OUR FUTURE LIES WITH A SOILS-FOCUSED FOOD AND FARMING POLICY

Food production must account for climate-change and GHG's, provide good nutrition, ever-improve animal welfare, minimize pollution, enhance biodiversity, reward farmers and rural communities, and, too rarely mentioned, restore and maintain soil health and fertility. But 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 lies within the way we now go about restoring 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 a complex process that requires the joining of numerous dots across a broad canvas. Focus on one issue alone and consequences happen elsewhere. Nonetheless, as one looks at soil regeneration, the solutions for many of our other problems emerge.

The following summarizes my own ideas; albeit they are derived from researching the work of many others. What brings it all together is my own diverse knowledge of farming and food. They are not 'evidence-based' in the narrow, scientific definition of the term, as too much necessary research has been neglected over the years, so, to a degree, they result from careful thought and logic.

Instead of ending with a conclusion, the paper starts with such and presents how, by addressing soil restoration in a specific way, we can also address a myriad of other food-related issues.

Food system transformation for our soils

We are told that our arable soils have sixty to a hundred years' harvests left 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. For a rising global population this is critical. If we are now to rely on natural weathering to rebuild soils, we are talking about 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 farmland 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 some others. Of these, the peat within say the English fens has long been disappearing while those soils naturally regenerated by riverine action are limited or, worse, now urbanized over. 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 ancient soils; not to mention releasing more previously 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 must be about both, as per *agroforestry*.

Rebuilding soil organic matter may mean vast composting operations to recycle organic materials and nutrients from the point of food consumption [urbanizations] to rural, maybe remote, food production zones. While this may be feasible at a local level, it is unrealistic on a global scale. Artificial nitrogen, albeit with vast and polluting seepage and fossil fuel costs, has allowed crop production without the cycling of organic matter into plant-growing soils, but it is a time-limited practice? Associated with it is a loss of soil organic matter that is destructive to soil fertility and health and, crucially, the soils ability to hold and store moisture for both crop growing and broader water resource management.

From a practical perspective, the only means to restore soil organic matter, health and fertility is to use the farmed animal in proximity to the land that provides their feed and fodder. Further, they must be reintegrated, preferably through grazing, with the soils that we use to grow direct-for-human-food plants. The latter itself now being obviously unsustainable on a large-scale without constant soil regeneration. It is what our Victorian gardening forbears knew all too well. 'Regenerative agriculture' is no hollow term, it describes the food systems that we must now adopt. It is nothing new, it is to return to the farming husbandry that we understood for Centuries and only recently forgot.

Food policy must begin with integrating livestock

The last significant writings specifically about British farming and food policy were published either side of the Second War. In them, the fundamental principle was the maintenance of soil fertility. The foundation of food and farming policy was soils; it was not debateable. It was only since c. 1960 that we have, policy wise, neglected soils. The consequences have been massive and if not soon rectified they will compromise the wellbeing of coming generations. We are destroying their food security.

From here on policy 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 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 hereon. '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 eventually fully restore soil health and fertility.

To provide a radical (even controversial for some) conclusion, a sustainable food system is not about reducing animal-product consumption so to 'free-up' land for direct-for-human-food plants, ***it is about using the land that grows feeds for shipping to animals confined elsewhere, for grazing livestock***, be they ruminants, pigs or poultry. Long-term we must live without divorced-from-the-land confined-animal 'farming', but ***we cannot live without soil-regenerating mixed-farming, livestock inclusive***. It is about returning to mixed farming on arable land [as per ley-farming] or soil-focused, pastoral, grazing systems on permanent, multi-species pastures, including both woodland and orchard pastures.

1. THE BENEFITS TO SOCIETY OF SOILS-FOCUSED FARMING

The conclusive statement above was "we cannot live without soil-regenerating mixed-farming, livestock inclusive". It will be controversial for those who are single-issue focused. A sustainable food system is complex as it is about finding the best fit to resolve many issues, even if it is not offer the perfect answer to any one issue. Focusing on soil-regeneration as the catch-all will, however deliver a multitude of benefits.

a) Reducing the GHG emissions from producing our food

As eating is a day-to-day necessity, is there an acceptable level of GHG emissions from food systems? With so many humans living within urban conurbations it is unlikely that food-system emissions can ever be zero. We can seek to minimize production emissions but there is still processing, packaging, transportation and distribution to consider; all necessary when taking food from rural to urban areas. Nevertheless, moving towards carbon-neutral farming [after measuring emissions and sequestration] must be a goal.

Transporting food creates nutrient flows that are rarely closed cycles as little human waste is returned to the land from which the food was sourced. The same goes for when we locate farm animals close to human urbanizations as the farm 'waste' occurs far from the place where the animals' feed, usually grain but there are major movements of fodder, is produced? Whereas weeds may be plants in the wrong place, nutrients so become pollutants. As a society we pay to replace nutrients lost at the point of food production and again to handle the various pollutants created elsewhere.

We have mined nutrients for years as we have broken cycles; but as with soil carbon loss, doing such will no longer an option. With nitrogen it has been artificial nitrogen fertilizers that have allowed humans, their pets and disconnected farm animals, to live lives independent of the soils that produce their foods. With carbon, it has been through the exploitation of fertility [as soil organic matter] built up in the soils over millennia under forests or native grasslands; the latter being grazed by equally native fauna. Urbanization is a fact, so we now must seek to sustainably feed populations living in 'unsustainable' locations.

There is a vast and unsustainable fossil fuel cost associated with nutrient replacement into food production systems, not least with the Haber-Bosch process. Thankfully, much is being done to get smart with the production and application of nitrogen fertilisers. Their use, however, does little to rebuild the organic matter in soils, often so depleted by many decades of continuous plant cropping. It is also time we asked, just how detrimental an impact does artificial nitrogen have on the functioning of the soil biome?

Realistically, the only low GHG emissions mechanisms to replenishing organic matter and nutrients is by using legumes to fix atmospheric nitrogen and to return composts and 'processed' manure to the soils. Given urbanization, compost-based recycling opportunities are limited. Hence, it is only through managed grasslands and forests, that we can rebuild secure, robust food systems founded upon, fertile, healthy soils. The bonus is that in restoring our soils we also return carbon to whence much of it came, the soil.

For those approaching the issue one-dimensionally as per, say, GHG's or promoting plant-only diets, it may be difficult to grasp, but *we can only approach carbon neutrality through judiciously using livestock raised on forages supplemented by locally-sourced feedstuffs* [including the by-products of food-processing] *to produce nutrient dense foods that can be GHG-efficiently transported from rural food-producing areas to*

urban, food-consuming areas. *Sustainable feeding urbanized humans and their pets is difficult enough, but* ***we have exacerbated the issue by also 'urbanizing' too many farm animals****.*

Methane is a major GHG problem and that must be reduced, captured and utilized as a fuel; or its carbon recycled within the farming system. Methane is a part of the process by which some indigestible-by-the-human plants are converted to digestible foods [by ruminants], not least in environments unsuited to the growing of crops that can be directly utilized by humans. *When methane is necessarily produced, we must ensure that the farming system is designed to cycle carbon back into the soil efficiently and effectively*.

If, as more farmers are coming to believe, carbon can be effectively sequestered into soils while rebuilding organic matter, we must encourage farmers to do so. Meanwhile they must grow crops, be they rotated or permanent, food or forages, in ways to minimize carbon losses. Grazing livestock, which predominately means ruminants, are going to be vital to these systems. We must not, however, in the pursuit of GHG reductions in isolation, look to plant-only diets as our soils will not sustain them.

b) Better nutrition and health and lower healthcare costs

What we eat and what we are recommended to eat has a major impact upon our environment. 'Eat less meat' is an increasingly common statement. However, *'eat less meat and dairy and better-quality meat' may be the statement that results in a more resilient food system; if by 'better', we mean animal-derived products that are sourced from farming systems that regenerate and rebuild soils and sequester carbon.*

There have been nutritional messages issued by governments over many decades, but still there is rising controversy over what constitutes a healthy diet. With so many eating-related disorders around, further dietary guideline change is inevitable. Identifying a sustainable food system amidst such flux is not easy. If it must be 'evidence-based', we may still be years away from having a technically-sound starting point.

Fats are necessary. All fats are, nonetheless, not created equal. Also, over the years, people have been recommended to consume different fats. At its simplest, it has been about moving from animal fats to vegetable fats. One result has been the dramatic expansion in palm oil production, a crop associated with massive tropical forest deforestation and extinction risks for numerous species reliant upon such habitat. *The learnt message must be that nutritional advise can have unforeseen but definite consequences.*

Many people would like to consume high-quality, plant-derived fats like those from olive or avocado, but severe production limitations mean that their availability and affordability is limited [nuts are widely seen as nutritionally positive, but the same often applies]. Can we all live on beans? Maybe, but we must look closely at the broader environmental costs of vast-scale, mono-cultured beans; albeit many of the costs are attributable to producing proteins for pigs and poultry rather than direct-for-human-eating beans.

Chicken is often promoted as the healthiest of meats as it is low in fat. Thus, consumption has risen sharply [helped by industrialisation driving down costs]. The availability and low cost of chicken meat has been possible due to soybean expansion in South America into savannah and the Pampas grasslands [not to mention the wellbeing of chickens]. Apart from habitat destruction, monocultured soybean has released carbon from what were long-term, highly stable, carbon stores; a recent example of what long-since happened in northern hemisphere, temperate grasslands. Again, unforeseen but definite consequences.

Obesity and its associated illnesses have become rampant. It is placing massive pressures upon health services around the world and greater scrutiny is now being placed upon what we eat, our lifestyles and nutritional guidelines. A common response has been the promotion of plant-based diets. It is assumed that they are both healthier and more sustainable; but are they? If one factors in the need to regenerate soils that have often been depleted by continual plant production, questions should be asked about the actual, real, genuine sustainability of plant-only diets for a human population of many billions. Again, food security is a highly complex issue that will not be resolved by focusing upon single issues alone.

One finger is now pointed at sugar. Another at fats. If, however, one considers that all highly refined carbohydrates swiftly convert to glucose and that they should be considered as 'sugar' one wonders where our energy will come from? Fruit juices are now recognized as being sources of 'free' sugar but how long will it be before potatoes, bread, pasta and rice are added to the concentrated-source-of-sugar list? Wholemeal versions may be better from a fibre perspective, but they still have a high glycaemic index. *The higher GI foods will become seen as less healthy and that will turn the whole 'what is a sustainable diet' conundrum on its head. For farming and food producers, it will be a game changer.*

As dietary management focuses on managing blood sugars and the reducing blood sugar spikes within normal eating patterns, dietary recommendations will change again. It appears that the human system can handle high, multiple-times-a-day, blood sugar surges for only a handful of decades until a failing ability to do so triggers numerous health issues. Few are likely to escape the consequences of excess blood-sugar loading. Exercise may help but not if it is frequently fuelled by the over-consumption of high-GI foods.

Often overlooked is the impact of frequent 'hunger' during the day and there is an associated link. Foods that leads to being sated, will become a key aspect of fighting obesity. Counting calories will not help if those calories still trigger significant blood-sugar fluctuations and, thus, frequent bouts of hunger.

The above will change our approach to foods and it will emphasis nutrient dense, lower-GI foods over high-GI carbs. They will be both plants based and animal derived and focusing on their production will change perceptions of what is sustainable food production. *As we move from diets where the calorific 'weight' comes from high-GI carbohydrates, the focus will and must fall upon high-quality fats and proteins.*

If one is to predict what a future sustainable diet will look like, *it will be about low-GI carbohydrates [with the emphasis on vegetables], plant-derived proteins and fats and a highly selective approach to animal-derived proteins and fats.* For the latter, it will be about nutritionally higher quality products from pasture-based systems that use minimal quantities of 'imported' grains. A supposition based upon the expectation that there will be increasing evidence that animal-products from animals that graze diverse pastures [as opposed to just having access to 'free-range' space] will provide healthier sources of fats and proteins.

For decades we have endured all sorts of nutritional guidance. This has meant, for example, that eggs have been good, then very bad and then good again. We have gone from butter to margarine and back. Certain animal fats are now in vogue [although there are those who argue that the shouldn't be]. For some red meats are an invaluable food source that has been falsely maligned. Or is it wiser to say that 'red meat' is a term that encompasses the good, the bad and the ugly? *With animal fats [and proteins] it will be about choosing which is which and deciding what are the 'eat better' choices. Such foods will be a core part of human nutrition going forwards; but we just need to be far clearer in our understanding of their qualities.*

Perversely as it may be for some, the *cropland freed up from grain production for animal feeds should not be viewed as just more land available for more human-consumption crops; it must be grazed by livestock within rotational farming systems*. The rational being that a sustainable diet can only be followed if its foods are derived from sustainable, soil-fertility-building farming; and that largely means keeping pasture-living animals. If that is indeed to be the case, we need to recognize that a sustainable diet and, hence, food system must be built from the ground up, or more literally, the soils up. There is no alternative.

c) Reducing the pollution from our food production systems

Is there a direct correlation between the separation of animal farming away from the soils that grow their feeds and forages and a wide array of the pollutions attributable to human-food production? As we have pursued means to supply large, urban populations with affordable animal-derived fats and proteins, has pollution become inevitable? Are we now deluding ourselves by ignoring externalities and the true cost?

Geographically separating feed and forage production from farm animals incurs transport costs and it also means that nutrients end up in the wrong place. As a plant in the wrong place can be called a weed, a nutrient in the wrong place can be a pollutant. Leaching from a broken cycle can be into the atmosphere and into the waterways. The 'dead zone' in the Gulf of Mexico is a case in point and many other lesser magnitude zones occur elsewhere. *When it comes to our marine and fresh water environments, drinking water inclusive, at what point will nitrates become the next 'plastics'*? It will happen, and it will have a massive impact upon food production. And it will not just be about leakage from large-scale animal-confinement farms, it will be about emissions from spreading manures, slurries and artificial fertilisers.

An issue that one is still below the horizon is just how do nutrient-rich farming wastes, sometimes rightfully called fertilisers, and artificial fertilisers impact the health of the trillions of organisms that reside in our soils? We are short of knowledge about the importance of such life to crop production and we are as equally at a loss when it comes to understanding the impact that manures, slurries and fertilisers have on soil-biome health. *It is probably wise to assume that we are treading a fine line between fertilising our crops and polluting the environment of a myriad of organisms invaluable to the food security of all life.*

Are we guilty of assuming that all manures and slurry applications are beneficial? Do we see them only as vital nutrients to feed crop-plants? Are we forsaking the health of all other organisms in the pursuit of growing our crops? Do 'artificials' even inhibit natural mechanisms from providing for crop growth? Yes, we are getting smarter in their use, and their rising cost will encourage us to do so, but how strong is the correlation between our reliance over the last 60 years on 'artificials' and the decline in our soils?

Taking it a step further, farmers are being encouraged to inject slurry into soils to minimize GHG emissions. Investing in equipment is often cited as an example of 'smart' agriculture and a way that food's GHG footprint can be reduced. Sometimes, the tax payer is even funding the low-emissions equipment used. In the natural environment, most animals 'wastes' are left upon the surface and nature has mechanisms to process them, they are not injected below the surface. Are we, therefore, injecting untreated animal wastes into our soils without considering the impact it will/may have upon the soil biome? Is this another case of not joining the dots and spotting the unforeseen consequences? Are we blissfully unaware that we are polluting another environment, albeit one that we too often consider to be inert?

Rebuilding our soils must be about recycling nutrients to our soils in a way that is beneficial to soil health. We must do it using methods that minimize nutrient/pollutant leakage and reduce the costs of moving nutrients [including creating artificial nitrogen] to replace those that have been consumed/lost at the point of food-production. Central is the choice of food production system and how well it can mimic the natural cycle of nutrient 'harvest' and return. When talking about carbon-neutral food production, it is these that we must aspire to. But what are they? Seeking them out is a journey we have hardly embarked upon.

Although some dislike animal farming on principle, grazed animals are crucial to sustainable food systems. Realistically, mega-scale composting aside, so grazing animals are vital to nutrient recycling. Further, they are vital to returning carbon and organic matter to soils on a broad-scale. There is just no other solution. It is just much easier to mimic the natural cycles with graziers than without them. It is such systems, allied to N-fixing legumes [to GHG-effectively recycle nitrogen moved within human foods back to cropland via the atmosphere], that will allow the move to farming systems that are carbon neutral and soil benefiting.

As a footnote, this is not about using 'grass-based' livestock systems, it is about managing multi-species living in diverse swards. It is also about adopting specific grazing practices that focus upon soil health and returning carbon and organic matter to soils. It will be about very careful use of externally-sourced nutrients, be they artificials or animal 'wastes' from winter housing. Within crop rotations, it will be about building fertility that can be later harvested as human-food crops. It will be about reducing carbon loss from excessive cultivations. Where pastures are permanent, it will be about maintaining permanency and not regularly reseeding grass swards, exhausted by successive and excessive defoliation.

Finally, in the context of complete food systems, fossil fuel usage must be scrutinized. From a dietary perspective, nutrient dense foods will become the preferred choice, not least to stave off the constant obesity-causing, Type-2 diabetes-inducing hunger that comes with high-GI-carbohydrate dependency. But their production must not be at the expense of polluting our air, water and soils. Also, such nutrient-dense foods must not come from out-of-a-natural-context, large-scale, confined-animal systems. In addition, we must focus upon minimizing the footprint from transporting nutrient dense foods from where they can be most 'naturally' produced to urbanizations. Our current system of keeping farm animals in convenient, financially-efficient-but-true-cost-ignoring locations creates too many externalities and it must change.

2. THE ON-FARM BENEFITS OF SOILS-FOCUSED FARMING

a) Restoring and enhancing our farmland biodiversity

Nobody can be unaware of the severe biodiversity loss that has occurred on and above our farmland. The plight of the larger species inevitably draws more attention, their disappearance is obvious as they are no longer seen or, as in the case of the iconic corncrake, heard. Frequently now, their loss is being directly connected to our food systems? We may not always know how strong the link is between our farming methods and biodiversity loss, but ignorance is not a justification for inaction. Also, we should not assume that our current approaches are right simply because we have not researched the consequences, or even attempted to logically construct a flow of implications accruing from actions. We, as a species, have no right to drive others to extinction in the name of our own food security; it is immoral.

Pollinator decline is a major threat to human food security, period. While there is widespread public awareness that climate change will impact upon our food systems and little about the grave risk posed by soil degradation, the precarious position of the pollinators falls midway between the two. Those in the know do, nonetheless, appreciate that human food production is not sustainable unless we swiftly reverse the decline in the numbers of those that pollinate our food crops. One can also assume that their decline is having an impact upon the food supplies of other, less adaptable, species. Farmers and growers can source bees to pollinate, but no other species can act in such a manner.

Minimizing the use of insecticides directly linked to pollinator loss is crucial and it is unfortunate that it requires legislation to bring about change. For food security reasons the concern is about pollinators, but do we know how damaging the array of insecticides used is to the organisms that inhabit our soils? Just how much damage are our chemical cocktails doing to the base of so many food chains? It is quite possible that we are losing entire farmland food systems but only just visually seeing the tip of the iceberg with birdlife loss. To say so may be called 'anti-farming' but, it is a view shared by those farmers who themselves increasingly seek to understand Nature and the consequences of their own operational choices.

There are no sustainable food systems that place short-term expedience ahead of the long-term interest. Food is not just for today, it is about all our tomorrows. Judging by the reported state of our soils, we have yet to learn this lesson; even though others have documented how civilizations that ignore their soils sooner or later decline, fall and disappear. *Our modern systems, are however, more extensively damaging in that we have gone beyond soil degradation to harm other key parts of our food-producing capacity*.

Recent concern for our soils has rarely gone beyond their nutrient status as per the immediate needs of the growing crop, the availability of enough water or its removal in times of surplus, and trafficability for machinery and livestock. Anecdotally, from a young age I was aware that more power was being required to cultivate the soils, a sure sign of detrimental change. Conservation tillage, no-till and cover crops are in increasing use [often to minimize soil carbon loss] so farmers are becoming more aware of soils, so it is not all negative. We still, nonetheless, need to concentrate far more on soil ecology rather than chemistry.

I am not an ecologist, although I now wish I was. I am, nevertheless, confident that serious biodiversity loss has occurred on farmland over the last seventy years or so and that it can be traced back to a much-changed farm management attitude to our soils. My supposition is that the soil biome provides the very foundation of all farmland food chains and the visible above ground biodiversity loss is only a reflection of what is happening below the surface. Hence, we must regenerate the one to recover the other.

To restore soil biodiversity, we need to restore diversity to our farming systems. *There is no longer space for monocultures or monocultural thinking within arable cropping or grassland management*. The latter is often no better that the former, albeit it is less visible to the untrained eye. *We cannot continue to see a separation between farmland and ecological focus areas and we must integrate one with the other*. Soil regeneration and fertility-farming must be central to productive farming going forwards. Thankfully, the farming practices needed will also regenerate biodiversity above and below ground. *If we restore the wellbeing of our soil fauna, most likely the recovery of our visible flora and fauna will follow*. Simply, farming needs to target restoring biodiversity every-which-way to our farmland. And while we do so, *we also need to ensure that the systems utilized are also the best at producing the right foods and viable farm incomes*.

Thus, there is a positive biodiversity scenario, but only if we recreate our farm-to-fork-to-farmer food systems to ensure that they highlight what are the most sustainable options for farmers and that they adequate financial rewards for their use. We must stop thinking only in terms of separate environmental schemes and we must address how to *mainstream ecologically-founded farming practices*. And they must be linked to markets that reward farmers. Soil fertility restoration is not about providing financial support to farmers in the name of food security [as a public good], it is about *ensuring that normal market rewards provide the resources to regenerate and maintain our soils and for farmers to preserve their primary asset*. Investigating the how to does, nonetheless, highlight how much food-system change is needed.

b) Water catchment, retention and flood management

There are benefits from a soils-focused approach to farming and food that will deliver benefits to society and to the farmer. Improved soil retention is one of them.

Notwithstanding trafficability, improved water-holding capacity can only improve the productive capacity of soils, not least during periods of drought. The use of minimum tillage on arable soils should also deliver better trafficability, a more dynamic soil fauna and better water retention. All will be necessary if we are to live by eating more plant products directly. Agroforestry and growing trees for food should by now be obvious choices for food-source expansion. With grasslands, we must look to minimize soil disturbance [as in ploughing to reseed] and to build diverse, highly-persistent swards. Long-season trafficability will be a problem on arable-rotation leys but it should be less so where permanent pastures are truly permanent.

Employing practices on farm to minimize soil run-off are an absolute priority. Cropping and cultivation practices that result in soil loss and silting of waterways must end, period. Not only do they incur downstream costs, it is where farms are losing topsoil to water erosion, it is likely that they are also not employing any soil rebuilding practices. Relying on natural subsoil erosion to replace losses takes millennia to create very little so is not an option, so losses must be minimized. That soils are still being lost to erosion by wind and rain is a failure of our times and demonstrates a slowness to learn. Simply, *all farmers must adopt soil regenerative practices and encouraging and supporting them to so must be a keystone of food and farming policy*. Sadly, it appears that regulation through cross compliance is likely to remain necessary.

Upland soils will be a different issue again. At some stage soon, their role in producing food will change. At present lamb consumption in northern Europe is in decline and *for upland sheep farmers it will be about producing specialist meat products*. More so if we find that sheep must return to lowland arable farms to support human-food growing soil restoration and, for example, blackgrass control. *Upland farm support will be channelled to water catchment management, ecological hot-spot management and landscape preservation*. Food production will become a specialist-product business integrated with these 'public service' activities. One would also hope that agroforestry will come to the fore in a way that food can be integrated with upland woodlands effectively. *When it comes to upland soils, their management will first require society to identify the role that they and their resident farmers are to play going forwards*.

c) Enabling us to further enhance farm-animal welfare

As food markets develop within a media-rich environment, meeting the animal-welfare expectations of consumers and society will rise in importance. Animal-welfare will continue to be *a significant food product*

differentiator. Farmers who wish to have a presence in the upper echelons of food markets, will need to act accordingly. And society must ensure that they are rewarded for doing so; ideally through efficient market mechanisms. Not least when animal-welfare orientated farming system change means investment. The market-derived rewards must make the investments feasible and rewarding. It is probable that there will be cases that justify 'public-good' support to provide grant aid to such investments.

Our ambitions to enhance animal welfare can be integrated with our yet fully recognized need to restore soil health and fertility. Indeed, the two must also be integrated with the need to rebuild soil humus and carbon and to capture carbon and return it into long-term, below-ground, storage. At times these C stores will have to be utilized for food production, but that must [again] happen within the context of cycles as opposed to 'carbon-mining'. If one believes that *animal-derived products must come from animals that lead as natural a life as possible, free-range, grazed and farmed within a soils-first system must become the default choice*. And the animal-products must be clearly sold to the consumer as such. We need to change farming systems but, equally, consumers must be willing and able [i.e. affordable and accessible] to support and pay for that change. For such to happen we also need to review our food-supply chains.

If soil restoration is the priority for food producers and a necessity for food security, it comes with every opportunity to enhance animal welfare. *Is it a coincidence that systems that compromise animal welfare also come with major negative impacts upon our wider environment? It is not well-managed, pasture-based animal-farming that has led to planetary degradation*; a point that many have yet to appreciate. We need to fully understand the role of such farming systems and to return to them; it will benefit our climate, our soils and, if humans continue to choose to exploit them, the welfare of farmed animals.

d) Returning to farming systems that allow Nature to work

There is no single reason for soil degradation around the world. Within pastoral systems it may be through over-grazing [i.e. poor grassland management]. In arable farming it has often been continuous cropping. Our ancestors, when few, were able to employ 'slash and burn' land clearance for their food-plant growing. They would clear the native plant cover and exploit the latent soil fertility built up by naturally regenerative processes. After a while fertility declined and it was time to move on and to allow Nature to regenerate the soils. It was exploitive, but the human population pressure was such that it remained sustainable.

It may seem improbable, but this still occurs within the European Union. There is at least one location where land is enough and populations so low, that the arable land has been rotated in and out of cropping. It is in a region where native legumes are abundant, and the land is farmed in narrow strips; thus, allowing the highly-diverse plant life to swiftly recolonize arable strips when left idle. The soils or course remain alive. It is, however, now very rare to be able to witness the regenerative powers of Nature where human interference is sporadic and relatively minimal.

The last wholesale 'slash and burn' probably happened in western Europe in the Second World War with the ploughing up of pastures that had never previously been cultivated. Their fertility was utilized to sustain populations during a period of dire food insecurity. Even then it was noticeable how swiftly that fertility, built up over generations, was lost. It is likely that very few of those soils were ever allowed to recover naturally as post-war food-security-orientated policy coinciding with the rapid development of agricultural chemistry meant that mixed farming fell totally out of vogue.

Whereas ‘slash and burn’ was employed over small areas, lasted for a few years and happened within an environment rich enough in native species to allow swift natural recolonization of exploited lands, *are we now seeing the results of the same exploitive practice, albeit we have been able to manage the decline for long enough to convince ourselves that our ‘modern’ food systems are sustainable*? Has agricultural chemistry allowed us to create a Fool’s Paradise where abundance appears to be everywhere but where the abundance is still really time limited? It is a question that must be asked bluntly and answered truthfully. We can only then plan how to go forwards.

e) Farming to preserve our valuable food-system technologies

An aspect of our current farming solutions that should be of major concern is their resilience. We are increasingly aware of the declining efficacy of antibiotics within human healthcare and their use within agriculture will be constrained. Few will question the necessity. The same efficacy decline is happening with animal health products and pesticides within plant-production. Apparently, *we have under-estimated the ability of natural evolution to resist our man-made ‘solutions’*.

The efficacy of weed-killers, wormers and fungicides is declining. As, for example, herbicide-resistant blackgrass becomes prevalent, are we able to develop new herbicides fast enough. Can we approve them fast enough? Should we? There are advocated for short-circuiting the approval process, but will doing so ignore the lessons of history? Just how many agrochemical products are no longer allowed on safety grounds. Solving one problem often seems to create another.

For the mainstream farmer in the UK, it will have come as a shock that an elder statesman of farming journalism could suggest that sheep may have to return to arable-crop rotations to control blackgrass. It will be of no surprise to those in the organic sector or well versed in the many pre-1960 writings about soil-fertility-focused agricultural husbandry. Another interesting idea is the growing of wildflower strips within arable fields to provide havens for those creatures that naturally control insect pests.

There are many such solutions emerging and we will come to recognize that the major benefit of an organic movement that provides only a few percent of our food, is that it moved husbandry research forwards outside the conventional farming mainstream. The transfer of ideas from organic will now help combat efficacy decline. *Profligate use of agrochemical will not be a part our future food system and they will be applied with caution or only preserved for ‘emergency use’ only*. Saving antibiotics is only the start.

The use of genetic modification has its advocates. It is nonetheless a technology that is associated with destructive monocultural crop-growing and herbicide resistance [glyphosate-resistance has now emerged in the UK]. As a technology it got off on the wrong foot and has been fighting a losing public-relations battle since. Its future use in general food production will likely be marginal. Within mainstream crop-growing, varietal disease resistance declines over time so one should never under-estimate the importance of plant breeding to rejuvenate crops’ natural resistance to, for example, fungus diseases. Hence, we need to be discerning when discussing the important role of plant breeding, it is vital to our food security.

In addition, while being concerned about efficacy we must ensure that our food-producing technologies are not counterproductive. Do we truly know the impact of nitrogen fertilisers or untreated animal ‘waste’ or regular insecticide use have on the soil fauna? In all honesty, we probably do not. We must be more

diligent in finding out what is happening within our soils. In the meantime, we need to be deploying 'smart' solutions to reduce agrochemical usage. *Reduction is almost certainly necessary for soil biome health, to minimize farming's impact upon the wider environment, and to improve farm incomes*.

Thankfully many of the agricultural practices needed for soil regeneration are also able to counter Nature's evolving resistance to manmade solutions. For example, with the animal health, just how much can be achieved by returning stock to outdoor, more extensive environments, using mixed-species grazing and grazing multi-species, herb-rich swards? Will, for example, tannins found in Sainfoins be recognized as a useful, natural way to control internal parasites in ruminants? If it is accepted that crop rotations are again a necessity to combat herbicide and fungicide resistance, at least *the accompanying more extensive use of legumes will come with positive, soil-improving, nitrogen-fixing benefits*.

When it comes to antimicrobial usage in farming there is significant differences between cattle and sheep and pig and poultry farming. The former may generate more GHG emissions per unit of produce but that should be *balanced against the carbon that can be sequestered by pasture-farmed cattle and sheep, their minor usage of brought-in feed grains, an ability to thrive on multi-species, biodiversity-enhancing pastures, and a much lesser need for antibiotics*. *Well managed within arable systems, cattle and sheep will also rebuild soil fertility, carbon and organic matter.* They can also play a role in weed and disease control. *'**Sustainable**'* f***ood production is all about complex husbandry and not simplistic solutions***.

3. 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 is a massive issue as food production is a major source of GHG emissions, *focusing more 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 tilled arable soils, it is where it must return. *For many decades now, we have exploited [mined] 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 be all about how to regenerate our soils and accumulate soil-carbon stocks. *It is already well known about carbon capture.*

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 and biodiversity* ***while regenerating and maintaining our food-producing 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 animals to 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 grassland is managed. Removing them is a long way from the answer. There are few locations where the best farming system is stockless and when it is practiced its environmental impact is often severe. The evidence says so.

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, resource need and the environment.

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 existing 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 the organisms that live within them.

a) 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 of 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 then the maintenance of soil fertility.

For farming to return a soil-fertility-first approach to food production it 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 under-writing support system with another. *A failure would be to change farming systems and to 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 and, for example, biodiversity restoration / preservation are integral to normal farming system rather considered to be a public service. There will be exceptions to the rule in terms of public access, landscape management, flood prevention measures, and '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.

b) 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 so many interested parties who prefer the *status quo*. The position of some farming lobbies is an interesting one; why do they so voraciously support the continuation systems that apparently do not deliver a sustainable farm income for the farmers that pay them? Do they just lack vision?

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 that 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, *into the farming-food mix must step forward 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;

- ♣ that they compensate farmers and land managers for income forgone while implementing change,
- ♣ they reward farmers and land managers for achieving public-interest-targeted actions [public goods],
- ♣ they are tapered-over-time payments to allow business adjustment during transition periods, and
- ♣ they include capital investments grants to encourage and directly support policy-identified changes to both farming systems and food supply chains without recreating annual, 'under-writing' supports.

A key objective must be to break the linkage between food production and annual payments. Farm incomes must be derived from the consumer and the 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 food-producing resource-usage and investments and the financial rewards/inducements to change offered by consumers.

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, in part, led to the farmers' dependency on production-support payments. If we are to demand that farm and food systems change, we must also demand and 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*.

c) What should new farming support mechanisms look like

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 focuses 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 alone 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 longer-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 initial yield falls during conversion and because produce cannot be sold as 'organic' until conversion is complete. The rational used with organic farming should also be used with, for example, adopting zero-tillage arable, integrating livestock into arable rotations, or establishing silvo-pastoral or agroforestry systems.

The following provides a few specific policy pointers, but they are only a few as, like changing the food system itself, policy and policy mechanisms will be complicated. One must suggest otherwise as they just cannot be simplified even if the actual final objectives are.

i. 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 even 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.

ii. 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 also 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 [i.e. in the fashion sector] 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 now, 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.

iii. 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, the question remains whether the spreading of unprocessed manures/slurry is beneficial or detrimental. Will their plant-nutrient values 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', all-year-confined-operations.

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. Such barns 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.

iv. 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 grants 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 excessively business plan and cash-flow focused 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 on-going asset usage.

Ensuring that we have regenerative and resilient food systems means that farms must be economically sustainable. In the light of recent experience, that will mean route-to-market investment in, for example, local, often 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***.

v. 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 replaced rapidly 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 techniques and 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 an 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*.

vi. 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 demands/societal 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 enough? 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 starting to usher in more choice for farmer and consumer.

vii. 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 ['Green'] 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. The Green Revolution's resilience is now also in question.

As farming has become heavily reliant on technologies manufactured outside the farm-gate, we are discovering that many of those come with 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 mainly limited to the organic domain. There is, however, 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 doing 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 resilient, regenerative 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 though again realize that technology plays a subsidiary role to farm management and not *vice versa*.