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VIEWPOINT

SUSTAINABILITY OF FARMING IN EUROPE: IS THERE A ROLE FOR CONSERVATION AGRICULTURE?

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There is increasing concern being expressed about the unsustainable nature of the intensive farming practices in the UK. While DEFRA accepts the fact that degradation of agricultural soils and habitats in the UK is due to intensive practices, it has not been able to elaborate the causes of degradation and an effective strategy to address them. This article presents an overview of the benefits and global spread of Conservation Agriculture which is a farming practice that is being increasingly promoted as constituting a set of principles and practices that can make a significant contribution to sustainability of farming, in Europe as well as elsewhere.

The Central Issue
Policy Commission on the Future of Farming and Food in the UK

The report of the government-appointed Policy Commission on the Future of Farming and Food in the UK, under the Chairmanship of Sir Donald Curry, concluded in 2002 that (DEFRA, 2002):

"Farming and food industry is on an unsustainable course in economic terms. We believe it is also unsustainable environmentally — without substantial change… in the last 50 years…Soil organic content has declined and phosphorus levels in top soils have increased. Agriculture is now the number one polluter of water in the country. Land use changes have contributed to increased danger of extreme flood events, affecting thousands of homes. Beyond any doubt the main cause of this decay has been the rise of modern, often more intensive, farming techniques. …things are still getting worse…in soil compaction and erosion, in the loss of certain species. A lot of the environmental damage in the countryside over the last 50 years has to be laid at the door of modern farming techniques. …. Much damage by farmers is not wilful but arises out of ignorance. We believe a major advice effort will be needed… to help farming meet its new challenges. It will be very important that advice should also cover environmental issues."

The Commission formulated a long list of recommendations but offered not a single recommendation to address the need for a substantial change in the farming techniques.

UK's First Food Security Assessment

On 10 August 2009, Mr Hilary Benn, DEFRA Secretary, in launching the publication of the country's first Food Security Assessment, said three big challenges needed to be met (DEFRA 2009a, 2009b). How to:

- meet the economic and environmental challenges of increased productivity in the food chain;
- help people eat more healthily and ensure people have access to safe, affordable food;
- ensure that the way food is produced today doesn't damage the natural resources on which future food production depends.

The Assessment resonates well with the sentiments expressed in the Policy Commission's report. However, the approach used and the analysis applied in the Assessment do not address the unsustainable nature of the intensive tillage-based production systems. Consequently, there is no explicit attempt made to elaborate on what new advice must be formulated for farmers on what changes must be made to current production techniques and practices to make farming more sustainable and environmentally friendly as well as productive and profitable. In fact, the issue related to the management of soil quality within production systems has been set aside in the Assessment as a topic requiring further research, and in the 'Approach' document (DEFRA, 2009a) "soil" is mentioned only once under threats and challenges in terms of soil erosion in the context of global resource sustainability, and there is nothing in the recommendation section to address the unsustainable nature of the intensive production practices. The 'Analysis' document (DEFRA, 2009b) mentions "soil" only once under the section dealing with fertilizer intensity under the theme of Global resource sustainability.

DEFRA's Vision 2030 -- Safeguarding Our Soils: A Strategy for England

A month later, in September 2009, DEFRA declared the following vision in its document: "Safeguarding Our Soils: A Strategy for England" (DEFRA, 2009c):

Our vision:

By 2030, all England's soils will be managed sustainably and degradation threats tackled successfully. This will improve the quality of England's soils and safeguard their ability to provide essential services for future generations.

The document states that "Soils have degraded over the last 200 years due to intensive agricultural production and industrial pollution. Soils face three main threats:

- Soil erosion by wind and rain. Erosion affects both the productivity of soils but also water quality and aquatic ecosystems.
- Compaction of soil reduces agricultural productivity and water infiltration, and increases flood risk through higher levels of run off.
- Organic matter decline. The loss of soil organic matter reduces soil quality, affecting the supply of nutrients and making it more difficult for plants to grow, and increases emissions to the atmosphere."

It further says: "We will deliver this Strategy primarily through improving our evidence base, providing information and guidance to those who are actively managing our soils, and using regulation and incentives where necessary to drive further action. However, government alone cannot safeguard our soil resource for future generations. Farmers and other land managers, developers, planners and construction companies must all play their part in managing soils sustainably and protecting soil functions. Consumers must also be given the information they need to make responsible choices when buying products such as compost."

Further more, it states: "As part of the review of CAP cross compliance, we will introduce a revised Soil Protection Review from January 2010 in order to improve soil protection and simplify the process for farmers wherever possible. We will also review the need for future options under Environmental Stewardship to improve soil protection and examine opportunities for further targeting of action on key sites."

It concludes by stating: "DEFRA funds a wide range of research in partnership with other organisations. Key gaps in our evidence base are highlighted throughout the strategy. We will work closely with other funders to coordinate the commissioning of research to fill these gaps and strengthen our understanding of the pressures on soils and the measures required to address degradation."

"We will also continue to promote sharing of best practice in soil protection at the European level. This Strategy has been informed by key elements of the EU Thematic Strategy for Soil Protection that was published in September 2006. In ongoing discussions on the proposed EU Soil Framework Directive we will continue to argue for a flexible and proportionate approach which complements existing national action."

This means that the proposed Directive will require Member States to take specific measures to address soil threats but it is up to them to decide on risk acceptability, to define targets and take measures to meet those targets.

The Policy Commission's review, DEFRA's First Food Security Assessment and its Vision 2030 for Safeguarding Our Soils, all describe the symptoms of degrading agricultural soils and habitats, and accept that the cause is intensive agricultural production and the farming practices that go along with it. However, they do not elaborate on what is it in the intensive agriculture production practice that is so destructive of our agricultural soils and their ecosystem functions? Also, there is an assumption running through these documents that the solutions to soil degradation lie with the so-called "best practice in soil protection". Again, there is no elaboration as to what this actually means in terms of farming practices.

It is my personal view that the 'best practice in soil protection approach' that does not address the fundamental causes of soil degradation in UK farming is unlikely to lead to any effective solution. The solutions for much of our agricultural soils are likely to be based on how we can manage the whole soil-crop-landscape system for ecosystem services (including for food and water provisioning) without the use of the plough and the harrow as well as uncontrolled heavy farm traffic.

This Article

In light of the above, questions must therefore be asked, for example: What is it in modern intensive farming techniques that continue to be so damaging to farm land, environmentally and economically as highlighted by the Policy Commission's review and by DEFRA? What kind of major advice effort will be needed to deliver what advice and to whom? What will inform the advice formulation process?

The cause of much of the degradation mentioned in the Policy Commission report is the intensive use of tillage practices in production systems which have little crop diversification, and no provision for managing plant organic matter to provide a protective soil cover and feed the soil biota for driving the important soil-based ecosystem processes. Output is maintained or increased through using tillage, modern varieties and ever increasing application of agrochemical inputs (with a simultaneous decrease in factor productivity and increase in pollution). Over time, the intensive soil tillage damages soil life and biodiversity (including natural enemies of pests), burns up soil organic matter (which is also a major substrate in the food webs of soil biota), and destroys soil structure and porosity, causing soil compaction, poor soil aeration, decrease infiltration and increase runoff, flooding, soil erosion and contamination of water systems. The loss of soil life and structure leads to decreasing factor productivities so that increasing the inputs leads to decreasing marginal output and loss in efficiency and profit, as well as increase in pollution.

There is now increased awareness that modern tillage-based farming methods are unsustainable and that there is a need for alternatives. During the past two decades, there has been growing evidence that the application of Conservation Agriculture (CA) principles and practices can serve as a good alternative that can address the unsustainable characteristics of modern tillage agriculture. CA is sometimes referred to as a win-win agricultural production system. In the 1940s Edward Faulkner in his revolutionary "Ploughman's Folly" stated that 'no one has ever advanced a scientific reason for ploughing'. CA has proved itself to be a good bet for a sustainable and productive agriculture in many countries and wherever CA has been adopted and practiced properly it has proven beneficial, economically and environmentally.

CA is being increasingly promoted as constituting a set of principles and practices that can make a contribution to sustainable production intensification (Pretty, 2008; FAO 2008) because it addresses missing components in the intensive tillage-based 'standardised' seed-fertilizer-pesticide approach to agricultural production which is the mainstream farming model in Europe. This article aims to provide an overview of CA, its benefits, global distribution, and relevance to farming in Europe including the UK. The article constitutes a personal viewpoint of the author.

Definition and Characteristics of Conservation Agriculture

CA is a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. CA is based

on enhancing natural biological processes above and below the ground. Interventions such as mechanical soil tillage are reduced to an absolute minimum, and the use of external inputs such as agrochemicals and nutrients of mineral or organic origin are applied at an optimum level and in a way and quantity that does not interfere with, or disrupt, the biological processes.

CA is characterized by three sets of mutually reinforcing practices (see www.fao.org/ag/ca):

1. Continuous no- or minimal mechanical soil disturbance (i.e., direct sowing or broadcasting of crop seeds, and direct placing of planting material in the soil; minimum soil disturbance from cultivation, harvesting or farm traffic);
2. Permanent organic-matter soil cover, especially by crop residues and cover crops; and
3. Diversified crop rotations in the case of annual crops or plant associations in case of perennial crops, including legumes.

These three practices have been quantified as follows:

1. Minimal Soil Disturbance: the disturbed area must be less than 15 cm wide or 25% of the cropped area (whichever is lower). No periodic tillage that disturbs a greater area than the aforementioned limits.
2. Soil cover should ideally be above 100%, measured immediately after the planting operation. Ground cover of less than 30% is not considered as a CA practice.
3. Crop rotation: Rotation should involve at least 3 different crops. However, monocropping is permissible as long as no other related problems occur.

When applied simultaneously these three practices utilize soils for the production of crops to minimise the excessive mixing of the soil, characteristic of tillage-based farming. CA maintains crop residues on the soil surface to minimize damage to the environment, and deploys diverse crop rotations and associations for enhancing soil and crop health. This produces more biomass of higher quality, assists integrated insect pest, disease and weed control, and improves nutrient uptake. As a consequence, CA:

- Provides and maintains an optimum environment in the root-zone to a maximum possible depth.
- Ensures that water enters the soil so that (a) plants seldom suffer water stress that will limit the expression of their potential growth; and (b) residual water passes down to groundwater rather than over the surface as runoff.
- Favours beneficial biological activity in the soil to (a) maintain and rebuild soil architecture, (b) compete with potential in situ soil pathogens, (c) contribute to soil organic matter and various grades of humus, and (d) contribute to capture, retention, chelation and slow

release of plant nutrients (see Figure 1).

- Avoids physical or chemical damage to roots that disrupts their effective functioning or limits their maximum potential for nutrient uptake.

Figure 1: Comparing soil in a farmer's trial – clods of top soil from adjacent plots, Paraná, Brazil (credit: Francis Shaxson)

PRO-BIOTIC ▲
Topsoil after 5 years with retention of crop residues and no-till seeding.

ANTI-BIOTIC ▲
Topsoil after regularly-repeated disk- tillage, without retention of residues

A typology of tillage practices is given in Kassam *et al*. (2009). CA is a no -tillage based cropping system, which by synergetic interaction of other techniques overcomes the known limitations of no-tillage as isolated technique. It can be complemented by other good agricultural practices for further improvement of the overall performance of the cropping system. The CA concept of soil and cropping system management is universally applicable, but it is not a ready-to-use blue print recipe for sustainable farming. The actual practices require site specific adaptations and eventually specially designed mechanical technologies or machinery. Based on the global evidence of adoption (see more information on this at FAO website: www.fao.org/ag/ca), it appears that CA can be practiced in all sizes of farms and ecologies including those in Europe.

Benefits from Conservation Agriculture

The widespread adoption of CA, largely outside Europe, shows it is capable of producing large and demonstrable savings in machinery, energy use, and carbon emissions, a rise in soil organic matter content and biotic activity, less erosion, increased crop-water availability and thus resilience to drought, improved recharge of aquifers and reduced impact of the apparently

increased volatility in weather associated with climate change. It will cut production costs, lead to increased profits, more reliable harvests and reduce risks especially for small landholders (FAO, 2008).

Conventional tillage-based ways of treating soils has resulted in damage to their inherent productive capacity and their biologically based sustainability as favourable rooting environments. CA is aimed at self-sustaining improvements of the overall health of the soil/plant ecosystem, and provides a more benign and beneficial alternative.

By avoiding tillage, the loss-rate of CO_2 from soil to atmosphere is greatly reduced. Permanent cover of mulch materials both sustains the soil biota, raises the soils' retention/release capacity for water and plant nutrients, and protects the surface from extremes of rainfall and temperature. Rotations limit pest build-up, favour nutrient-cycling in the soil, and increase levels of soil organic matter at different depths. In these ways CA improves and sustains soil health on land already in good condition, can regenerate land in poor condition, and favours the self-repeating sustainability of soil processes. As such it furthers the aims of a number of international conventions on, for example, combating desertification, loss of bio-diversity, and climate-change effects.

Although much of the CA development to date has been associated with rainfed arable crops, farmers can apply the same principles to increase the sustainability of irrigated systems, including those in semi-arid areas. CA systems can also be tailored for orchard and vine crops with the direct sowing of field crops, cover crops and pastures beneath or between rows, giving permanent cover and improved soil aeration and biodiversity.

Wherever CA has been adopted properly it appears to have had both agricultural and environmental benefits. Yet CA represents a fundamental change in production system thinking. It has counterintuitive and often unrecognised elements that promote soil health, productive capacity and ecosystem services. The practice of CA thus requires a deeper understanding of its ecological underpinnings in order to manage its various parts for sustainable intensification where the aim is to optimise resource use and protect or enhance ecosystem processes in space and time over the long-term. It is for these reasons that CA is knowledge intensive.

Global Distribution of CA

The area under CA systems has been growing exponentially, largely due to the initiative of farmers and their organizations. It is estimated that, worldwide, there are now over 106 million hectares of arable and permanent crop lands which are grown without tillage in CA systems (Kassam *et al*., 2009). The rate of increase in CA area globally since 1990 has been some 5.3 million hectares per annum, mainly in North and South America, Australia and New Zealand.

Except in a few countries, such as USA, Canada, Australia, Brazil, Argentina, Paraguay, Uruguay, Kazakhstan, China, Kenya, Tanzania, Lesotho, Malawi, South Africa, CA approach to sustainable farming has not been "mainstreamed" in agricultural development programmes or backed by

suitable policies and institutional support. Consequently, the total global area under CA is still very small (about 7% of total crop land) relative to areas farmed using tillage.

Currently, South America has the largest area under CA with 49.6 million hectares (46.6% of total global area under CA) followed by North America (39.0 million hectares, 37.5%). Australia and New Zealand have 12.2 million hectares (11.4%), Asia 2.6 million hectares (2.3%), Europe 1.5 million hectares (1.4%) and Africa 0.5 million hectares (0.4%).

In Europe, ECAF (European Conservation Agriculture Federation -- www.ecaf.org) has been promoting CA since 1999, and adoption is visible in Spain, France, Germany, Ukraine and Finland, with some farmers at 'proof of concept' stage in the UK, Ireland, Portugal, Switzerland, Slovakia, Hungary and Italy.

The Role of CA in Farming in Europe

As seen above, CA is being widely practiced outside Europe, including in areas with similar agro-climatic conditions, particularly in North America (Baig and Gamache, 2009). There is now a growing conviction amongst many agricultural development experts that CA has an important role in transforming agriculture everywhere towards a more sustainable and efficient system (Goddard et al., 2008; FAO, 2008). However, currently, CA is not being popularised in the EU generally, and is not being seriously researched. The lack of knowledge on CA systems and their management, and the absence of dynamic and effective innovation systems and lack of policy support, makes it difficult and socio-economically risky for European farmers to give up ploughing which is a farming practice rooted in their cultural traditions. In Finland, Germany and Spain the adoption of CA is being encouraged and subsidised in order to mitigate soil erosion. In other European countries the adoption process seems mainly farmer driven motivated by the reduction in the cost of machinery, fuel and labour. Soil and water conservation concerns do not appear to be the main drivers in the European farmers' decision to shift to CA or not. This adoption trend may grow in the future in response to increasing energy and input costs.

EU policy on sustainable farming and sustainable production intensification

CA as a different paradigm to underpin "sustainable production intensification" recognizes the need for a productive and remunerative agriculture which at the same time conserves the natural resource base and environment, and positively contributes to harnessing the environmental services. Sustainable crop production intensification must not only reduce the impact of climate change on crop production but also mitigate the factors that cause climate change by reducing emissions and by contributing to carbon sequestration in soils. It should enhance biodiversity in crop production systems above and below the ground, to improve ecosystem services for better productivity and healthier environment. CA delivers on all of these goals. It saves on energy use in farming and thus reduces emissions. And, it enhances

biological activity in the soils, resulting in long term yield increase. In fact CA represents a practical concept to achieve and sustain improved soil health and better soil-crop-nutrient-water management in agricultural landscapes leading to ecologically and economically sustainable agriculture.

I believe that the European agricultural development policy can and should have a clear approach to sustainable farming which is not possible with tillage-based agriculture; hence all development activities dealing with crop production intensification in EU states should be assessed for their compatibility with CA principles. Environmental management custodian schemes in Europe do not promote the principles and practices of CA. This is because CA practices do not attract special rewards in the single farm payments to European farmers. On the contrary, commodity related subsidies or payment for set-aside land work against the adoption of CA. Thus environmental costs arising from intensive agriculture in Europe continue to be externalised and shifted to the society at large. Consequently, the degradation of soil, biodiversity and environment continues largely unabated.

It is perfectly feasible to meet food security needs in the UK and Europe at lower economic and environmental costs through CA systems. The transformation to such systems will require effective political will and commitment backed by active support from the farming industry, including the farm machinery sector, which are currently lacking.

EU governments must make a firm and sustained commitment to encourage and support CA, expressed in policies which are consistent and mutually reinforcing across the spectrum of government responsibilities and sufficiently flexible to accommodate variability in local characteristics. Facilitation should include tapered financial and logistical support for the number of years needed for farmers to make the changeover and become familiar with the functioning of CA. Formal recognition should be given to the public goods value of environmental benefits generated by adoption of CA. The research and education system should be permeated with understanding of well-managed CA as an optimum expression of sustainable productive agriculture.

The EU proposed Soil Framework Directive, resulting from the Soil Thematic Strategy, for example, would have facilitated national policies in support of CA and enhancing the role of soil under CA as a repository of carbon. Unfortunately it was not adopted and UK was one of the five EU members who opposed it. However, the new EU Water Framework Directive includes permissible levels for pollutants in water such as nitrates, phosphates or pesticides, and only under permanent no-till systems (i.e. CA) can the erosion and leaching of agrochemicals into surface and subsurface water bodies be reduced to a level compatible with the new directive.

Within EU there is an increasing concern about the sustainability of farming, and organizations promoting CA in Europe, such as ECAF, have begun to raise awareness of CA at the practical as well as policy level. CA principles, knowledge, skills and practices as well as the associated learning and dissemination processes are of a ‘public goods’ nature and are effective in reducing purchased exogenous input requirements while enhancing the natural

endogenous biotic and ecological productivity enhancing processes. EU member governments and European Commission will have to take responsibility of promoting the transformation of current production systems towards CA systems through the EU's Common Agricultural Policy (CAP) mechanisms which have been generally rather effective in managing agricultural change over the past several decades.

Farm machinery and mechanization for CA.

If CA is to spread in Europe, it must be understood that in the context of sustainable agricultural mechanization it is more than just a technique, such as no-tillage and direct seeding. It represents a fundamental change in the soil-crop-landscape system management and in the cropping system design and management which in turn will lead to consequential changes in the required operations and mechanization solutions. This will involve a major shift in the current mix of mechanical technologies, some of which will remain but with only marginal use in the future, and there will be the development of completely new set of mechanical technologies, changes in farm power requirements, and in land use suitability for sustainable intensification (Baker and Saxton, 2007).

Another aspect which will have to gain increasing importance under CA as a permanent no-till system is the avoidance of soil compaction, particularly in mechanized farming and in humid climates such as northern Europe. Existing mechanical technologies to reduce the danger of compaction, such as low pressure tyres and rubber tracks, tyre pressure adjustment systems and wheel track monitoring to warn the driver, will become economically more feasible for the CA farmer since the mechanical removal of soil compaction or surface tracks will not be a standard operation as is in the tillage-based farming. A safer approach to completely avoiding soil compaction in the crop zone is the controlled traffic farming (Baker and Saxton, 2007) which is increasingly gaining popularity in Australian CA farms, but also in mechanized no-till farms in Africa and Central Asia, using satellite based guidance and eventually auto-steer options. The consequent application of controlled traffic concepts would eventually lead to completely different generations of farm machinery, from tractor through seeders to sprayers and spreaders to harvesters and transport equipment (Theodore Friedrich, personal communication, 2 October 2009).

Concluding Comments

With increasing awareness of the need for sustainable production intensification, and of improved understanding of how to achieve it, CA is a good bet for a sustainable and productive agriculture. Yet the question arises: if CA is so good, why is it not spreading faster? CA is knowledge intensive and a complex system to learn and implement. It cannot be reduced to a simple standard technology thus early adopters face many hurdles before the full benefits of CA can be reaped. The scaling up of CA practices to achieve national impact requires a dynamic complement of enabling policies and institutional support to producers and supply chain service providers. Only

then will it become possible for all stakeholders to transform the prevailing tillage-based production systems to CA-based systems as a basis for sustainable production intensification.

The Single Farm Payment scheme under CAP is unlikely to provide the intellectual and political momentum for such a transformation as its main purpose has been to increasingly manage the farming sector in Europe in a similar way to how it manages the education or the health service sectors on behalf of and for the public. The decisions regarding the farming operations are less driven by market forces and more by government directives. Given that there is no effective publicly funded research and extension system operating in Europe that can serve as the major advice effort needed to transform European farming towards CA, it is difficult to visualize the corporate sector addressing this need unilaterally. EU member governments and EU as a whole will have to realize that there are no market forces that can bring about the needed changes in the unsustainable farming practices that currently characterize European (and UK) farming.

The primary restriction to CA adoption is the assumption that soil tillage is essential for agricultural production. Other restrictions include those of intellectual, social, technical, environmental and political characteristics. Key restrictions with mainstreaming CA systems relate to problems with up-scaling which is largely based on the lack of knowledge, expertise, inputs (especially equipment and machinery), adequate financial resources and infrastructure, and poor policy support (Friedrich *et al.*, 2009). As Europe is not currently generating the knowledge needed for transforming its farming sector towards CA, it must perhaps rely on: (a) the evidence and successful experience outside Europe; and (b) establish a network of publically funded on-farm operational research in which farmers can be provided with an opportunity and financial support to experiment with CA practices and adopt them to suit their socio-economic and agro-ecological conditions. Also, the engagement of the machinery sector to develop a new set of mechanical technologies for CA farming will be necessary.

Ultimately, it must be recognised that a behavioural change in all stakeholders must be encouraged and facilitated if CA practices are to take off in Europe. This includes the role and competences of the key national extension, research and education institutions, the government departments, development agencies and donors that support them, as well as the private sector including farmers and farm managers who have an important and often unique role to play in innovation processes and in input supply markets including for equipment and machinery.

CA is knowledge intensive with many new aspects and those who must promote it or practice it require training and practical experience. In the case of farmers, an opportunity to test, learn and adapt is necessary. For extension staff, training is necessary in alternative mechanization technologies. Similarly, in universities and research institutions, there is a need to include training and research on CA-related agronomy and cropping system management at the field, farm and landscape level, as well on the equipment options for different sources of farm power.

EU governments must make a firm and sustained commitment to encourage and support CA, expressed in policies which are consistent and mutually reinforcing across the spectrum of government responsibilities and sufficiently flexible to accommodate variability in local characteristics. Facilitation will need to include tapered financial and logistical support for the number of years needed for farmers to make the changeover and become familiar with the functioning of CA. Formal recognition should be given to the public good value of environmental benefits generated by CA.

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