#SoilMatters

SO HOW DO WE TREAT IT?

Soil Matters is an article series we ran on the ARC2020 website. It featured detailed articles on the best approaches to soil management, as well as articles on the wider impacts of how we deal with soil. The aim was to explore soil matters from a number of different perspectives, as if soil mattered. And once you've read this, hopefully you'll agree - #SoilMatters.

Content

Soil has become an increasing pertinent topic in agri-food, but what are the best management techniques for saving what we have and for building better soil for the future?

#SoilMatters

So How Did Our Authors Treat It?

Oliver Moore

Unusually, our opening contribution was perhaps the most controversial of all. Soil Scientist **Andrea Beste** writes about us about humus, soil structures and the limits of no-till. Emphasising soil biodiversity, humus and soil structure is typical enough, but criticising no till - at all - really seems to rile people up.

Beste's position is not against no-till per se, but, rather, considers it in relation to its contribution to humus building, micro vs. macro pores and desirable sponge structures vs. soil compaction, deeper carbon below 15 cm, use of fertilizers and broad-spectrum herbicides. Importantly, she also emphasises how it can work in highly diverse agroecological systems, contextualised by increasing prevalence of extreme weather like droughts and floods.

As his opening contribution to #SoilMatters, Soil Scientist **Mario Catizzone** outlines some immutable soil facts, while introducing the UN FAO's Voluntary Guidelines on Sustainable Soil Management.

The role of farming in climate change mitigation is controversial and fraught. The UN COP (Conference of Parties) Climate Change has tentatively introduced soil and carbon sequestration into its workings, via 4 pour 1000. However, the role of particular agronomic practices involving livestock is under special scrutiny. Does livestock release more than it sequesters, or does the farming model matter? What about deep carbon storage? And how will policy makers work with new research and 4p1000? **Oliver Moore** asks these questions.

"But it's not just about what's on top, it may be about what's deeper down too. Published work in Nature Scientific Reports in 2017 revealed soils with high clay content in deeper layers lock away carbon for much longer, and at much greater depth than previously known.

While topsoil carbon is quite volatile, at deeper layers, carbon can be stored for longer. This is especially the case for "grassland soils with high clay content in deep layers, where the clay particles have washed from the topsoil to the subsoil."

The researchers claim that the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC) "has thus far only considered the top 30 cms of soil, known as topsoil."

When we change how land is used, it doesn't just impact on this one area. Italian trio **Riccardo Scalenghe**, **Francesco Malucelli** and **Mario Catizzone** examine soil matters in the Emilia-Romagna Plain, Italy, and help us understand what is truly lost when we loose soil without thinking about all the impacts.

"In Emilia-Romagna in Italy the conversion of 15,000 ha of agricultural soil caused a net loss of the calories needed by 14% of local population. When economic, environmental and social criteria are balanced, the planning of land–use systems could be perceived as sustainable. This is especially the case when natural soil functions are considered – its best to avoid aberrations of natural processes while soil disturbances are extremely demanding to correct."

"A sustainable food system is not about reducing animal-product consumption so to 'free-up' land for direct-for-human-food plants: rather, it is about using the land now used for feeds for shipping to animals confined elsewhere, for grazing livestock – be they ruminants, pigs or poultry." **Stuart Meikle** outlines his position.

"If there is a universal panacea for our food systems, it can be found in how we restore the health and productivity of our soils. By saying such one could however be guilty, as is often the case, of allowing a single issue to dominate. Whereas identifying a sustainable food system, differing as they must region by region, is in fact a complex process that requires the joining of numerous dots across a broad canvas. If you focus on one issue alone, lo and behold, unforeseen consequences happen elsewhere.

And yet, intriguingly, as one looks at soil regeneration, the solutions for many of our other problems emerge."

Roy Neilson and **Blair McKenzie** of the James Hutton Institute start with the consideration – what do we want from our soil? They move from here on a fascinating journey into the difference between soil texture and structure, into soil management, organic matter, and the impact of different practices on soil.

"...farmed soils deliver a wide range of functions and benefits, both for the farmer and society at large. With expanding populations and the loss of soil to housing, roads and other infrastructure associated with urbanisation there is less soil available to deliver these societal goods. In many cases there will be trade-offs between functions – both in space

(e.g. large-scale crop production vs biodiversity) and in time (e.g. the response to amendments) and maintaining the functions and benefits that soil deliver is a balancing act of management strategies. There are multiple threats to soils and the first part of any consideration to improve soil functions must be the preservation and protection of the soils that we have."

Stuart Meikle focuses on three main areas: society, farming and transitioning – all to soil-focused farming. The transition section includes seven suggestions for new farm support mechanisms. These suggestions focus on both payments and practices.

Interested in reducing the GHG emissions from producing our food? Better nutrition and health and lower healthcare costs? Reducing the pollution from our food production systems? Then read what **Stuart Meikle** has to say about how a soil-focused farming benefits these and other aspects of society. This builds upon Stuart Meikle's earlier contributions and includes a comprehensive examination of soil in society - in all its facets.

Micro vs. macro pores and desirable sponge structures vs. soil compaction

Humus, Soil Structures & the Limits of No-Till

Andrea Beste

What is Europe's agriculture doing to the soil

This year, on January 31, Luca Montanarella, Soil Action Leader of the Unit Land Resource Management of the Joint Research Centre, European Commission, gave a presentation on the state of Europe's soil at an event in the European Parliament. There are probably only few people who are as familiar with international soil issues as he is. From the data, collected with great effort in recent years within the European soil observation system LUCAS, for which he is responsible, he cited the following: Soils under agricultural use show the symptoms erosion, soil compaction and humus loss. The humus content has fallen steadily in recent years and has been overestimated so far by 25 percent. These are threatening signs that we are not taking the resource soil seriously enough or are practicing wrong land use practices.

Humankind's ability to use the resources of the soil was and is the basis of all human cultures. In his book "Collapse," award-winning biologist and geographer Jared Diamond refers to the mismanagement of the soil and, as a result, the decline in soil fertility and erosion as the cause of the collapse of many ancient cultures. Societies that were in the deepest belief of technical superiority, despite clear warning signs for the overuse of the resource soil, continued to drive towards disaster. The geologist David R. Montgomery describes similar in his book "Dirt: How Societies Choose to Fail or Survive", also for our current society [1]. This applies worldwide – and unfortunately also for Europe.

What's going wrong?

Loss of soil biodiversity

From 2008 to 2011, the European SOILSERVICE project [2] examined the impact of varying levels of intensive agricultural use on soil ecosystem services throughout Europe. The project results revealed that intensive farming results in the loss of soil biodiversity. Monocultures, intensive fertilisation, frequent application of pesticides and a lack of organic matter to sustain soil organisms have all contributed to declining soil biodiversity and humus loss.

If soil life decreases, the contribution of soil organisms to maintaining soil functions also is lost. For instance, fungal-based food webs show less nitrogen loss due to leaching. They are also able to store more carbon in the soil. Examinations in the SOILSERVICE project show that the organisms making up fungal-based food webs are especially vulnerable to the intensification of agriculture. Mycorrhizal fungi, in particular, are sensitive to fungicides and mineral fertilisers and their biomass declines drastically when they are exposed to these substances. Mycorrhizal fungi also play a significant role in supplying crops with phosphorus, as they can free phosphorus from the parent rock and make it available to the plants. If this function is no longer performed – as is the case for the most intensively farmed soils – then plants must rely exclusively on external sources for their phosphorus supply. This aggravates the problem of globally limited phosphorus reserves and polluted phosphorus fertilizers [3].

Fungal-based soil food webs have many other benefits: they make soils more resistant to drought and release less carbon dioxide. In addition, mycorrhizal fungi can increase the resistance of crops to soil-borne and some leaf diseases [4]. We should use these services of soil life instead of decimating it.

Humus loss

There is an organic carbon lack in arable farming, which tends to monocultures and intensive (mineral) N- fertilization. There is not enough rotting material in the soil, which feeds the soil life, while the rooting is monotonous. An evaluation of the German Federal Institute for Geosciences and Natural Resources (BGR) from 2008 in Germany stated that 4 percent of the soil contained less than 1 percent humus, 30 percent have 1 to 2 percent humus. Contents of 2 to 4 percent apply to 47 percent of the soil [5]. In my experience from 20 years of agricultural advice and training in soil protection, the vast majority of intensively managed agricultural soils contain no more than 2 percent humus. According to agronomists from the European Soil Bureau Network (ESBN), soils that contain less than 3.6 per cent organic matter are in the early stages of desertification [6]. The cross-compliance conditions for the reception of CAP direct payments call for a humus content of 1.0 to 1.5 per cent (depending on the soil's clay content). Compared with the ESBN's findings, this would certainly seem to be insufficient for maintaining soil functions and enabling adaptation to climate change.

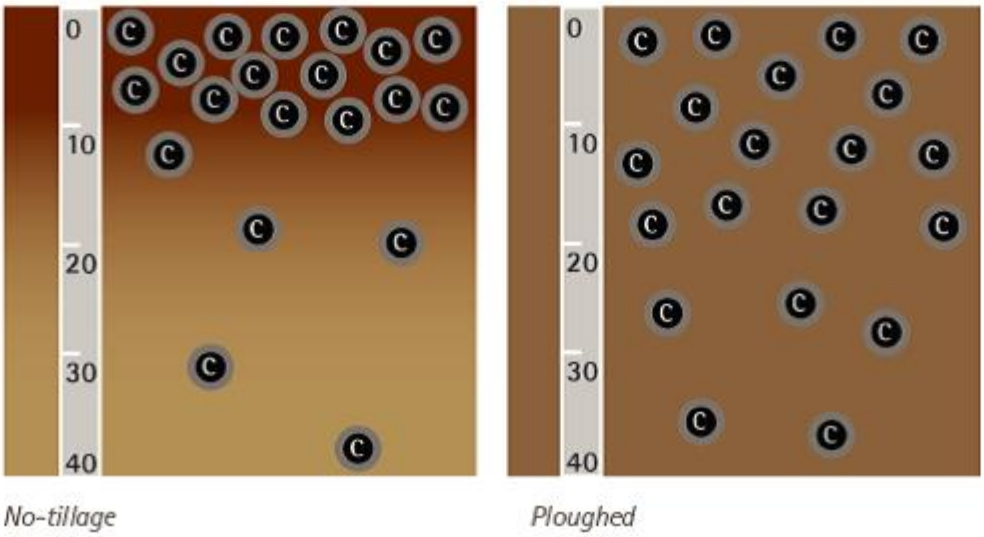
Not just sequestering C but humus-building initiative

What we need is not just putting as much carbon into the soil as we can, but a humus build-up initiative for our soils: with high quality organic fertilizer, which brings enough "living" carbon into the soil, with diverse crop rotations, in which humus-consuming and humusgaining crops alternate, with mixed and under cropping. This is what organic farming has successfully practiced for years. Implementing permaculture and agroforestry would go some innovative steps further. In the vast majority of international and European policy recommendations, however, instead of a questioning of fertilizer management, we find very often the indication that no-tillage or conservation tillage can be used to increase humus content. That is just wrong.

Missing assessments lead to incorrect interpretation:
no-tillage or conservation tillage

Simple technical solutions, such as the conversion to conservation tillage or no-tillage (sometimes also called conservation agriculture – and fundamental part of so called climate smart agriculture) do not help us with the humus question. This technique produces neither a healthy soil structure [7] nor more humus content because humus accumulation depends primarily on how much and which organic material is brought into the soil and not whether it is ploughed or not. To stop ploughing, contrary to often-repeated claims, does NOT result in any noteworthy humus build-up. This has been confirmed by an evaluation of 69 worldwide comparisons [8].

The Thünen Institute in Germany also comes to this conclusion: “Regarding conservation tillage, a shift of humus between the horizons but no carbon accumulation was observed under Central European conditions. [9]“ The incorrect claim comes simply from missing measurements in deeper soil horizons: Many studies showing carbon accumulation had measured the carbon content in depths of only 15 cm or less but not below.



Carbon distribution comparing no-till to ploughing

In terms of climate relevance, the technology is even counterproductive, as the N2O emissions (which are 300 times more climate warming as CO2) increase because no-till-soils show more compaction, which promotes nitrous oxide emissions [10]. At the same time, the use of broadband herbicide glyphosate increases as no-tillage is not possible without it in conventional intensive agro systems. As glyphosate and its degradation products have a negative impact on earth worms and other soil organisms [11] the claim “soil protective” should finally be debunked as fake labelling. Nonetheless, many recommendations on climate action at EU level and some of the agricultural support programs of EU member states (CAP pillar 2, agro-environmental measures) still incorrectly assume carbon storage and claim no-tillage as soil protective (even farmers associations [12]).

More protection from erosion with crop diversity

Practicing no tillage, crop residues are no longer incorporated into the soil and remain at the surface. Granted, this residue layer does indeed protect the soil from erosion. However better effects can be achieved with intercrops or under sowing. Intercropping and under sowing, beside erosion protection, perform the additional service of providing food for soil organisms and of loosening and stabilising the soil aggregates with their roots and polysaccharides. Soil organisms are also fed humus build-up takes place and a “sponge structure” can develop [13]. It has often been observed that compacted no-till soil structure shows many macro pores (high earthworm population). However, if there are a lot of vertical macro pores with a high capacity to absorb rainwater (a characteristic judged to be positive by most studies), but not enough micro pores, there is a risk that the percolation water may run quickly and almost unfiltered into the groundwater. Therefore, the water is not kept and cannot be stored for later periods of drought. Water storage (and cleaning) works only with a sponge structure built by microorganisms. In terms of climate change, such compacted soil structure is detrimental to drought resilience and harvest security [14].

No-tillage only makes sense in high diverse agroecosystems, for example in organic farming – where diverse roots of diverse crop mixtures take over the soil loosening as well as aggregate stabilisation. But in this case, we gain erosion protection and humus accumulation due to the diversity in the ecosystem and the organic fertilization and not due to the lack of ploughing [15].

Need of system change

Described symptoms of soil degradation in Europe are simply not compatible with the “Cross Compliance” agreement’s principle, which makes the receipt of direct payments conditional upon ‘‘maintaining the land in a good agricultural and environmental condition’’ [16] – neither where soil protection is concerned, nor if adaption to climate change is necessary.

With regard to soil services that are important for the long-term sustainable production of food and other important ecological services in European landscapes, there is an urgent need for action. In order to cope with heavy rainfall events and overcome drought periods in agriculture, the soils in Europe need an active humus management initiative that lives up to its name. In developing stable and resilient food supply systems innovative solutions from agroecology will bring us much further than just technical solutions, high-tech farming or big data.

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The original article can be found at the ARC2020 website.

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[2] SOILSERVICE (2012): Conflicting demands of land use, soil biodiversity and the sustainable delivery of ecosystem goods and services in Europe. SOILSERVICE has brought together natural scientists and economists in an inter- and transdisciplinary approach in order to understand how competition for land use influences soil biodiversity, and sustainable provision of ecosystem goods (bioenergy, food and timber, nature) and services (clean water, control of greenhouse gases, control of pests and invasive weeds). SOILSERVICE has studied ecosystem services and biodiversity in European agricultural soils in order to test and promote strategies for sustainable management of soil resources, and to mitigate degradation of soils that are under pressure from intensive land use, climate change and urbanisation.

Partners: Lund University, SE; Swedish University of Agricultural Sciences, SE; Netherlands institute of Ecology of the Royal Dutch Academy of Arts and Sciences, NL; Justus-Liebig-University of Giessen, DE; University of

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arc 2020 agricultural & rural convention

"The earth has music for those who listen"

William Shakespeare

Sustainable Soil Management

Mario Catizzone

Think first, and then consider about soil

It sometimes feels like one category of scientists that no-one listens to is the soil scientists. We cannot blame people for that. We as soil scientists have to blame ourselves because for long time we focused exclusively the soil profile and its classification. Luckily, things have changed, and soil science has evolved to consider soil in its ecosystem and now focuses on how to restore soil fertility and functions.

Here we can list few points acknowledged by soil science community:

Soil functions within its ecosystem

Soil, in addition to food production, affects vital ecosystem services such as water absorption, filtering and buffering capacity, as well as biodiversity.

Soil time cannot be "compressed"

To create 1 cm of soil it takes, according to natural condition, between 100 and 200 years. When you see a soil profile of 80 cm, you are contemplating between 8000 and 16000 years of history.

Soil consumption

Best agronomy technologies can do nothing in front of soil loss (percentage of arable surfaces) due to urbanisation, soil sealing, land grabbing and pollutions. The multifunctional nature and competing demands on soil and land resources from various actors (builders, planners, administrators, unions, CSOs …) need to be balanced with each other.

Financial threat to soils

There is a financial speculation on soils. Considered a highly profitable investment, more and more speculators buy land subtracting it from small farmers. In this way, the financial sector can control the whole chain of marketing from farm to fork. These financial aspects interest also different mafias for money laundering.

Equity: the world soil parameters

About 33% of world global soils are estimated moderately or highly degraded. By 2030, the Sustainable Development Goals ask for progressively improved land and soil quality. The SDG's demand that we *"restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world".*

These points are few and clear. #SoilMatters puts on the table different issues seeking solutions, best practices, and ecological initiatives to implement. What we recommend is to analyse each issue but always within the frame of with the above-mentioned points.

Furthermore, Voluntary Guidelines for Sustainable Soil Management (UN FAO) indicates the good actions that each soil actors should adopt.

These guidelines were developed through an inclusive process within the framework of the Global Soil Partnership over 2016 and published in 2017. They emphasise the following areas for Sustainable Soil Management (SSM).

- Minimize soil erosion
- Enhance soil organic matter content
- Foster soil nutrient balance and cycles
- Prevent, minimize and mitigate soil salinization and alkalinisation
- Prevent and minimize soil contamination
- Prevent and minimize soil acidification
- Preserve and enhance soil biodiversity
- Minimize soil sealing
- Prevent and mitigate soil compaction
- Improve soil water management

Equally, SSM is associated with the following characteristics:

1. Minimal rates of soil erosion by water and wind;

2. The soil structure is not degraded (e.g. soil compaction) and provides a stable physical context for movement of air, water, and heat, as well as root growth;

3. Sufficient surface cover (e.g. from growing plants, plant residues, etc.) is present to protect the soil;

4. The store of soil organic matter is stable or increasing and ideally close to the optimal level for the local environment;

5. Availability and flows of nutrients are appropriate to maintain or improve soil fertility and productivity, and to reduce their losses to the environment;

6. Soil salinization, sodification and alkalinization are minimal;

7. Water (e.g. from precipitation and supplementary water sources such as irrigation) is efficiently infiltrated and stored to meet the requirements of plants and ensure the drainage of any excess;

8. Contaminants are below toxic levels, i.e. those which would cause harm to plants, animals, humans and the environment;

9. Soil biodiversity provides a full range of biological functions;

10. The soil management systems for producing food, feed, fuel, timber, and fibre rely on optimized and safe use of inputs; and

11. Soil sealing is minimized through responsible land use planning.

MARIO CATIZZONE is an Italian Agronomist and Soil Scientist. He has worked for NGOs, IGOs and the UN FAO on activities related to environmental and agricultural concerns. From 1989 to 2013, he was Scientific Officer at the European Commission, Research Directorate General (RTD), dealing with environmental research (soil, water, remote sensing, terrestrial ecosystems and biological diversity), agriculture research (farming systems) and with sustainable development, in developing countries and in Europe. He then became Senior Scientific Officer at the 'International Dimension of the Framework Programme' with specific responsibility on Africa, India and China. he was detached two years in Sweden at the "Swedish Environmental Protection Agency" – NV (Stockholm) and six months at the Africa Union Commission Headquarters (Addis Ababa, Ethiopia). In 2014 he joined the Save the Landscape Forum (Forum Salviamo il Paesaggio) where he helped create the Soil Europe Group in which he acts as a referent.

The original article can be found at the ARC2020 website.

> *"But it's not just about what's on top, it may be about what's deeper down too. Published work in Nature Scientific Reports in 2017 revealed soils with high clay content in deeper layers lock away carbon for much longer, and at much greater depth than previously known."*

Soil, Carbon and Policy

Oliver Moore

Where now for 4p1000?

The role of farming in climate change mitigation is controversial and fraught. The UN COP (Conference of Parties) Climate Change process has tentatively introduced soil and carbon sequestration into its workings, via 4 pour 1000. However, the role of particular agronomic practices involving livestock is under special scrutiny. Does livestock release more than it sequesters, or does the farming model matter? What about deep carbon storage? And how will policy makers work with new research and 4p1000?

What is 4p1000 – 4 pour 1000?

The role of the 4 per 1000 initiative *"aims to increase the soil organic matter content and carbon sequestration, through the implementation of agricultural practices adapted to local environmental, social and economic conditions, as proposed in particular by the agro-ecology, agroforestry, conservation agriculture or landscape management."*

The name comes from the aim: increase carbon sequestration by four parts per 1000 per year for 20 years. (Pour comes from French, it is variously called 4P, pour or per 1000) Governments and organisations around the world are partners in this, which was launched at COP22 in Marrakesh. Interestingly, it was not discussed at COP23 in Bonn.

Recent Research Critiques 4p1000

However recently published research has criticised the potential of initiatives like 4p1000. The mitigation potential of soil carbon management is "overestimated by neglecting N2O emissions" according to a February publication in Nature Climate Change.

This study, which specifically name checked 4p1000 in the opening line of its abstract, states that "soils can be a net sink of greenhouse gases through increased storage of organic carbon". However, "unless the use of fertilisers is adjusted to balance additional nitrogen inputs, any climate change mitigation benefit may be offset through higher nitrous oxide (N2O) emissions from soil" the researchers found. This impressively large study involved over 8000 sites around Europe.

Crop residue retention, lower soil disturbance and nitrogen-fixing cover crops were all beneficial for carbon sequestration, the researchers noted, but, importantly, only for a set period of time. Eventually – in a matter of two to four decades these practices eventually lead to net emissions. Because of this mitigation does occur for the first two to three decades, but, after that “nitrogen inputs should be controlled through appropriate management practices to counteract N2O emissions from soil.”

Another very recent publication is specifically critical of the 4p1000 approach. Using a site with soil data available from the mid-19th Century on, the Rothamsted research, published in Global Change Biology calls out 4p1000.

This publication does note other benefits of increases in soil organic carbon, but as Paul Poulton, lead author, put it, “the results showed that the “4 per 1000” rate of increase in soil carbon can be achieved in some cases but usually only with extreme measures that would mainly be impractical or unacceptable”.

An example given is “moving from continuous arable cropping to a long-term rotation of arable crops interspersed with pasture led to significant soil carbon increases, but only where there was at least 3 years of pasture in every 5 or 6 years”. This is also described as “uneconomic under present circumstances” and “would require policy decisions regarding changes to subsidy and farm support”.

Failure – or failure of ambition?

So despite the Rothamsted researchers finding, in 65% of the cases (involving 114 onsite tests) increases in soil carbon at or above the target level, 4p1000 is “unrealistic”. As the paper itself states, one of the four main problems is that “the necessary change of management would be uneconomic to the farmer under current conditions or impractical for some other reason. To implement such changes would probably require changes in government policies, regulations or subsidies to promote the practice.”

There are a number of issues with this. In a context of an ongoing CAP reform process, and it’s supposed purpose of providing public good for public money, the simpleton in me thinks that there is an opportunity to bring in these kinds of measures. Indeed, these are the kinds of measures in the original CAP plans of the previous Commissioner in 2010.

For example, greening is a compulsory component of Pillar one of the CAP, supposed to make a contribution to agri-food’s environmental and climate change performance. Originally, it was intended to include not just crop diversification – a fairly meaningless term – but actual crop rotations. With the CAP greening failing so badly in delivering environmental and climate change improvements, as the European Court of Auditors clearly laid out in December, the case for a more robust agri-food policy with real delivery of deep greening is clear. Greening has led to change only on 5% of farmland, and is basically, despite the name and the rhetoric, still simply income support.

We need a CAP that becomes a Marshall Plan for bettering agriculture and food, not a band aid for business as usual.

There are some signs that the UK may be moving towards environmental performance in agri-supports, and away from direct payments. The new delivery vehicle offers some hope, however tentative, that this may happen with CAP too. (Alan Matthews compares both in a blog post). Indeed, moving away from direct payments was also the main recommendation of the European Parliament's Ag committee's Dorfmann report, as we revealed.

In a context of tighter post Brexit finances, bigger challenges on the horizon, and such a verifiable poor performance of farming and food in environmental and climate change terms, is it really so ambitious to expect farmers to adjust their agronomic practices to justify the public money they receive?

Digging Deeper

Emerging grazing techniques, such as adaptive multi paddock grazing, has been shown in studies, including this 2018 publication in Agricultural Systems to be beneficial in terms of carbon and climate change mitigation in a number of ways. Not only can adaptive multi-paddock grazing "sequester large amounts of soil C" (Carbon), the emissions "from the grazing system were offset completely by soil C sequestration" according to the study. Thus, "soil C sequestration from well-managed grazing may help to mitigate climate change."

And increasingly, the positive role of soil microbes for carbon sequestration in grassland systems has been noted by researchers, including a team published in Geoderma in 2017. "SOC soil organic carbon gains were essentially due to increases in POM-C (particle organic matter carbon) and MBC (microbial biomass carbon), accounting for 50.04 and 15.64% of SOC sequestration at 0–30 cm, respectively." And this carbon could be built in under 80 years, the researchers claimed.

But it's not just about what's on top, it may be about what's deeper down too. Published work in Nature Scientific Reports in 2017 revealed soils with high clay content in deeper layers lock away carbon for much longer, and at much greater depth than previously known.

While topsoil carbon is quite volatile, at deeper layers, carbon can be stored for longer. This is especially the case for "grassland soils with high clay content in deep layers, where the clay particles have washed from the topsoil to the subsoil."

The researchers claim that the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC) "has thus far only considered the top 30 cms of soil, known as topsoil."

While this is indeed where most of the carbon is, as Dr Gemma Torres, lead author, explained: "most of the carbon in the topsoil is bound to the larger soil particles. These provide a tasty meal to soil organisms, which quickly release the carbon back into the atmosphere. This means that most of the carbon in the topsoil is locked away for less than 10 years".

And this could have policy implications too. Speaking in 2017, Rogier Schulte said that "the new proposals by the European Commission for an Energy and Climate Framework for 2030 allows for a degree of flexibility in using soils to offset some of the agricultural emissions. After all, locking away carbon into the soil is one of the more cost-effective ways in which agriculture can contribute to reducing greenhouse gases in the atmosphere. Our research shows that grassland soils with high clay content in deeper layers have even more potential than previously thought and can play an important role in the plans of EU Member States to meet their climate obligations; this opens up opportunities to incentivise climate-smart land management, customised for contrasting soils."

The Stakes (for steaks) are High

All of this of course throws up as many questions as answers. Does this deep carbon let conventional grazing farming practices, and all that goes with them, off the hook? What about livestock farming's other impacts – including its production of other greenhouse gases such as Nitrous Oxide and Methane? There are arguments on both sides for this both these gases. Will EU Member States just take this as an opportunity to reduce their already meagre climate change activities? Why not just re-wild this land, and introduce nature based economies, as George Monbiot and others have argued?

Most pertinently, how does this, to use one of the terms that describes it, regenerative agriculture research, square with the high profile Grazed and Confused report, led by Dr Tara Garnett of the Food Climate Research Network? This report considered 300 studies and found extensive grazing at best can remove between 20% and 60% of the greenhouse gas emissions it produces. Much can – and should - be said about this study, which, among other things, emphasises other regenerative practices not involving livestock, and also points to the paucity of animal protein produced from extensive grassland compared to other sources. These are the questions to which we must turn next, in considering where now for 4p1000.

Of course, sustainable farming is not just about climate change. Indeed, "one could argue that it is precisely this 'single issue' approach to investigating problems and solutions that has got us into the mess we're in in the first place". And who better than Tara Garnett of FCRN to say this?

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The original article can be found at the ARC2020 website.

"In Emilia-Romagna in Italy the conversion of 15,000 ha of agricultural soil caused a net loss of the calories needed by 14% of local population. When economic, environmental and social criteria are balanced, the planning of land–use systems could be perceived as sustainable."

Change of Land Use

Riccardo Scalenghe, Francesco Malucelli and Mario Catizzone

What do we really loose, when we change how land is used?

In Emilia-Romagna in Italy [1] the conversion of 15,000 ha of agricultural soil caused a net loss of the calories needed by 14% of local population. That's 425,000 people. But, this fact has a minor impact in financial terms, because such a loss in agriculture production is just 0.02% of gross domestic product of the region. In fact, the income from the new land use is greater than the one generated by agriculture, as in the case of extraction of raw materials, or by urbanization.

Nevertheless, there are negative consequences at wider scales – human health, cultural heritage, biodiversity, carbon sequestration and hydraulic security. Some of them are quantifiable but none is refunded to the whole society.

When economic, environmental and social criteria are balanced, the planning of land–use systems could be perceived as sustainable. This is especially the case when natural soil functions are considered – its best to avoid aberrations of natural processes while soil disturbances are extremely demanding to correct.

Unfortunately, today, too often when natural functions of soils are inadequate for certain types of land use, technology is used to try to overcome the situation. So, soils too wet to permit the growth of crops are drained, dry soils are irrigated, and poor soils enriched with fertilisers. This vanishes the link between land use and soil functions. As drainage can induce oxidation and, in turn, greenhouse gas generation, irrigation can salinize, and fertilization can provoke eutrophication, it's clear that altering natural soil functions comes at a price.

Natural soil functions then, should be our point of reference. A soil should perform numerous functions: the production function, producing crops; the carrier function, bearing traffic and buildings; the filter-, buffer- and reactor function, allowing transformations of solutes passing through; the resource function, providing base materials for industry; the habitat function, providing a living environment for plants and animals, and the cultural and historic function, reflecting past practices.

Thus, soil has to be considered the basis of the human right to healthy and sufficient food and it should not be treated as an ordinary item of merchandise. At the same time, we have to start from the assumption that it is not just the job of businesses and builders, in a market economy like ours, to take full and complete responsibility for how soil is treated in our society. It should be easy to enable optimal soil functionality, in a way that balances the competing needs from various actors.

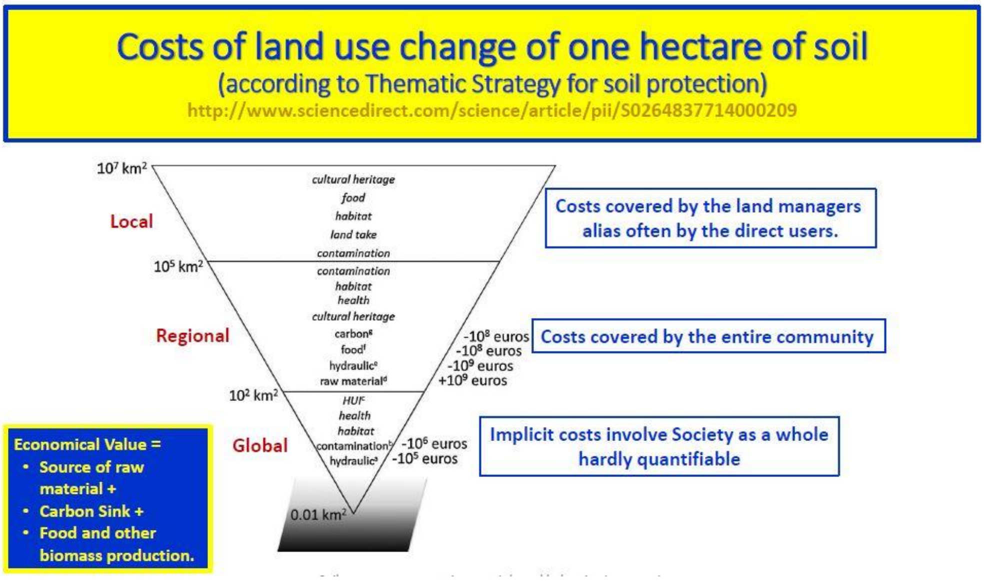
To promote awareness and responsibility among all concerned actors related to soil is crucial. It needs to be clear that taking decisions on transition from one land use to another one has consequences on how soil functions and must be considered with care. Local choices are crucial driving factors of soil management at wider scale: implicit costs in altering an individual hectare of soil disturb a much larger group of people than the one who decided on the transformation.

Returning to our opening point, we note that, in Italy, municipalities have significant freedoms in determining their own land use policy.

Below we summarise the effect on diverse scales of changing land use for a single hectare of land in monetary terms. The triangle is portioned into three slices: local, regional, and global.

Costs from negative ramifications of the top portion of the triangle are really covered by the land managers and, sometimes, by the direct users. In the second portion, the regional level, costs are covered by the entire community that experiences land transformation. Implicit costs at the bottom of the triangle involve society as a whole. They are scarcely measurable and never charged to beneficiaries. The total costs of the transformation of one hectare may sum up to 1010 €.

What's more, this still leaves out other possible types of impact that further increases the embedded cost of transforming land use. Examples include as site-specific decontamination, nursing people affected by related diseases, loss of biodiversity, and additional energy requirements.



Cost of land use change of one hectare of soil

Ramifications of land use change of one hectare of soil at local, regional, and wider scales. Spatial influence is on the left side and economic impact on the right one. Words in italic indicate ambits where costs are difficult to estimate.

Summary

The authors estimated the value of the productive soil lost in the Emilia-Romagna Plain, Italy. The value of the land use changes for the period 2003–2008 at regional scale was 109 euros. The agricultural soil losses mean a vanished food security of 440,000 people equivalent per year. Local land use change produces massive social environmental and economic consequences at wider scale.

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The original article can be found at the ARC2020 website.

[1] Malucelli et al., 2014 [https://doi.org/10.1016/j.landusepol.2014.01.019]

REF: Malucelli, F., Certini, G., Scalenghe, R., 2014. Soil is brown gold in the Emilia-Romagna region, Italy. Land Use Policy 39, 350–357. Doi: 10.1016/j.landusepol.2014.01.019

"A sustainable food system is not about reducing animal-product consumption so to 'free-up' land for direct-for-human-food plants: rather, it is about using the land now used for feeds for shipping to animals confined elsewhere, for grazing livestock – be they ruminants, pigs or poultry."

Soil, Ruminants & Sustainable Food

Stuart Meikle

Food production must take account for a whole plethora of distinct yet inter-related areas: climate-change and GHG's, good nutrition, better animal welfare, reduced pollution, enhanced biodiversity, while rewarding both farmers and rural communities. Too rarely mentioned is food production's role in restoring and maintaining soil health and fertility.

Interestingly, it is only through the latter that we can link everything else together to create a truly sustainable food system.

If there is a universal panacea for our food systems, it can be found in how we restore the health and productivity of our soils. By saying such one could however be guilty, as is often the case, of allowing a single issue to dominate. Whereas identifying a sustainable food system, differing as they must region by region, is in fact a complex process that requires the joining of numerous dots across a broad canvas. If you focus on one issue alone, lo and behold, unforeseen consequences happen elsewhere.

And yet, intriguingly, as one looks at soil regeneration, the solutions for many of our other problems emerge.

The following is not a narrow scientific treatise. Rather, it summarises my own ideas on this topic, based on extension work conducted over the years in different farming locations around the world.

Food system transformation for our soils

We are told that our arable soils have sixty to a hundred years' harvests in them. From walking some of the fields of Eastern England in recent years, it is a statement that it is difficult to disagree with. If we are now to rely on natural weathering to rebuild soils, we are talking thousands of years to create very little.

It is, however, the loss of soil organic matter that is of real concern because along with it goes both the microbial life that creates a healthy plant-growing environment and the very bottom of the food chains for so much of our declining fauna.

The soils of most of the world's broad-scale arable regions were formed under ancient forests or grasslands. The drainage of marsh and river flood plains created others. Of these, the peat within, say, the English fens has long been disappearing whilst those soils naturally regenerated by riverine action are limited or, worse, now urbanized.

Although we focus on tropical forest clearance, much of which is linked to palm oil and soybean production, there should be no less a concern for the loss of ancient Savannah or grasslands. As a human society, we are still unsustainably consuming soil fertility by ‘ploughing out’ ‘old’ soils; not to mention releasing yet more highly stabile soil-carbon.

We could and should be looking to recreate new, ‘ancient’ forests, to sequester and store carbon, to create forest-grown timber resources and to regenerate soils. It may never be necessary for future people, centuries hence, to exploit these soils as we have done, but they should have the option. If they do, they will probably have learnt their lessons from history.

We must, nonetheless, not overlook forests as food sources and there are plants and animals that can thrive in a woodland environment. We should not see forestry and food as mutually exclusive, it should be about both.

Rebuilding soil organic matter can mean vast composting operation to recycle organic materials and nutrients from the point of food consumptions [urbanizations] to food production zones. The latter may be rural and remote so while it may be feasible at a local level, it is hardly realistic on a global scale.

We have been very successful at using artificial nitrogen to ‘cycle’ nitrogen, albeit with vast and polluting seepage and fossil fuel costs, but where does this leave the cycling of organic matter into our plant-growing soils? And it is the loss of soil organic matter that is so destructive, be it in terms of soil fertility and health or, crucially, its ability to hold and store moisture. And we should not overlook how vital healthy soils are to the broader water resource management issues.

From a practical perspective, the only instrument we have available to restore soil organic matter, soil health and soil fertility is the farmed animal. It is, nonetheless, not about farming animals in isolation of the land that provides their feed and fodder, it is about maintaining them near the land that sustains them.

Further, animals must be reintegrated, preferably through grazing, with the soils that we use for direct-for-human-food, plant production. The latter itself being unsustainable on a large-scale without constant regeneration. ‘Regenerative agriculture’ is no hollow term, it describes the food systems that we must reach sooner rather than later. This is, nevertheless, nothing new, it is to return to the farming husbandry that we understood for Centuries, and only recently forgot.

Food policy must begin with integrated livestock

The last significant writings specifically about British farming and food policy were published either side of the Second War and they make interesting reading. In them, the fundamental principle behind any policy was the maintenance of soil fertility. The foundation of food and farming policy had to be soils; and there was no debate about it. It was only since around 1960 that we have, policy wise, neglected the soil. The consequences have been massive and, if not soon rectified soon, will be even greater for coming generations. Simply, we have compromised their food security.

From here on it must again be all about soils. Surprisingly for some, the changes to our food system that soil regeneration will dictate, will begin to resolve numerous other food-linked issues; many of which will be highlighted below.

Although some will continue to promote a simplistic 'eat plants for a sustainable food system' solution, we must return to integrated, nutrient-cycling, mixed farming. We cannot, however, continue to be profligate with animals in food systems and they need to be outdoors as much as is practicable and grazed in ways that regenerate and maintain soils – period.

Ruminants are a strategic resource that we must husband and use with care. How and where we use them must become the central pillar to farming and food policy; for wherever it is being written.

If there is a universal panacea for our soils and, henceforward, our food systems, it lies with how we manage farmed livestock going forwards. 'Eat less meat and dairy and eat better' is a positive approach, at least for the overly-nourished, but by 'better' we must recognize that the core principle of 'better' is that the food comes from farming systems that fully restore soil health and fertility.

To provide what for some will be a radical, even controversial conclusion, a sustainable food system is not about reducing animal-product consumption so to 'free-up' land for direct-for-human-food plants: rather, it is about using the land now used for feeds for shipping to animals confined elsewhere, for grazing livestock – be they ruminants, pigs or poultry.

Long-term we must live without a style of farming that is divorced-from-the-land and confined. We cannot live without soil-regenerating mixed farming, which is inclusive of livestock. It is all about returning to mixed farming systems on arable land [as per ley-farming] or soil-focused, pastoral, grazing livestock systems on permanent, multi-species pastures, including 'agro-forestry' woodland and orchard pastures.

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The original article can be found at the ARC2020 website.

"If there is a universal panacea for our food systems, it can be found in how we restore the health and productivity of our soils."

What do we want of our soil?

Roy Neilson and Blair McKenzie

What do we want of our soil? And how do we get it?

What do we want of our soil?

When talking with groups of farmers about soil, one way to get participation is to ask, "what do we want of our soil?" This allows us to develop a list of the things or functions we want from our soils. This usually includes to:

produce food and fibre; be soft and stable so that the soil holds together, but still allows roots to proliferation to depth; hold water and nutrients but also to drain away excess water so that the soil does not - become water logged; be free from contaminants including heavy metals, pesticides and hydrocarbons (including plastics); transform and filter the wide range of solids and fluids that are added either naturally or by humans; have functioning "good" biology to cycle organic matter and mineralise nutrients; and be free from "bad" biology as pests and diseases.

When put in that context we expect our soils to do, provide and deliver a wide range of things. This is without bringing in any of the functions or uses of soil that go beyond the farm gate. Beyond farming, increasingly we are looking for our soils to mitigate climate change (by sequestering carbon), preserve biodiversity (remembering how much of global biodiversity is actually in the soil) and prevent flooding (by ameliorating flow rates). In some cases that flood prevention is to protect infrastructure (roads, railways, towns) that has been built on the soil and thus prevented large areas of soil from contributing to the function!

But even confining ourselves to a farming context under values the diversity of functions we expect from the soil. This is because "farming" is not one thing! The list (above) includes "to drain away excess water". This seems an innocuous requirement until we mention: rice! For rice production, particularly as paddy, the absence of drainage is required. While rice is an extreme, other crop will have greater or less need of drainage and may have different requirements at different growth stages. So, we need and expect soil to be adaptable and responsive to deliver some functions continuously and others to different extents at different times.

Simple Definitions – soil texture and structure

It is necessary here to state a couple of simple definitions. It is necessary because the misuse of language about soil is commonplace and leads to false and misleading claims. Soil texture is the amount of sand, silt and clay that comprises a soil. Texture can only be changed by selectively adding or removing mineral particles. While this may happen e.g. to create a golf course it does not happen as part of normal farm practices. As the particles that comprise the soil remain unchanged, similarly the mineralogy of the particles at any location is also constant. Note that the soil texture is the inorganic material – it is independent of organic matter. Practices that change the organic matter status of soil do not change texture. The arrangement of soil particles and the pore spaces between them is soil structure. It is in the pore spaces that fluids (water & air) and the soil biota exist.

Soil structure can be easily changed. By definition, tillage (be it with a plough or with a spade) changes the arrangement, but so does the mole or the earthworm creating a burrow, the compaction (decreasing the amount and arrangement of pores) caused by machinery or animals, and the swelling and shrinking of groups of particles as the soil wets and dries or freezes and thaws. The ability of the soil structure to hold together and remain unchanged under external influences (e.g. if wet rapidly by rain or irrigation) is the soil stability. Soil management deals with soil structure and stability, and it is from these properties that there is the ability to alter or manage soil functions.

Soil management

One of the first rules for the medical profession when dealing with a patient is “to do no harm”. Similarly, for farming practices to improve soil functions an underlying principle should be “do not intervene without a clear purpose”. This may sound obvious, but there can be a tendency, particularly where machinery is available, to perform operations such as tillage, irrigation, or applying amendments simply because the equipment or resources are available. From a soil management perspective anything that changes the soil structure unnecessarily is likely to make the soil less stable more vulnerable to threats such as erosion and compaction.

For any given soil texture and mineralogy, the soil structure and its stability are driven by the concentration and charge of the cations in the soil solution and by the nature and amount of organic matter. Ultimately all the organic matter in soil is derived from plants, whether as root exudates as the plant is growing, parts of the above ground plant or even as manure after the plant has been consumed by heterotrophs. The amount of organic matter in a given soil at a given time depends on a range of factors including site conditions, biological activity and soil management.

Organic matter

In general, the amount of soil organic matter is correlated with soil properties connected to soil functions. For example, water retention, porosity, stability, fluid transfer and ability to rebound after loading are all generally positively correlated with increased concentrations of organic matter in soil. Thus, practices favouring increased soil organic matter are generally associated with improved soil functions.

Before we consider individual practices to improve organic matter and thus soil functions, the distinction between carbon and the various forms of organic matter needs to be made. Organic matter in plants or in soil is composed of carbon, hydrogen, oxygen, nitrogen, phosphorus, sulphur and numerous other elements in decreasing amounts. Over time the ratios of these elements in soil organic matter tends to stabilise. When measuring or estimating the amount of organic matter in soil it is common to simply determine the amount of carbon that can be burned off and to use that as a surrogate for organic matter. This works well under most circumstances, however there is scope for deception as e.g. adding coal (a form of organic carbon) to soil will not deliver improved functions.

Practices that increase inputs of organic matter to soil include:

- maintaining growing plants for as much time as possible,
- adding manures or plant residues and
- leaving crop residues on the soil surface.

Practices such as appropriate fertilisation and irrigation will support greater plant productivity. Conversely practices that are likely to decrease amounts of organic matter in soil include:

- burning crop residues (now largely banned),
- excessive cultivation that exposes organic matter previously locked within the soil pores to oxidation and mineralisation, and
- leaving the soil bare (without plants) for long periods.

Breakdown of some organic matter to forms available for plant uptake is an integral part of the carbon cycle. Many of the processes that bind organic matter to the mineral particles and that mineralise matter to available nutrient forms are driven by the soil biology. Increased soil organic matter typically supports a more diverse soil biota and a more resilient food web that helps maintain a fully functioning soil.

What do we do to our soil?

Not all amendments applied to soil to improve plant production are organic. Lime (as calcium carbonate) is applied to increase soil pH (i.e. decrease acidity). Gypsum (as calcium sulphate) is applied to improve particle aggregation particularly in saline or sodic soils. These amendments are intended in the longer term to improve plant production but may in the short term stimulate the activity of the soil microbiology and lead to mineralisation of organic matter. So, as noted above, there is a need to consider soil functions over different time scales.

The production of crops (particularly annual crops) aims for uniformity so that seedlings emerge at the same time, plants are all at the same stage of development when irrigation or fertilisers are applied, and waste is minimised with all plants ready for harvest simultaneously.

However, many of the above functions are most effective when there is heterogeneity in the soil structure. For example, a wide distribution of pore sizes is needed; with large pores allowing drainage and aeration, intermediate sizes storing water available for plants and small pores protecting organic material. Each of the different sizes will provide habitat for the wide range of biological groups that mediate different soil processes. Here again there can be a trade-off between practices and the different soil functions (e.g. the production of food and fibre and the filtering and transforming of fluids).

One of the major threats to soil function acknowledged by the EU is soil compaction. With the average mass of agricultural machinery increasing the resulting compaction (i.e. loss of soil porosity, particularly larger pores that contribute to drainage) is associated with increased runoff, sediment transport and biotic redistribution (the movement of soil biota in runoff). Providing drainage and thus attenuating flood is compromised by compaction and farming practices that favour less massive machinery or control traffic should be favoured.

Conclusion

In conclusion, farmed soils deliver a wide range of functions and benefits, both for the farmer and society at large. With expanding populations and the loss of soil to housing, roads and other infrastructure associated with urbanisation there is less soil available to deliver these societal goods. In many cases there will be trade-offs between functions – both in space (e.g. large-scale crop production vs biodiversity) and in time (e.g. the response to amendments) and maintaining the functions and benefits that soil deliver is a balancing act of management strategies. There are multiple threats to soils and the first part of any consideration to improve soil functions must be the preservation and protection of the soils that we have.

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BLAIR McKENZIE an agricultural soil scientist at the James Hutton Institute in Dundee, Scotland has 30 years' post-doctoral research experience. He has worked in a wide range of agricultural systems from dryland cereal cropping to irrigated perennial horticulture in Australia, Asia and Europe. His research interests include using soil and plant sciences to manage agricultural production in a sustainable manner. In particular his research focuses on understanding soil structure and strength, their modification and interaction with plant roots, water, solutes, and soil fauna to deliver improved crop production. He is Secretary-General of the International Soil Tillage Research Organisation (ISTRO).

The original article can be found at the ARC2020 website.

Seven suggestions for new farm support mechanisms

Soil, Farming and Society

Stuart Meikle

Soil, Farming and Society: support mechanisms for the necessary transition

To complete our article series on soil – #SoilMatters – Stuart Meikle has written a comprehensive op-ed style article on the topic. In this, Meikle builds upon his own earlier contribution to the debate – Soil, Ruminants & Sustainable Food – above.

This new long read initially summarises his existing article, noting the range of areas food production is supposed to sort out, while also emphasising the role of livestock in farming systems. Meikle then focuses on three main areas: society and soil-focused farming; on-farm benefits of soil-focused farming; transitioning to soil-focused farming. This latter section includes seven suggestions for new farm support mechanisms. These seven suggestions focus on both payments and practices, and you can read them below in the excerpt we've selected. You can download the entire piece as a PDF, and read an excerpt below.

Part Three – Making the Transition to Soils Focused Farming
When one looks at what is sustainable production from a soils-first perceptive, one realizes that while climate change as food production is a major source of GHG emissions, focusing on soil restoration offers a multitude of benefits. If there is such a thing as a silver bullet when it comes to how we produce our food, returning our focus to building and maintaining soil fertility is it.

Also, given that a significant proportion of our increased atmospheric carbon has originated from our arable soils, it is where it must return. For many decades now, we have exploited the carbon deposits of millennia, be they from cleared forest or ploughed grassland and that must halt. We have continued to release carbon accumulated in soils and we must stop. Farming now must all be about how to regenerate our soils and accumulate soil-carbon stocks again.

I, like others, have concluded that some populations do need to eat less meat. Simultaneously, it must be about wide access to better quality meat and dairy produce. And by better one means its eating and nutritional qualities, ethical and rural-society-supporting properties, and the way its production delivers for the environment while regenerating and maintaining our soils.

However, where I differ from others is to say that eating less meat and dairy is not about freeing up the land used for grains to feed livestock so it can grow direct-from-the-plant human foods. It is about using that land, managed within cropping rotations, to graze livestock. In the extreme that we do not consume animal-derived products, we will still have to graze animals to build soil-fertility, such is their importance. There are also vast areas only suited to pastoral systems and there it is about how that land is best managed with livestock. Removing them is not the answer. There are few locations where stockless farming is the most appropriate system and where it is practiced its impact is often severe.

My rational is that it is only by so integrating pasture-reared cattle, sheep, pigs and poultry with food crops that we can efficiently close nutrient cycles and return organic matter and carbon to soils, restore degraded soils and produce nutrient-dense foods for a growing human population [noting that nutrient density is about food transport efficiency and our nutrition and health]. Categorically, food and farming must be foremost about soil restoration and maintaining soil fertility. The alternative is to rely on 'synthetic' foods that may yield unknown consequences for health and resource-usage.

One can say that our food systems are facing the most complex array of problems in human history. There will be further global population growth, but the problems are such that intensifying current food production systems will not work. In too many ways their resilience is already failing. It is also extraordinary that population growth is cited as a reason to intensify production in land-limited regions while land-rich countries have failing food systems, often due to endemic corruption. Feeding the World in 2050 is about resolving the latter, not further stressing the environments of the former. Of course, if one ignores many of the externalities, the intensification option can look attractive.

Nevertheless, the magnitude of the difficulties only truly come into focus when one accepts that soil degradation and loss is so great that their future productive life can now be measured in decades. Thus, 'crisis' is a major understatement for what will face the younger humans who are already alive today. Tinkering around the edges is no longer an option, we must change significantly and change swiftly. If not our children and grandchildren face a bleak future. As for us of the older generations, we must face up to the responsibility of repairing our damaged food systems now, not later. And for that, we must start with prioritising the fertility of the soils and the health of all that live within them.

Support for building robust, soil-first food systems

Implementing major change will incur significant costs to food producers. Within a European context, support is provided to the primary producers, often to the extent that it is the main provider net farm income. It is not an acceptable position, but it exists because prices have moved towards 'global' levels, albeit the products of concern are entirely produced and sold within a local or national market, while farms frequently remain small and cost inefficient. As the Sustainable Food Trust, recently pointed out, the externalities of food production are massive and not reflected in retail prices. Hence, cheap food on a total cost basis is a myth. Food is also not just about cost, it is more complex, and consumers can value numerous quality characteristics; locally produced and traceable being but two.

It is therefore reasonable to assume that taxpayers will retain a willingness to support farmers but in doing so they will demand a greater say in the production methods employed. Food security is often given as a justification for on-going farm support, but it is fatuitous argument if it is not recognized that support must be exchanged for the restoration of soils and the maintenance of soil fertility.

For farming to return a soil-fertility-first approach to food production will inevitably mean change. It will mean less single farm enterprise specialization and more 'mixed' farming. It will mean returning farm animals to land that may not have carried stock for half a century or more. It will be a radical change and have cost implications. The multiple benefits from doing so should, nonetheless, outweigh the costs. If one accepts the necessity for change, farm support needs re-focusing to encourage it.

We must not, nevertheless, replace one support system with another. A failure would be to change farming systems and remain in a position where annual payments are still needed to provide farmers and growers with sufficient for farm household income. Change needs to be comprehensive, but it must occur alongside reformed and improved linkages between the consumer and primary producer.

There is the argument that public goods should be paid for. We must, nonetheless, reach a point where soil maintenance, biodiversity preservation and water catchment are integral to normal farming system rather considered a public service. There will be exceptions to the rule in terms of public access, landscape management and specific, 'hot-spot' ecologically-focused schemes, but we should ensure that into the longer-term, markets reward farmers; albeit that there will have to be a transitionary period to get there. Agricultural policy must now be about managing that transition.

We must focus upon change and not the status quo

The Common Agricultural Policy is due for another reform and the UK is going its own way and will create its own farming and food policy. Will either deliver much-needed radical change? It is unlikely due to the lobbying power of many involved. There are also vested interests that would prefer the status quo. The position of some farming lobbies is an interesting one; why do they so voraciously support the continuation of a system that apparently does not deliver a sustainable farm income for the farmers that pay them? Is it just that they lack the vision to see better, viable alternatives?

The fear is that CAP reform and/or the development of new UK policy will neither recognize the need for change or introduce radical enough mechanisms to support farming through necessary change.

The car industry is now providing an example of the change required with its intended departure from the internal combustion engine to electric and/or fuel cells. It has reached a point where Society and its consumers are demanding change. The difference between car manufacturing and farming is one of scale and that individual farmers are unlikely to be adequately capitalized to handle such change. Hence, within the farming-food mix is the consumer-taxpayer. Eventually, it will be their combined purchasing and lobbying power that will be the dictating force behind policy. It is only a case of when. Farmers must prepare for change, embrace it, and ask for support to make the transitions needed.

Four principles should govern future payments made to farming and rural communities under a new food, farm and rural policy. They are, a) that they compensate farmers and land managers for income forgone, b) they reward the same for achieving public-interest-targeted actions, c) they must be tapered to allow business adjustment during transition periods, and d) they offer capital investments grants to encourage policy-identified changes to both farming systems and food supply chains.

A key objective must be to break the linkage between food production and annual payments. Farm incomes must be derived from the consumer and route-to-market mechanisms must operate to transfer a fair proportion of the retail price to the farmer. It is not about under-writing the uneconomic but ensuring that farmers who produce what consumers demand are rewarded for doing so. It is about ensuring that trading-relationship imbalances within the food system do not distort the connection between resource usage and investment and the financial rewards.

In recent decades, farmers have seen their influence over their routes to market dramatically eroded. Policy and support must be focused upon redressing this. While many farming organisations continue to resist any erosion of direct support, it is their failure to protect the farmers interests within their routes to market that has led to the farmers' dependency on production-support payments. If we are to demand that farm and food systems change, we must also support route-to-market change. It is the 'new' consumers desire for local, traceable, eco and animal-friendly food that now also provides the opportunity for reconnecting the farmer with the consumer and the consumer with the farmer.

What should new farming support mechanisms look like

To conclude this document, seven suggestions for farming support mechanisms are suggested. To facilitate change, the emphasis must move from annual payments to providing capital grants to support system changes. These could be in the form of grants for initial capital investments and capital allowances for asset renewal. Such a methodology would promote changes that directly focus upon policy-desired deliverables whilst not putting in place any long-term food production subsidies.

Further, capital grant availability must not be limited to farming and it should be accessible to those seeking to remove impediments to change within routes to market. It should also be available to those who wish to create products that are defined by how they are produced as it is only with such products that farmers and supply-chain intermediaries can fairly and honestly communicate with consumers.

After decades of support payments, it will be necessary to operate transitionary periods. Anything else will not be ‘politically’ acceptable. Into the long-term, annual payments must only relate to delivering environmentally-linked services like, for example, climate-change mitigation, rainwater catchment, biodiversity enhancement or landscape preservation. They must not be linked to food production.

Going forwards, direct farming-related payments must encourage specific farming-system change. These must be tapered as the changes must, in time, substitute one productive farming system for another. The market should provide the returns needed to reward the farmer for adopting changes.

Conversion-to-organic-farming payments provide an example. They offer ‘compensation’ for yield falls during conversion and because produce cannot be sold as ‘organic’ until conversion is complete. The rational used for organic farming should be used with, for example, adopting zero-tillage arable, integrating livestock into arable rotations, or establishing silvo-pastoral or agroecological systems.

The following provides a few specific pointers, but they are only a few as, like changing the food system itself, policy and policy mechanisms will be complicated. The whole must be amalgam of policies to address the many issues. It cannot be simplified even if the actual final objectives are.

Stuart Meikle's seven suggestions for farm support mechanisms – A to G!

A) Transitionary annual payments schemes;

B) Reintroducing mixed, rotational farming;

C) Housing farm animals to create products;

D) Providing capital re-investment grant aid;

E) Scrappage schemes for dated technology;

F) Support to modify existing supply-chains;

G) Farm-focused research and development.

A) Transitionary annual payments schemes
Farming-system change will take time and incurs costs. It is why countries where the belief in organic farming is greatest are willing to support farmers through that transitionary period. Such schemes now need to extend beyond organic to encompass regenerative-agriculture, agro-ecology, soil-first farming etc. It will be difficult in that some countries are still reluctant to support organic even though it is now a well-established and widely recognized approach to food production. That must change.

In theory, one could say that the future is 'organic'. That will, however, stifle innovation. It is also unlikely that organic as it is now defined is the complete package. Nevertheless, it will be challenging to develop and define farming systems that can be packaged so that the consumer at the time of product purchase can identify with the farming-system objectives. It will be difficult to create complex food-production solutions while defining them in a consumer-friendly way. It has been achieved with organic. so new farmer-consumer connections must not now be limited by a lack of ambition.

Transitionary changeover payments should be calculated according to the likely impact on production during any transition period when output is depressed and when there is no likelihood that the market will pay any 'new-farming-system' premium. Payments should be tapered and short to medium term.

B) Reintroducing mixed, rotational farming
Reintroducing grazed farm animals to arable land [from where directly-consumed plant-derived food products come] will, in many countries, be the single greatest change that has occurred in agriculture for a century. Such a change will require capital investment;

especially so when grazed animals must be housed in GHG-emissions-minimizing winter accommodation. Technologies will play a part in reducing fencing costs, but drinking water is always needed. There will also be innovative solutions to animal ownership, land access and stock management but, whatever, the capital costs will be high.

The change will also have local employment implications. Farm animals require people and often the agricultural housing stock in arable regions has long since been sold off. Hence, policy changes must go beyond food and farming to include local planning and housing policy. A focus on 'better', higher-value animal-products should offer an often-long-awaited opportunity for rural regeneration.

Realizing a sustainable food system is not only going to be about policy changes at government level. It will require a mindset change by the many whose policies have been to persuade people that they must stop consuming animal-derived products. That manmade alternatives are not biodegradable often seems to go unnoticed. Thankfully, many environmental and food campaigners are now aware that it is about 'regenerative agriculture' and that it is about being highly selective when choosing which animal-derived products to purchase. We must, however, focus on creating policy mechanisms that make 'better' affordable to all and not just to the wealthier few. Beyond that there now needs to be a strong educational message about the importance of grazing livestock to soils regeneration, soil fertility, nutrition, healthcare, re-establishing biodiversity to farmland, and farm-animal welfare.

C) Housing farm animals to create products

Temperate locations where farm animals can be outwintered are few. It is almost inevitable that stock will have to be housed for a winter period; thus, incurring capital costs and the problem of 'waste' storage and handling. The term 'waste' is, of course incorrect in that farm manures, correctly used, are a valuable fertilizer. When it comes to their application to agricultural soils, it is likely that jury will be sitting on whether the spreading of unprocessed manures and slurry is beneficial or detrimental. Will their plant nutritional properties outweigh any damage they do to the soil biome? If it is the latter, there will be major problems for the entire livestock industry but especially for 'industrial-scale', year-around confined operations. If we find that we must soon look at livestock housing from a soils-first perspective, we may be staring at some of the largest investment needs in farming history.

Manures and slurry are currently looked upon as plant-nutrient sources. Their value as such partially offsets the costs of storing and handling. Well-rotted farmyard manure and composts are, however, also valuable as sources of organic materials for soil conditioning. Where livestock are reintroduced to arable regions, it is likely that housing will favour composting barns over slurry systems. They may also eventually become the default build in traditional livestock areas. In addition to compost, biogas systems must become the norm where livestock are housed, along with solar panels on the roof.

D) Providing capital re-investment grant aid

Governments must encourage change by offering precisely-targeted investment grants. If farming is to help mitigate climate change, restore soils and the natural environment, improve animal welfare and reduce its reliance on production techniques that are losing their efficacy, major change over the coming years is inevitable. It means investment and support should encourage and facilitate such.

Governments should choose to offer capital investment grants [as opposed to open-ended annual payments]. As with the proposal for tapered, transitionary payments, capital grant provision is about encouraging and supporting system change, not replacing one set of direct payments with another.

After years of over-complicating grant provision, new grant schemes must be simple and efficient. We must move away from over-complicated, often business plan and cash-flow-based grant applications to schemes where those who offer the grants know what farmers need and what the typical costs are. Grant scheme management must shift to on-the-ground monitoring of expenditures and asset usage.

As mentioned below, ensuring that we have robust and resilient food systems means that farms must be economically sustainable. In light of recent experience, that will mean route-to-market investment in, for example, local, small-scale abattoirs to ensure that farmers and consumers have greater choice. Hence, capital grant provision should support both on-farm and route-to-market investment.

E) Scrappage schemes for dated technology

Scrappage schemes have become common place in the automotive sector as governments seek to see highly-polluting internal combustion engines with new generations of less polluting ones. One can imagine that when ‘zero-emission’ cars become widely available, such schemes will usher in the changeover. More so in urban areas. if we wish to see major system changes in agriculture, we should also consider a similar approach to aid the removal of highly polluting farming systems.

Adopting change will mean that the existing technologies will be obsolete sooner than anticipated. As an illustration, the widespread adoption of minimal and zero tillage will bring to end centuries of using deep cultivations. Such a change will have consequences for machinery manufacturers and farmers. There has also been massive investment in confined animal systems that Society may choose to make obsolete sooner rather than later. It will largely depend on lead-in time, but when swifter change is demanded the stronger is the case for introducing a scrappage schemes to help facilitate change.

F) Support to modify existing supply-chains

A central objective of any policy reform must be to avoid a repetition of a situation whereby annual production support becomes the norm. Annual support will be necessary where the provision of public goods occurs but that must occur independently of food production. That said, the quid pro quo of such a major change must be that food supply chains are capable of effectively linking the consumer to the farmer when it comes to rewarding the farmer for providing multi-characteristic foods that deliver upon multiple objectives. Inevitably, producer groups, co-operatives and designated-origin schemes will have to be revisited to provide effective supply-chain entities and linkage mechanisms.

There are occasional attempts to ensure that food supply chains are fair and equitable. Indeed, the EC is currently voicing its intention to regulate upon trading practices. Will that, however, be sufficient? Recent decades have seen post-farm gate consolidation to the degree that there is a major trading imbalance between retailer and farmer. The consequences have been inevitable. It is not realistic to think that regulation can now bring about great change. From here on it is about supporting farmers and producers to introduce new routes to markets over which they have greater control. Inevitably they will be small-scale and local, but it is about ushering in more choice for farmer and consumer.

G) Farm-focused research and development

British farming's history is one of innovation. It was from the county of Norfolk that the four-course cropping rotation came, a system that was to underpin soil-fertility-focused farming for generations.

Over the last half-a century, research and development has moved away from the farm. As it has become more science-based its costs have risen and its very nature has taken innovation out of the hands of the farmer and into the hands of the scientist. A consequence of the later 20th Century agricultural revolution is farming that is now reliant on external research and bought-in inputs. It does not appear to have delivered in terms of farm incomes. Its resilience is now also in question.

As farming has become more reliant on technologies manufactured outside the farm-gate, we are discovering that many have high natural resource and environmental costs. The twin problems of these costs and efficacy decline means that food systems must become less reliant on off-farm technical solutions. This fits with a soils-first, husbandry-orientated approach to food production.

Recently, husbandry-focused research has been limited largely to the organic domain. There is also a body of non-mainstream research which has focused on alternative grassland management, carbon sequestration and soil regeneration. Farmers have also certainly not given up their own informal on-farm research. Sadly, there is often little financial incentive for agri-input suppliers to get involved with such work, thus little is being done. The question of who funds research therefore must be revisited. Simply, a future robust and resilient food system needs extensive public funding of farming research.

Reducing farming's reliance on the present suite of technologies does not mean turning away from innovation and technology. For example, precision farming techniques will reduce nitrogen fertiliser and pesticide usage and plant breeding will have no less a role going forwards than now. We must, however, again realize that technology plays a subsidiary role to farm management and not vice versa.

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