forest and carbon actions resulting in the long-term improvement of carbon sequestering in natural forests.

Looking ahead

This review of LIFE project contributions to mitigating climate challenges in agriculture emphasises the value of the programme as a popular and productive source of support for Europe's farmers. LIFE has helped Member States to test, validate, and implement a broad spectrum of innovations that reinforce farmers' efforts to remain competitive in environmentally-friendly ways.

LIFE's future on the farm therefore looks set to continue and the new LIFE funding period up until 2020 will undoubtedly see Member States using LIFE co-finance to generate an even more impressive set of multi-functional climate-friendly benefits for Europe, and the wider world, from our farms.