TEAGASC TECHNOLOGY FORESIGHT 2030

Sustainability / Climate Change Challenges

We recognise that the development of the agri-food sector must take place in an environmentally sustainable manner. As an export-driven food producer, the sustainability of Ireland's production systems is a critical point of differentiation for our food and drink produce on international markets. As food production increases in the coming years, we will face challenges in meeting EU and national environmental targets on climate change, biodiversity, air and water quality etc.

Our challenge will be to build on existing policies and standards to promote more sustainable agriculture, forestry and fisheries and to meet our national, EU and international commitments in these areas How do we reconcile these actions with the need to optimise food production, economic growth and job creation?

Sustainability in Food Harvest 2020

Food Harvest 2020 profoundly changed the role of sustainability in agriculture. Before Food Harvest 2020, i.e. during the first decade of the 21st century, the protection of the environment, e.g. water quality, biodiversity, greenhouse gases and soil quality, were positioned as constraints to further growth of agricultural production (Figure 1a).

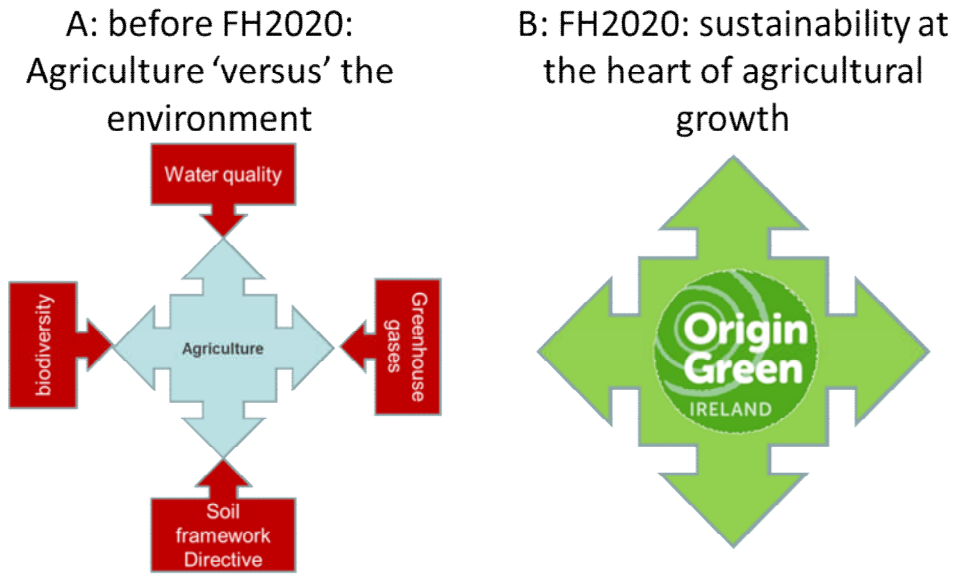

Figure 1: *The role of sustainability before Food Harvest 2020 (FH2020) (Figure 1a) and as part of FH2020 (Figure 1b).*

The Food Harvest 2020 Strategy changed this juxtaposition: it placed sustainability at the heart of agricultural growth, as summarised in its tagline 'Smart, Green Growth'. This change in perception was consistent with two contemporary developments at global scale:

1. The renewed interest in achieving and maintaining global food security, following the global food price crisis in 2008;

2. The publication of international sustainability metrics by the FAO and the European Commission, which showed that the environmental performance of Irish agriculture compares favourably to many of its competitors.
3. These developments translate into an opportunity for Irish agriculture to contribute to 'Sustainable Food Security', which was captured by Bord Bia's *Origin Green* initiative and used as Unique Selling Point in marketing Irish produce. Therefore, Food Harvest 2020 changed environmental sustainability from a *constraint* to a *driver* of growth (Figure 1b).

The green credentials of Irish agriculture

Indeed, this is supported by scientific evidence. An analysis by the European Commission's Joint Research Centre shows that the carbon footprint of Irish dairy and beef is the lowest and fifth lowest in the EU, respectively (Leip *et al.*, 2010). This supports the finding by the FAO that the carbon footprint of milk is lowest in 'temperate grass-based systems', such as those that are commonplace in Ireland (FAO, 2010). An earlier assessment and comparison of water quality shows that Ireland is in fifth place in the ranking of the proportion of 'good status' water bodies across the EU (European Commission, 2010).

This positive environmental performance has been driven by on-going gains in resource use efficiency by Irish agriculture since 1990. Recent Teagasc data shows that that the carbon-footprint of Irish produce has been reduced by *c.* 15% since 1990 (Schulte *et al*., 2014). Similarly, the 'Nitrogen-footprint' of Irish produce has been reduced by c. 25%. This means that Irish farmers now apply 25% less nitrogen fertilizer per kg food produced, through more efficient production methods and use of inputs such as fertilizer. Data from the Teagasc National Farm Survey shows that these efficiency gains present a win: win scenario for environmental *and* economic sustainability. For example, an analysis of data from 2013 shows that the most profitable dairy farms were those with the lowest carbon footprint per litre of milk (Hennessy *et al.*, 2013).

Challenges to environmental sustainability

However, these positive developments regarding the sustainability of Irish agriculture must not lead to complacency. There are pressing reasons why our approach to environmental sustainability must continue to evolve. These include:

1. *"Has the low-hanging fruit been picked?":* Further sustainable growth of agricultural output will require further and concurrent reductions in the environmental footprint of this output, in order to avoid increased pressures on the environment. And while this environmental footprint has been reduced progressively since 1998 through gains in technical efficiency, the scope for further reductions is becoming more limited, as the 'low hanging fruits' have been picked. For example, recent increases in animal numbers and fertilizer use have resulted in an increase in absolute agricultural emissions in 2012 and 2013 for the first time in a decade (EPA, 2014). While this increase is in line with projections by the Teagasc FAPRI-Ireland model, the subsequent predicted 'flat lining' of emissions can only be achieved if the technical potential for further efficiency gains actually materialises (Schulte *et al.*, 2013). At this point, it is unlikely that these efficiency gains will result from market incentives alone: further incentives, such as a mainstreaming of the Teagasc-Bord Bia Carbon Navigator, are likely to be required.

2. *"Further sustainable growth will require further gains in efficiency"*: In 2013, an independent analysis of the environmental sustainability of Food Harvest 2020, commissioned by the Department of Agriculture, Food and the Marine (DAFM), concluded that Food Harvest 2020 would have a "slight negative impact" on the environment, which 'can and must be mitigated' (Farrelly, 2013), again pointing at a technical potential that must be turned into practice. Further growth of the agricultural industry towards 2030 is unlikely to have a smaller impact on the environment and will therefore require further steps to translate the technical potential for efficiency into practical measures.

3. *"Environmental targets are becoming more stringent"*: environmental policies continue to evolve at global, EU and national levels. For example, the EU greenhouse gas reduction targets for 2020 will soon be superseded by more stringent reduction targets for 2030, albeit that recent European Council decision allows for more flexibility towards integrated land management that accounts for both greenhouse gas emissions and sequestration by grassland and forestry. Similarly, the EU Nitrates Directive has been superseded by the Water Framework Directive. Instead of setting thresholds for chemical water quality, this latter Directive requires the biological quality of all water bodies to be returned to at least 'good status', and for the maintenance of 'pristine' water bodies. In 2015, EU Member States will be required to report on progress made during the first 'cycle' of the Water Framework Directive, which ran from 2008 to 2015, and to present plans for the 7-year second cycle. In the context of biodiversity, Ireland has successfully designated NATURA 2000 sites, in line with the Habitats and Bird Directives, but the specific transposition and implementation of these Directives into national law has been challenging and challenged, culminating in a negative judgement by the European Court of Justice in December 2012 (Schulte *et al.*, 2014). In relation to soil quality, the proposed Soil Framework Directive was formally withdrawn by the European Commission in summer 2014, but work has commenced on a new Land Use Directive that seeks to integrate environmental concerns in land use management. The corollary of these developments is that *even in the absence of growth*, further gains in agricultural efficiency will be required to remain in compliance with environmental legislation, which is a prerequisite to maintaining the 'green credentials' of Irish agriculture as a point of differentiation for Irish produce.

4. *"Competitors are closing in"*: In this context, it is important to note that Ireland is not the only country that prides itself on (and markets its produce under the banner of) its green credentials. Industries and governments abroad are increasingly investing and competing in the 'sustainability space'. For example, see:
www.fonterra.com/global/en/sustainability
www.embrapa.br/en/meio-ambiente
www.arla.com/about-us/responsibility/environmental-strategy/
www.frieslandcampina.com/english/sustainability.aspx

5. *"Will land become a constraint post 2020?"*: in a post-quota environment, we expect to see an increased demand on land, both for agricultural purposes and environmental purposes, e.g. new incentives for afforestation of agricultural land to maximise the national carbon sequestration potential. A recent preliminary study by Teagasc (Schulte *et al.*, 2014) concluded that there is sufficient land available to meet both the

Food Harvest 2020 targets and environmental targets, provided that this process is managed. However, the study also indicates that land may become a constraint beyond 2020, which may ultimately require 'hard choices', not only between agronomic and environmental objectives, but also between individual environmental objectives themselves (see also Schulte *et al*., 2013). This latter concern was echoed by the 2014 Report on Land Use by the Joint Oireachtas Committee on Agriculture (2014).

Agri-Food 2025: 'putting Sustainable Intensification into practice'

If the objective for Agri-Food 2025 (the successor strategy to FH2020) is to build on the success of its predecessor in delivering sustainable growth, then this will require a deeper approach to environmental sustainability. Food Harvest 2020 could capitalise on efficiency gains that were achieved over a 12-year period: this ensured that the environmental footprint of agricultural produce was already on a downward trajectory before growth of the industry commenced in earnest in a post-quota environment. If further growth is desired and pursued post 2020, then there is a need to further accelerate the efficiency gains in order to avoid increased pressures on the environment in future and to maintain the green credentials that underpin the Origin Green marketing of Irish produce.

In practice, this means that Agri- Food 2025 strategy must be based on the contemporary concept of sustainable intensification, which implies a decoupling of growth in output from environmental impact. Put simply: produce more output or value while at the same time reducing pressures on the aquatic, atmospheric, biotic and pedological environments. Teagasc research has shown that sustainable intensification is *technically* possible. For example, the Marginal Abatement Cost Curve for Irish Agriculture (Schulte & Donnellan, 2012) and more recent projections for 2030 show that there are practical and cost-beneficial measures available that reduce greenhouse gas emissions from agriculture. Similarly, the Teagasc Agricultural Catchments Programme has demonstrated successfully that it is possible to reduce nutrient losses to water without compromising productivity (Torpey & Fay, 2014).

However, in absence of incentivisation, this *technical* potential for further gains in efficiency is unlikely to materialise fully in practice, for a variety of reasons that pertain to socio-economic constraints and / or knowledge deficits. Interactions between farm practices and various aspects of the environment are complex: at times, these are synergetic, while on other occasions, they may be antagonistic, even between environmental indicators (for example: not all measures aimed at reducing the carbon footprint are beneficial for water quality or biodiversity). It is for this reason that Farrelly *et al.* (2013) specifically recommend a significant Knowledge Transfer programme on environmental sustainability to be mainstreamed and made available to the farming community.

Recommendation:

In summary, Teagasc recommends that the Agri-Food 2025 strategy specify pathways for sustainable intensification based on an explicit *ex-ante* assessment of both the technical opportunities for further gains in resource use efficiency, and opportunities for knowledge transfer and implementation.

- In the context of the development of the agri-food sector to 2025, what specific actions should be taken by farmers/fishermen, processors and the State on:

- Greenhouse gas emissions and sequestration
- Air, water and soil quality
- Biodiversity
- Bioenergy development
- Sustainable fisheries and aquaculture.

Action 1: define specific sustainability objectives

In the previous section we discussed how we expect demands on land to increase during the Food Harvest 2020 period, and more specifically post 2020. These include agronomic demands to meet food security objectives, but also include environmental demands to meet environmental sustainability objectives set by EU Directives. Examples include the need for land to sequester carbon to partially offset agricultural greenhouse gas emissions, the demand for quality drinking water to be extracted from land, the demand to provide a habitat for both functional and intrinsic biodiversity, and the demand to find a sustainable receptor ('home') for external nutrients from sewage sludge and intensive enterprises.

In principle, land can meet these demands through the provision of land-based ecosystem services, also known as soil functions. To date, in a scenario where land availability has not been the main constraint to the provision of soil functions, the tenet of contemporary thinking on sustainability has been to *maximise* all these soil functions. Put simply: "the more carbon sequestration, the better, the more biodiversity, the better, etc". However, in the emerging scenario where land availability is becoming one of the constraints to sustainable food security (not only in Ireland, but indeed at EU and global scales), it may not be technically possible to *maximise* food production *and* carbon sequestration *and* water purification *and* biodiversity *and* the nutrient recycling capacity all at the same time, on each parcel of land. A more realistic aim is to *optimise* (rather than maximise) each of these functions, so that they meet the various demands set by EU Directives and national policy objectives.

Figure 2: Soil functions provide a framework for 'Sustainable Food Security' in the context of Food Harvest 2025. (White = primary productivity; blue = water purification; black = carbon sequestration; green = habitat for biodiversity; purple = receptor of external nutrients)

In a recent scoping study, Teagasc assessed the 'demand' for each of these soil functions under a Food Harvest 2020 scenario, as well as the potential national 'supply' of each function to meet these demands (Table 1):

Table 1: *Supply and demand for soil functions at national level under the Food Harvest 2020 scenario (Schulte* et al.*, 2014).*

LAND USE FUNCTION	PROXY (IN THIS STUDY)	PROJECTED 'DEMAND' FOR SOIL FUNCTION	MAXIMUM 'SUPPLY' OF SOIL FUNCTION	CAVEATS/NOTES
Food, fibre and fuel production	Stocking rate	1.0 LSUa per hectare	1.5 – 1.8 LSU per hectare	Large differences in carrying capacity exist between contrasting soil types, from 0.5 – 3.0 LSU per hectare.
Water purification	Denitrification capacity	8 kg N per hectare per year	24 kg N per hectare per year	Large differences in denitrification capacity between soils and regions, from 5 – 63 kg per hectare per year.
	Phosphorus (P) sorption (Index 1 and 2 soils)	National P-"surplus": 2.2 kg per hectare per year	National soil P build-up capacity: 2-5 kg per hectare per year	The lack of P sorption capacity in soils with an organic matter content > 20% has been accounted for in these figures.
Carbon sequestration	Sequestration capacity by farm-afforestation	3.5 – 5.3 Mt CO_2e^b per year	5.8 Mt CO_2e^b per year	Requires significant acceleration in farm-afforestation rates to meet government targets. This Land Use Function should include carbon sequestration in grassland, but international scientific consensus on grassland sequestration rates has not yet reached conclusion.
Habitat for biodiversity	Above-ground biodiversity	1. Habitat Directive: SAC 2. Birds Directive: SPA designation 3. Strengthen conservation within designated habitats	- Natura 2000 sites - Non-designated peatland - Rare species - HNV farmland?	Obligations regarding Birds Directive and strengthening of conservation within designated habitats are currently not fully met.
Recycling of (external) nutrients	Recycling of P in pig manure	5,674 t P per year	Tillage + suitable grassland (Index 1 and 2): 29,509 t P per year	Large differences exist between regions in the availability of suitable tillage and grassland soils. Emerging demand for recycling of sewage sludge (EU Sewage Sludge Directive) may compete for recipient soils.

a: LSU = livestock unit. b: CO_2e = Carbon dioxide equivalent emissions.

This study concluded that it is technically possible to meet both the agronomic and environmental objectives of Food Harvest 2020, but with important caveats. The first of these is that there is a need to match the supply of each soil function to the corresponding policy demand by 2025. In other words: there is a need to specify how much carbon needs to be sequestered at national level, how much nitrate can be denitrified, which habitats must be maintained, as well as the quantity of external nutrients that need to be recycled.

It is worth noting that Teagasc has received €5million from Horizon 2020 to lead to a 22-partner international consortium (LANDMARK) to extend this concept of 'Functional Land Management' at a European scale.

Recommendation:
Where Agri-Food 2025 specifies this ambition at national scale, both in terms of targets for agronomic and environmental sustainability, this will enable an integrated approach to land management that maximises the co-benefits of farm management actions.

Action 2: Develop a framework for context-specific solutions
However, it is worth noting that the supply of each of the soil functions differs between pedo-climatic environments. For example, whilst at national level the denitrification capacity of Irish soils averages 24 kg of N per hectare per year, this ranges from 5 to 63 kg N per hectare per year, depending on soil properties and climatic variables. Similar ranges can be observed in the supply of the other soil functions.

In addition, the demand for the soil functions operates at a range of spatial scales (Table 2). For example, the Nitrates Directive prescribes a target for nitrate concentrations in groundwater that must be met ubiquitously, i.e. at the smallest spatial resolution. By contrast, the EU Energy and Climate Package 2030 has thus far only set targets at EU level, and is expected to result in national, rather than sub-national targets. This has important implications for the management of each of the soil functions. It means that some soil

functions (such as carbon sequestration) can be 'traded' between regions, whilst others (such as water purification) cannot.

Table 2: *Spatial scale of application for each of the policies aimed at incentivising specific soil functions*

Soil function	Policy driver	Spatial scale
Primary productivity	CAP	Multiple (farm – European)
Water purification	Nitrates Directive	Ubiquitous (farm)
Water purification	Water Framework Directive	Catchment
Carbon sequestration	EU Energy and Climate Package 2030	National
Habitat for biodiversity	Habitat Directive, Bird Directive	Multiple: from individual (rare) species to national level
Recycling of external nutrients	Nitrates Directive, Sewage Sludge Directive	Regional (transport as limiting factor)

The variation in both the supply of, and demand for, soil functions means that the optimisation of soil functions requires context-specific solutions that are tailor-made for the unique circumstances that each farm operates in. Put simply: 'blanket policies' may unduly restrict primary productivity where these restrictions are not required, and at the same time be insufficiently effective where the demand for other soil functions is high. In principle, this is not a new finding, but it has been assigned a renewed urgency in the context of the aforementioned increasing demands on land.

In recent years, policy formation has already progressed significantly to facilitate such a context-specific approach. For example, the Water Framework Directive objectives are being implemented at catchment scale through the development of River Basin District Management Plans. Work is on-going to delineate new Areas of Natural Constraint, based on the (in-)capacity of soils to support primary productivity, and a similar approach is possible in the implementation of the forthcoming GLAS. These developments are aided by the recent publication of the Irish Soil Information System (http://gis.teagasc.ie/soils) and the Indicative Land Use Map of Ireland (O'Sullivan *et al*., submitted).

Recommendation
Inclusion of a framework for context-specific solutions into the Agri-Food 2025 strategy will maximise the efficiency and cost-effectiveness of incentivisation initiatives for soil functions. In other words: it will help ensure that both agronomic and environmental targets are met at least cost and with maximum effectiveness.

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