Can Ireland feed itself?
Options for greater food security in a climate changed world

Andi Wilson
The Sustainability Institute

Can Ireland feed itself? Options for food security in a climate changed world

Discussion Document

Draft 2.1[1]

Andi Wilson
The Sustainability Institute
15 November 2019

[1] The 2.0 and later versions include the 2018 emissions data from the EPA., also projected emissions 2020-2040 (see *The Emission Reduction Reality Gap* p34). Updated versions will be posted at http://www.sustainability.ie/foodsecurityscenarios.html

andi@sustainability.ie
www.sustainability.ie

Table of Contents

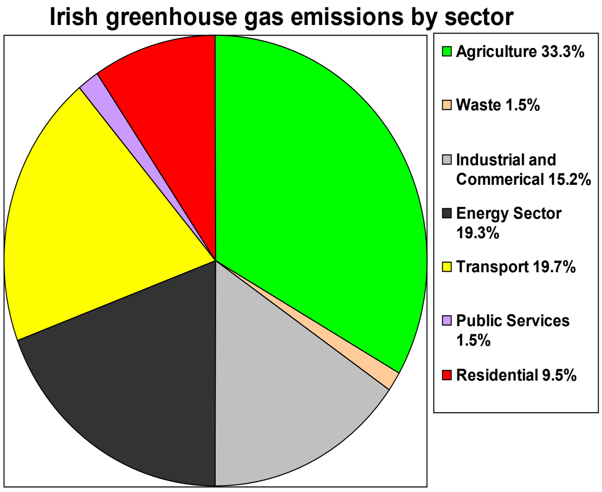
Author's note: all omissions and errors are my own. Some errors discovered in the earlier drafts have now been rectified.

Andi Wilson, 15 November 2019

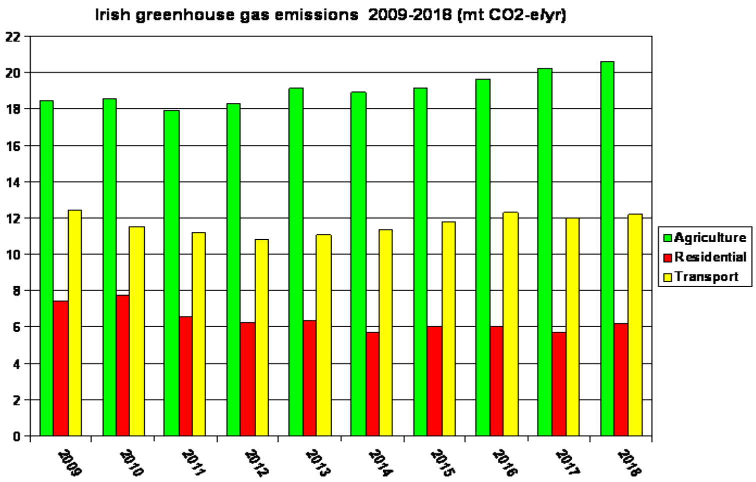
Executive Summary

Anthropogenic climate change is now a major threat to the entire global ecosytem, including our species' survival. The United Nations has stated unambiguously that the world must achieve net zero greenhouse gas emissions by 2050. To achieve even this target - which many climate scientists are already saying will need to be brought forward - will require a complete transformation of how the world does business, including a massive reduction in car usage and a paradigm shift in the global diet away from meat and dairy products and towards a diet based on grains, pulses, seeds and nuts.

In per capita terms, the highest emitting nations emit more than one hundred times the emissions of the lowest. Ireland's per capita emissions are the third highest in the EU and 60 percent above the EU average. Ireland's current emission target for 2050 - as determined by the Irish government's Climate Change Action Plan of June 2019 - is an 80 percent reduction on current levels (not 100 percent as targeted by the EU). Although total Irish emissions have fallen by 12.7 percent since 2010, the current rate of annual emission reduction would lead to a reduction of only around 50 percent by 2050. A much steeper rate of emisson reduction is required. The 2019 Climate Change Action plan does not provide convincing information as to how this might be achieved, and pins much on the development of renewable energy technologies and the massive ramping up of electric vehicles, without addressing the deeper structural problems underpinning the current high levels of emissions.



Greenhouse gas emissions 2017



Sectoral greenhouse gas emissions 2009-2018 (milliion tonnes CO_2-e/yr). Source: EPA

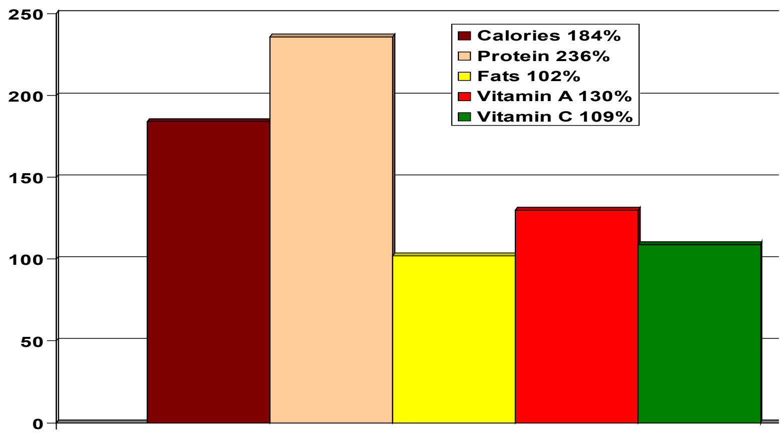
One third of Ireland's greenhouse gas emissions come from agriculture, *more than the residential and transport sectors combined*. More than 96 percent of agricultural emissions are attributable to livestock or land use related to livestock farming. Agricultural emissions have risen by 8.9 percent since 2010 and according to goverment projections - as based on the intended expansion of the dairy sector - will rise further by 2030. This proposed expansion - combined with the likely agricultural trajectory beyond 2030 - is incompatible with the Irish government's stated aim of an 80 percent reduction in Irish greenhouse gas emissions by 2050.

Irish agriculture is primarily export driven and plays only a secondary role in meeting Ireland's domestic needs: providing only one fifth of Ireland's food calorie requirements, one third of protein consumed and one quarter of fats. The remainder of Irish food requirements are met by food imports, many of which - along with a high proportion of imported animal feed - originate in countries vulnerable or very vulnerable to the effects of irreversible climate change, or come at a high environmental cost owing to their role in on-going tropical rainforest destruction.

Historically, Irish agriculture has shown tremendous versatility to respond to changing circumstances. Of particular note is the period from 1939-1948 when the Second World War caused Ireland's food imports to decline to a trickle and Ireland had to ramp up indigenous grain production or starve. *The Emergency* - the name by which this period is known - accurately reflects the nature of the problem: this was a national crisis of life threatening proportions requiring a resolute, coordinated and public-supported national response, and to its lasting credit Ireland rose to the challenge.

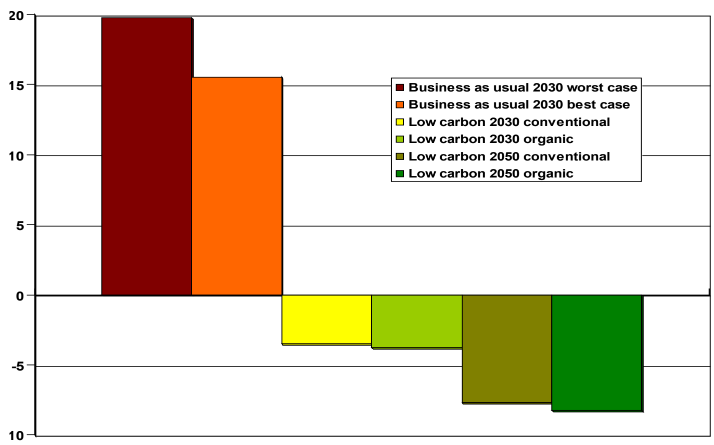
Irish food self sufficiency 2017, by percentage (calculations by author)

The new emergency - which will be global in its impact - is *irreversible climate change* and unlike the Second Wolrd War this crisis will not be over within a relatively short number of years. However, the outcome - both for the global ecosystem and our own species - will depend largely on how global societies acknowledge and respond to that challenge between now and 2030.



Potential Irish food self sufficiency in low carbon alternative agriculture (calculations by author)

Appropriately reconfigured, Irish agriculture has the potential to meet all national nutritional requirements - thereby reducing food import dependency to very low levels - while also becoming an important net carbon sink with which to offset one fifth of all greenhouse gas emissions originating in the non-agriculture sectors. The new look, low-emission agriculture, specifically tailored to meet Ireland's needs, would be characterised by historically low numbers of livestock, a doubling of the current level of tillage and the repurposing of the still considerable grassland resource as a carbon sink.



Carbon balance of business-as-usual agriculture (as per Irish government 2019 Climate Change Action Plan) versus low carbon alternatives. Figures in millions of tonnes carbon dioxide equivalents (calculations by author)

Global Warming and Food Security

Two unfolding and non-avoidable global events, namely fossil fuel depletion and global warming, are set to alter human societies out of all recognition in coming decades. Even in isolation, the depletion of geological oil and gas deposits as a consequence of over-extraction - fuels on which human society completely depends - would represent a crisis on a scale far greater than anything humanity ever faced before. However, in recent years the looming crisis of fossil fuel depletion has been completely overshadowed by the damage already caused to the earth's delicate climate from the burning of these same fuels, from agricultural activities and in particular the massive increase in livestock numbers, and from the on-going destruction of the tropical rainforests, through the release of greenhouse gases that are now known to be causing the earth to warm up.

These gases, in terms of impact primarily carbon dioxide, methane and nitrous oxide, cause outgoing solar radiation to be be absorbed and trapped within the earth's atmosphere. All three of the primary greenhouse gases occur in the atmosphere naturally, but since the beginning of the industrial era their atmospheric concentration has begun to rise, and has risen at ever-increasing rates during the last 40 years. There is now irrefutable evidence that the increased presence of these gases in the atmosphere is causing the temperature of the earth to rise, hence the expression *global warming*. The consequences will be both widespread and severe, and will increase exponentially as the temperature rises further. These consequences include species extinction, desertification, permanent changes to the earth's hydrological cycles, icecap melt and the associated sea level rise, and severe impacts on global agriculture and on the ability of humanity to feed itself.

Approximately 76 percent of anthropogenic (human-caused) global warming is attributable to carbon dioxide, 16 percent to methane and 6% to nitrous oxide. By sector, agriculture and other land use activities are responsible for 24 percent of emissions, electricity generation, heating and other energy sector emissions account for 35 percent, industry 21 percent, transport 14 percent and buildings 6 percent (IPCC 2014).

A 1.5ºC increase in global temperature by 2100 is regarded by climate scientists as being about the maximum that the planet can accommodate without massive impacts upon both ecosystems and human welfare. Currently, emissions from human activity and associated feedbacks (for example methane released as the Arctic region warms up) put the earth on a trajectory for a temperature increase of 3-6ºC by 2100 (and further increases after this date), trajectories which if not addressed within a very narrow window of time will cause massive species' extinction, possibly including our own.

"The past four years were the warmest on record, with the global average surface temperature in 2018 approximately 1ºC above the pre-industrial baseline. These data confirm the urgency of climate action. This was also emphasized by the recent Intergovernmental Panel on Climate Change (IPCC) special report on the impacts of global warming of 1.5ºC. The IPCC found that limiting global warming to 1.5ºC will require rapid and far-reaching transitions in land, energy, industry, buildings, transport, and cities, and that global net human-caused emissions of carbon dioxide need to fall by about 45% from 2010 levels by 2030, reaching net zero around 2050."
(António Guterres, United Nations Secretary-General, 2018)

Runaway global warming will be devastating for global food security, resulting in wholesale collapse of food production systems followed by famine on an almost unimaginable scale. Even if all anthropogenic greenhouse gas emissions miraculously ceased tomorrow there is sufficient momentum in the planet's climate processes for global temperatures to continue rising for decades and for icecaps to continue melting and sea levels rising for a further five hundred to one thousand years. The best case scenario for achieving net zero global emissions (the point at which all unavoidable anthropogenic greenhouse gas emissions are cancelled out by sequestration/carbon capture) would be around 2040-2045, and achieving that target will require societal changes on a barely conceivable scale .In the meantime, global greenhouse gas emissions will continue at a level of tens of billions of tonnes of carbon dioxide equivalents per annum for many years to come, accelerating the rate of warming further.

Global Warming: Implications for Ireland

The *Climate Change Action Plan*, published by the Irish Goverment in June 2019, identified the following threats from global warming:

- *Rising sea-levels threatening habitable land and particularly coastal infrastructure*
- *Extreme weather, including more intense storms and rainfall affecting our land, coastline and seas*
- *Further pressure on our water resources and food production systems with associated impacts on fluvial and coastal ecosystems*
- *Increased chance and scale of river and coastal flooding*
- *Greater political and security instability*
- *Displacement of population and climate refugees*
- *Heightened risk of the arrival of new pests and diseases*
- *Poorer water quality*
- *Changes in the distribution and time of lifecycle events of plant and animal species on land and in the oceans*

A notable omission from this document was the risk to food security, namely the ability of Ireland to feed itself, either from food production from within Ireland or from food imports. Ireland currently imports four calories of every five that it eats, two thirds of the protein eaten and three quarters of the essential fats. Yet as a consequence of global waming, many countries that currently supply Ireland with food or animal feed - particularly those of the mid latitudes of the Northern and Southern Hemispheres - will experience diminishing levels of precipitation (and consequently reduced access to water for irrigation), with considerable impact on crop production. This document takes it as an absolute certainty that the food imports that Ireland currenly takes for granted will not be available in a global warming impacted future on anything like the scale currently enjoyed .

In terms of per capita greenhouse gas emissions, Ireland is one of the worst offenders in the EU, at around 13.3 tonnes carbon dioxide equivalents per annum compared to the EU average of 8.8 tonnes. Approximately one third of all Irish emissions comes from agriculture (compared to the EU average of about one tenth). The Irish figures relate only to the emissions created within Ireland and exclude the emissions attributable to the three million tonnes of animal feed and one million tonnes of artificial fertiliser imported each year.

The table below compares emissions of different foods per unit of usable protein produced:

Output	**kg CO_2-e per kg edible protein produced** [1]
Beef	73
Milk	29
Eggs	23
Potatoes	13
Wheat	4
Hazelnuts (cobnuts)	3
Pulses	2

[1] Kilograms of associated greenhouse gas emissions in carbon dioxide equivalents, per kilogram of animal or plant protein produced. Figures are for production only and exclude the carbon footprint associated with bulk transportation, processing, retailing, transportation from retail outlet to customer, food preparation and cooking

In summary, it costs 6-11 times in greenhouse gas emissions to produce protein from eggs as from grain, nuts or pulses; 7-14 times as much to produce it in dairy products, and up to 36 times as much to produce it in meat.

Global Warming and Ireland continued

How will Irish agriculture rise to the challenges ahead? Many different scenarios are possible. Business-as-usual agriculture could continue until forced to change by diminishing availability of imported energy, or the reduced availability of artificial fertiliser or animal feedstocks (which are also predicated upon cheap oil and gas), or perhaps by a more pressing need to feed the Irish population because food imports have dried up. Unfortunately, the current governmental approach of waiting until something goes badly wrong before changing course will not lead to a good outcome: many of the required changes towards sustainability in agriculture will take decades to fully come on stream and will not be achievable during crisis conditions.

Minimum objectives

Some suggested *minimum* targets are set out below:

1 *To reconfigure Irish agriculture to deliver a diverse, nutritious, wholesome and ecologically sustainable diet that will feed the population of Ireland, and specifically:*

2 *Carbon neutrality (zero net emissions) in agriculture by 2030*

3 *80% self sufficiency in staple foods by 2035 (with clear intermediate targets for each 5 year period prior to that)*

4 *100% self sufficiency in staple foods by 2050*

Although the emphasis in food security must be on grain, the author believes nuts could also play a small but important role to in future food security. Nuts could help Ireland meet its dietary lipid (fat) requirements as well as offering increased crop diversity and insurance against extreme weather events and a changing climate. And although in terms of calories and protein produced per unit area of land, an intergrated rotation of grains, potatoes and pulses would provide a much better return than nuts, the latter still farsurpasses beef, as the tables below illustrate:

Beef Cow		**Hazelnut (cobnut)**	
Cows per ha [1]	1	Trees per ha	400
Weight gain/yr (kg)	365	Yield/yr (kg)	1500
Hot carcass gain/yr (kg)	220	Shelled weight (kg)	750
Usable meat/yr (kg)	146		
Protein kg/ha/yr	38	Protein kg/ha/yr	106
Calories 000s/ha/yr	365	Calories 000s/ha/yr	4875

[1] This seemingly very low figure factors in the land needed to produce the feed

	Beef Cow	**Cobnut**	**Tillage Crops (6 year rotation) [1]**
Protein kg/ha/yr	38	106	561
Calories (000s/ha/yr	365	4875	14483

[1] 1 year each of potatoes, wheat, oats and peas/faba beans plus 2 years of green manures

Nut crops could have a critical role on land difficult or impossible for tillage (for example land unsuited to machinery). In a new food security-focused agriculture, livestock would be downgraded to an anxillary role for nutrient recycling, making use of land unsuited to either nuts or tillage and combining with nuts in agroforestry enterprises. However, although the case for incorporating nuts into a long term agricultural strategy is strong, the main focus of this document will be on tillage crops because it is these primarily that in a climate changed future will keep the Irish population fed.

Can and should Ireland be self sufficient in food?

How self-sufficient is Ireland?

In 2010 I had attempted to answer this question but to calculate this figure is far from straightforward. *How exactly is self sufficiency determined?* Should it be based on calorific intake, protein, lipids, vitamins and minerals, or some combination of all? And then there was the question of determining the quantities of food consumed, and whether the necesary information was available. In order to make the study more manageable I decided to concentrate solely on calories, as figures for the calorific value of food and of dietary intake were more readily available.

United Nations FAO data showed the per capita calorific intake for Ireland to be around 3650 kcal per day[1]. My initial reaction was that this figure was implausibly high as the minimum daily requirements for good health are around 2000-2600 kcal, depending on gender and age. If the FAO figures were correct then Ireland was eating at least 38 percent more food than it needed. Was this credible? It was hard to say.

It is worth asking how exactly are such figures reached. Are they from derived from per capita food purchased or from food known to be consumed? The two figures will differ by the proportion of food purchased that ends up as waste. My suspicion was that some of the calories included in the FAO data were not consumed at all but were destined for the bin. Also, I thought it very unlikely that the methodology used in calculating calories consumed will be the same in every country. More recent FAO data shows the daily per capita intake in Ireland to be 3590 kcal, which is the eighth highest in the world and seventh highest in Europe.

To calculate the proportion of food eaten in Ireland that was derived from Irish sources required some creative thinking. Much food purchased in supermarkets is processed and combines many different ingredients, derived from a wide range of places both within Ireland and abroad. However one starting point was the amount of food produced in Ireland for any given year, the data for which was readily available. From export statistics, the proportion of Irish-produced food that stayed in Ireland could be determined and once food waste was factored in this in turn would provide a figure for total calories of Irish-produced food consumed.

My rough calculation yielded a figure of 2.4 x 10^{12} kcal[2]. Allowing for wastage of 33 percent, this left 1.6 x 10^{12} kcal actually consumed, or about 26.7 percent of total calories consumed. The remainder (77 percent) by definition was imported.

Food self-sufficiency in Ireland: Indigenous food production versus imports (2010)		
Daily per capita calories consumed (kcal)	3650	
Food production and consumption		% of diet
Annual consumption (population 4.86 million) 10^{12} kcal	6.0	
Food produced in Ireland for Irish market 10^{12} kcal	2.4	
Irish produced food consumed (allowing for 33% food supply chain waste) 10^{12} kcal	1.6	26.7
Food imports consumed 10^{12} kcal	4.4	73.5

For reasons that will be outlined further overleaf, I was not entirely happy with the figure for self sufficiency. For one thing it seemed very low. Could it really be true that Ireland - an agricultural nation - produced barely of one quarter of the food it consumed? Read on to find out more.

Notes

[1] 1kcal = 1000 calories. However in popular usage kcal are frequently referred to as *calories*, which can be a little confusing
[2] 10^{12} means 1 followed by 12 zeros, or one thousand billion.

Can and should Ireland be self sufficient in food? cont...

How self-sufficient is Ireland in Food? Flaws in the calculations

There were a number of potential errors in the methodology used. These are listed below

Potential Error		
Error	Problem	Outcome
Imports	Ireland imports considerable quantities of poultry meat, pork, beef and cheese. It exports all these products also. Hence the difficult in knowing which production streams end up where	Unclear
Estimates of quantity	The difficulty of translating raw agricultural production figures (for example gross product weight) into food purchased. With such a diverse stream of products reaching the supermarket shelves, the potential for error was considerable. There was also the issue of in-stream wastage (see below)	May have overestimated the quantity of food reaching the consumer
Wastage	Wastage figures may have been underestimated	May have overestimated the proportion of food reaching the plate

In October 2019 I decided to carry out a follow up study. The results are given in the table below:

Food self-sufficiency in Ireland: Indigenous food production versus imports (2019[1])						
Daily per capita calories consumed (kcal)						3590
Annual consumption (population 4.86 million) 10^{12} kcal						6.37
Food production and consumption	**Best case**		**Worst case**		**Most likely scenario**	
	10^{12} kcal	% of diet	10^{12} kcal	% of diet	10^{12} kcal	% of diet
Food produced in Ireland for Irish market[2]	2.29		1.47		1.88	
Irish produced food consumed[3]	1.53	24.0	0.98	15.4	1.25	19.6
Food imports consumed[4]	4.84	76.0	5.39	84.6	5.12	80.4

Notes

[1] Population data is derived from 2018, food production data mainly from 2017 and 2018. The butter, cheese and cream figures were from 2011 (the latest year for which tonnage data for imports and exports could be found), however the flatlining of production for the Irish market in the half decade prior to 2011 suggested that in spite of the growing population in Ireland, demand demand for these products had peaked.

[2] The calculations used have been mainly on the side of caution. In the best case scenario, it is assumed that all Irish-produced goods prioritise the Irish market, while all imports of dairy products and meat are re-processed for export. This is almost certainly not the true situation as any cursory examination of the cheese counter in any supermarket will reveal. Also, 60% of Irish cream produced for the Irish market is used in the Irish food and beverage industry, and a significant proportion of the final products (for example the Irish cream liquers) would be destined for export.

In the worst case scenario, the opposite is assumed, that all imports of dairy and meat are retained in Ireland and that Irish produced goods are prioritised for export. The true figure (before food chain waste) probably lies around 1.88×10^{12}, or 1.25×10^{12} kcal consumed, giving a final self sufficiency rate of 19.6%. The exact calculations are provided at the end of the document.

[3] Assumes 33% food waste in food supply chain (between slaughterhouse, dairy or field and plate).

[4] This figure is the Irish produced food consumed, deducted from total food requirements

Conclusions

My conclusion is that the proportion of food eaten that is produced in Ireland is at best no higher than one quarter and in the worse scenario could be below one fifth. Establishing a more precise figure - although certainly possible - is not something that needs to be determined. For the purposes of this study, the key message is that the greater portion of food eaten in Ireland is imported and that import dependency is extremely high, thereby leaving Ireland dangerously exposed to any significant disruption to the global supply chain. An equally important message - which Ireland's government must begin to acknowledge - is that in a global warming challenged world, agriculture in Ireland is simply not fit for purpose.

Should Ireland feed itself?

More specifically, should Ireland strive towards reducing import dependency? In real terms, Ireland last enjoyed food self sufficiency in the early nineteenth century. Since then, self sufficiency in food has followed a consistently downward trend, interrupted only by the two world wars, when the disruption to global food supply chains necessitated increasing production at home.

Viewed in the most rose tinted light, importing food instead of producing it at home allows access to a greater diversity of products and also to cheaper food elsewhere - though this is frequently predicated on lower labour costs and associated exploitation including child labour, and poorer or non existent environmental protection. It is also predicated upon political and economic stability within the international arena of trade and on cheap fossil fuel energy for transportation. However food importation comes with many downsides, not least of which are the greenhouse gas emissions costs of long distance transportation and the destruction of ecosystems eleswhere.

Global warming is predicted to bring many irreversible changes to the earth's climate, many of them occuring disproportionately in countries that supply Ireland with food. These countries include Spain, Portugal, France, Italy, Greece, Netherlands, Egypt, Israel, Kenya, Ghana, Pakistan, India, Thailand, China, Indonesia, Philippines, Australia, New Zealand, USA, Canada, Costa Rica, Honduras, Panama, Colombia, Brazil, Argentina and Chile. Few of the climate changes these countries will experience will lead to increased agricultural output. Conversely many of the predicted changes will result in reduced yields or even complete failures of certain crops. Withoutquestion, this reduced production will require a greater proportion of crops to be retained by these countries for domestic consumption and will impact significantly on export availability and price. In turn these constraints and price increases will felt by recipient countries, who will either have to pay much more or find alternative supplies.

It seems prudent, if not essential that Ireland reduces import dependency, and especially from countries particular vulnerable to climate change. A further issue is Ireland's greenhouse gas emission footprint, which in per capita terms is far higher than can be justified, and for which the intensive, livestock-based and export-orientated type of agriculture practised must take a significant portion of blame.

Having determined reasons for Ireland seeking a greater self reliance, we may then ask how high a degree of self sufficiency is *desirable*, and what is *achievable*. For the purposes of this exercise we will presume that *all* food imports are threatened that climate change, and that self sufficiency in food of close to 100 percent is desirable.

And in order for there to be consistency with the ojective of healthy eating we will presume it desirable that per capita food consumption in Ireland falls from 3500 kCal to 2800 Kcal, putting Ireland on a par with Japan (the country at the top of the global index of life expectancy). Daily protein consumption, currently around 110g per capita is presumed to fall to 92g (also in line with Japan). Daily per capita fat consumption is presumed to fall from 126g to 80g. Also included in the study are vitamins A and C, primarily to demonstrate the degree of self sufficiency achievable but also to show such calculations are relatively straightforward (and could be extended to include minerals and all other vitamins in food).

Irish food security: Agricultural targets in order to achieve 100% nutritional self sufficiency		
Criteria	Daily per capita consumption	National requirements per year (target)
Population 2030 (estimate) = 5 500 000		
Calories required (kcal)	2800	5620×10^9
Protein required (g)	92	185×10^9
Fats required (g)	80	160×10^9
Vitamin A required (µg beta carotene equivalent)	9600	19300×10^9
Vitamin C required (mg)	90	181×10^9

How self-sufficient is Ireland in Food? cont...

Assessing the Land Resource

The next step in determining Ireland's long term food options is to accurately assess the land resource available. The total land area of Ireland is 70 270 km² or 7 027 000 hectares (ha). Historically, many different classification systems have been used to categorise the various types of land. From a food security perspective, the most useful analysis is one that identifies grades of agricultural land. The breakdown can be seen in the table below:

Irish Land Resource		
Category of land		ha
Agricultural land		
1	Tillage land (land currently used for crops)[1]	378 000
2	Historical tillage land currently used for silage or hay[2]	622 000
3	Other land used for silage or hay[3]	666 000
4	Pasture[4]	2 338 000
5	Rough grazing[5]	474 000
Total agricultural land		**4 478 000**
Non Agricultural Land		
6	Forestry[6]	770 000
7	Scrub[7]	150 000
8	Peatlands (excluding forestry and agriculture)[8]	970 000
9	Water[9]	149 000
10	Built-on land	150 000
11	Mountain and other	360 000
Total non agricultural land		**2 549 000**
Total Land		7 027 000

[1] Includes berries, orchards and nurseries (c1 500 ha). The largest portion (c250 000 ha) is used to produce crops for animal feed. A further 25 000 ha is used for the production of crops for beverages (mainly whiskey and beer)

[2] Presumed to be the higher quality portion of the land used for silage and hay. Much of this land would have been tilled up till about 1950 and can be considered potentially available for crops.

[3] Presumed to be the poorer quality portion of the land used for silage and hay. However, some of this land would have been tilled until the 1950s and almost all of it would have experienced tillage at some point during the previous 180 years. A significant proportion of this land can be considered to have some crop-growing potential.

[4] Land rarely tilled (some may have been tilled by hand in pre-famine times)

[5] Untilled land, often unenclosed, used for grazing

[6] Woodland and plantation forestry, mainly coniferous

[7] Marginal woodland and gorse scrub

[8] Natural peatlands, cutaway bog from domestic turf cutting and indsustrial extraction and rehabilitated bog

[9] Lakes and other bodies of water

These categories are by no means static (and in some cases definitions can change). As a result of large-scale coniferous planting the area covered by forestry has increased dramatically since 1960, at the expense of peatland and agricultuiral land. The proportion of land used for tillage has fallen significantly since the Second World War. The area of built land, although small in total percentage terms, continues to increase. Much of the land recently lost to roads or buildings has been high grade agricultural land.

Food Self Sufficiency Scenarios

I have presented a number of possible scenarios for future Irish food security. The first 4 scenarios are based on current agricultural practices and intended trends as determined by government policy, hence the acronym BAU (Business as Usual). In these scenarios agriculture is dominated by dairy and beef production, geared primarily towards serving export market. The other scenarios are based on various alternatives to livestock-based agriculture.

Scenarios Business as Usual (BAU)	
IR2018	The current situation
BAU	Agriculture continues on current trajectory. It's not clear whether the lower calorific intake would lead to reduced import dependency as here the world continues on its present path and diet is determined by consumer choice, availability and price. We are assuming no change in self sufficiency.
BAU ES	Export Substitution (exports replace imports like-for-like). Some limiited export substitution opportunities exist in the dairy and meat sectors. Ireland produces six times more cheese than its domestic market requires yet imports an estimated 50 % of all cheese consumed. However as the imports include many types of cheese not produced in Ireland, substitution is not straightfoward.
BAU RS	Robust Substitution, Products intended for export are used instead to replace broadly similar but not identical products. Here all the Irish cheeses destined for export are assumed to be acceptable replacements for different types of imported cheese. Similar substitutions would be possible in the meat sector However the proportions of dairy and meat in the Irish diet do not significantly change.
BAU MW	As above but with reduced waste in food chain (20%). Assumes overall production volumes unaffected.

The figures for BAU emissions are those provided in government documents and are for the year 2030. The beef herd is forecast to decrease slightly while the dairy herd is predicted to expand (in line with stated objectives to increase dairy output). In the latest policy documents for agriculture, the presumed upward trend in emissions attributable to the livestocksector is offset to varying but limited degrees by attempts to increase efficiency within the sector. At best these can be regarded as deckchair rearranging exercises, with little scope for any significant emissions reduction while dairy herd numbers continue to increase.

In these scenarios, the base line carbon sequestration figure of 2.0 kT CO_2-e is from existing tree cover, primarily coniferous forestry.[1] Any additional carbon sequestration achieved would be predicated upon an expansion of coniferous forestry. However, as the expansion in forestry could only be achieved at a reduction in the land available for livestock, how this would be reconciled with an overall increase in animal numbers is not clear. In all BAU scenarios, emissions attributable to agriculture would result in Ireland's overall emissions being in breach of Ireland's international obligations and targets on climate change.

Somewhat generously, the BAU self sufficiency figures offered here assume that the increase in population between now and 2020 will be matched by an increase in Irish produced food allocated to the Irish market (at a cost in land allocated to exports).

[1] kT CO2-e = thousand tonnes of carbon dioxide equivalents of all greenhouse gas emissions combined

Scenarios Ireland during WW2	
These scenarios are actual figures of land allocated to crops during the WW2 Emergency	
IR1937	Based on land allocated to specific crops and estimates of food imports for that year
IR1944	Criteria as for 1937

These scenarios are offered for comparitive purposes, to show how quickly food production can be reconfigured towards self sufficiency when the national situation demands it.

Food Self Sufficiency Scenarios cont

Scenarios Low Carbon

In all the low carbon scenarios, food waste in the supply chain ispresumed to be 20% (as in BAU MW above). The crops and areas allocated to them are not intended to be a precise blueprint for future food security, but simply an example of how Ireland's dietary requirements could be met. In a real life sitation, the range of crops would be more diverse and would include sugar beet and crops for alcohol, energy and a host of other needs arising from the consequences of climate change.

LCC	Low Carbon, Conventional 660 000 hactares allocated to tillage, as follows: Wheat 160 000, oats 160 000, beans 80 000, peas 80 000, potatoes 50 000, linseed 24 000, hempseed 24 000, oilseed rape 48 000, carrots 10 000, kale 1 000, other brassicas 1 000, squashes 2 000. Conventional methods of production using artificial fertilsers to supply nutrition. 4 yr rotation: wheat, oats, pulses, all other crops in year 4. Additionally 20 000 hectares are allocated to berries: aronia 5 000, blackberries 4 000, sea buckthorn 1 000, cranberries 5 000 blueberries 5 000. The cranberries and blueberries require acid conditions and are not allocated agricultural land but cutaway bog instead. No livestock, no other field crops, All spare agricultural land is allocated to uncut grassland or broadleaved woodland for carbon sequestration.
LCO	Low Carbon, Organic 980 000 hactares allocated to tillage, as follows: Wheat 160 000, oats 160 000, beans 80 000, peas 80 000, potatoes 50 000, linseed 24 000, hempseed 24 000, oilseed rape 48 000, carrots 10 000, kale 1 000, other brassicas 1 000, squashes 2 000. Fallow land 320 000 hectares Organic methods of production using green manures to supply nutrition. 6 yr rotation: wheat, oats, pulses, all other crops, plus 2 fallow years. Additionally 20 000 hectares are allocated to berries: aronia 5 000, blackberries 4 000, sea buckthorn 1 000, cranberries 5 000 blueberries 5 000. The cranberries and blueberries require acid conditions and are not allocated agricultural land but cutaway bog instead. No livestock, no other field crops. All spare agricultural land is allocated to uncut grassland or broadleaved woodland for carbon sequestration.
LCFNC 2050	Low Carbon plus Fruit and Nuts, Conventional. Reference year is 2050, population 6 000 000. Crop scenarios as above with addition of 20 000 ha apples and 20 000 ha cobnuts (hazelnuts). This is deducted from the area allocated to new woodland (696 000 ha). No livestock, no other field crops, All spare agricultural land allocated to uncut grassland or broadleaved woodland for carbon sequestration. The first tranch of woodland (from 2030) is now carbon negative and is included in the sequestration figures. The area of grassland allocated to sequestration has been reduced by 696 000 ha as this has been allocated to additional woodland instead
LCFNO 2050	Low Carbon plus Fruit and Nuts, Organic. Reference year is 2050. population 6 000 000. Crop scenarios as above with addition of 20 000 ha apples and 20 000 ha cobnuts (hazelnuts). This is deducted from the area allocated to new woodland.(696 000 ha). No livestock, no other field crops. All spare agricultural land allocated to uncut grassland or broadleaved woodland for carbon sequestration. The first tranch of woodland (from 2030) is now carbon negative and is included in the sequestration figures. The area of grassland allocated to sequestration has been reduced by 696 000 ha as this has been allocated to additional woodland instead.

The maximum area of tillage allocated (970 000 hectares agricultural land plus 10 000 bog) in these scenarios is almost identical to the maximum area of tillage in Ireland during WW2 (1039 ha in 1944), when Irish food imports declined to almost zero. The carbon footprint allocated to each scenario has been calculated from the individual footprints for each crop. In the case of the organic scenarios, allowance has been made for net carbon sequestration during the two green manure years.

Food self sufficiency scenarios: Summaries of land allocation

Area for crops

Scenarios		Area (000 ha)												
		Potato	Veg	Fruit	Oil crops	Nuts	Sugar beet	Grain for food	Grain for alcohol	Grain for feed	Total grain	Other fodder Crops	Green manure crops[4]	Total crops
1	IR2018	8	4	2	2[1]	0	0	4	17	241	262	52	0	357
2	BAU	8	4	1	2[1]	0	0	4	17	241	262	52	0	357
3	BAUES	8	4	1	2[1]	0	0	4	17	241	262	52	0	357
4	BAURS	8	4	1	2[1]	0	0	4	17	241	262	52	0	357
5	BAUMW	8	4	1	2[1]	0	0	4	17	241	262	52	0	357
6	IR1937	132	not known			0	25	110[2]	265		375	265	0	644
7	IR1944	167				0	33	329[3]	387		716	307	0	1039
8	LCC	50	14	20	96	0	0	320	0	0	320	0	0	660
9	LCO	50	14	20	96	0	0	320	0	0		0	320	980
10	LCFNC 2050	50	14	40	96	20	0	320	0	0	320	0	0	700[5]
11	LCFNO 2050	50	14	40	96	20	0	320	0	0	320	0	320	1020[5]

Notes

All data for BAU crop, fodder and grazing areas from CSO (2018)

[1] Total oilseed rape in BAU scenarios = 11 kha. The balance was for animal feed

[2] 1937 Grain for food is taken as the wheat area (89 kha) plus 5% of the allocation for oats (the balance of oats being for feed

[3] 1944 Grain for food is based on total wheat area plus 15% of the area allocated to other grains (primarily barley and oats). This figure may underestimate the proportions of barley and oats used for food.

[4] These are cover crops grown specifically for incorporation into the soil. Some of these crops would also be nitrogen fixing. The net result would be increased soil carbon and nitrogen

[5] Includes 20 000 ha each of fruit trees and nuts

Area allocated to hay, silage, grazing, tree cover and carbon sequestration

Scenarios		Area (000 ha)							
		Hay Silage and Grazing				Grassland for carbon sequestration	Tree Cover		
		Silage and Hay	Grazing	Rough Grazing	Total Hay, Silage and Grazing		Existing	2020-2030	2030-2050[4]
1	IR 2018	1256	2379	524	4139	0	770	70	n/a
2	BAU	1256	2379	524	4139	0	770	70	[4]
3	BAUES	1256	2379	524	4139	0	770	70	[4]
4	BAURS	1256	2379	524	4139	0	770	70	[4]
5	BAUMW	1256	2379	524	4139	0	770	70	[4]
6	IR1937	not known			4350[3]		130[3]	n/a	
7	IR1944				3950[3]		130[3]		
8	LCC	0	0	0	0	3132	770	696	n/a
9	LCO	0	0	0	0	2812	770	696	
10	LCFNC 2050	0	0	0	0	2436	770	656	696
11	LCFNO 2050	0	0	0	0	2126	770	656	696

Notes

[3] Authors' estimates for 1937 and 1944 (Department of Agriculture figures: 1928 89 000 ha, 1949 144 000 ha)

[4] No data available

Source of IR1939 and IR1944 data: *Rationing in Emergency Ireland 1939-48* Ciaran Byran (unpublished thesis Maynooth 2014), taken from *Irish Trade Journal and Statistical Bulletin 1939-46.* This is a hugely impressive document and a valuable resource for the student of Irish food security.

Scenario details: Self Sufficiency and Carbon Footprint

Self Sufficiency

Scenarios		Self sufficiency: % of national food requirements produced in Ireland							
		Calories		Protein		Lipids (fat)		Vit A	Vit C
		current	reduced intake[1]	current	reduced intake[1]	current	reduced intake[1]		
1	IR 2018	**20**	24	**35**	42	**24**	38	**34[4]**	**25**
2	BAU (2030)	**21**	24	**37**	44	**25**	40	**36[4]**	**25**
3	BAU ES (2030)	**22**	27	**40**	48	**27**	43	**38[4]**	**25**
4	BAU RS (2030)	**24**	30	**46**	55	**32**	50	**40[4]**	**25**
5	BAU MW (2030)	**29**	36	**55**	66	**38**	60	**48[4]**	**30**
6	IR 1937	55[2]		60[2]		70[2]		not known[5]	
7	IR 1944	90[3]		90[3]		80[3]			
8	LCC (2030)	**184**		**236**		**102**		**130**	**109**
9	LCC (2030)	**184**		**236**		**102**		**130**	**109**
10	LCFNC 2050	**172**		**218**		**98**		**119**	**107**
11	LCFNO 2050	**172**		**218**		**98**		**119**	**107**

Notes

[1] Reduced dietary intake as per reduced dietary requirements used in the low carbonscenarios. Per capita intake: Calories 2800/day, protein 92g/day (these are in line with modern day Japan, the country with the world's highest life expectancy). Fat = 80g/day. However, with the business as usual diet this would leave the proportion of dietary requirements met by meat or dairy products at unhealthily high levels.

[2] Author's estimates. Irish wheat and sugar imports alone would have accounted for around 35% of calorific intake. Even prior to the Second World War, the urban poor would have experience considerable food hardship.

[3] Author's estimates. Although Ireland came close to achieving food self sufficiency towards the end of the war years, there was also massive food hardship amongst the poorest members of society, compounded by a chronic scarcity of fuel for cooking and heating.

[4] Owing to the great variation in vitamin A fortification of low fat dairy products, these figures should be treated with caution.

[5] The diets of many of the urban poor would have been chronically deficient

Carbon Balances (per scenario)

Scenarios		Carbon balance Mt CO_2-e/yr (million tonnes carbon dioxide equivalent per year)							
		Footprint	Sequestration						Net emissions
			Forests and Woods			Set aside grassland	Other[11]	Total	
			Existing	2020-2030	2030-2050				
1	IR 2018	20.21	-2.0						+18.21
2	BAU (2030)	19.45 21.75[1]	-2.0	0[6]	n/a	0[9]	-1.85 0	-3.95 -2.00	+15.50 +19.75
3	BAUES (2030)	19.45 21.75[1]					-1.85 0	-3.95 -2.00	+17.50 +19.75
4	BAURS (2030)	19.45 21.75[1]					-1.85 0	-3.95 -2.00	+15.50 +19.75
5	BAU MW (2030)	19.45 21.75[1]					-1.85 0	-3.95 -2.00	+15.50 +19.75
6	IR 1937	not applicable							
7	IR 1944								
8	LCC (2030)	2.88[2]	-2.0	0[6]	n/a	-4.39[10]	0	-6.39	-3.51
9	LCO (2030)	2.17[3]				-3.96[10]		-5.96	-3.79
10	LCFNC 2050	2.88[4]		-4.13[7]	-1.10[8]	-3.44[10]		-10.67	-7.69
11	LCFNO 2050	1.99[5]		-4.13[7]	-1.10[8]	-3.00[10]		-10.23	-8.24

For notes see overleaf

Notes in relation to the carbon emission and sequestration figures

[1] The different figures represent best and worst case scenarios presented in the Irish government's 2019 Climate Change Action Plan.

[2] Total emissions from crops (2.67 Mt CO_2-e/yr) plus total soil carbon and nitrous oxide losses from the conversion of 283 kha of grassland to crops amortised over 10 years. These are 2t/ha CO_2-e carbon and 5.3t/ha CO_2-e nitrous oxide = 7.3t/ha CO_2-e over 10 years. Hence 0.73t ha/yr CO_2-e x 283 kha = 0.21 Mt CO_2-e/yr.
The final calculation is thus 2.67+0.21 = 2.88 Mt CO_2-e/yr.

[3] Total emissions from crops (2.91 Mt/yr) plus total soil carbon and nitrous oxide losses from the conversion of 603 kha of grassland to crops amortised over 10 years. These are estimated as 2t/ha CO_2-e carbon and 5.3t/ha CO_2-e nitrous oxide = 7.3t/ha CO_2-e in total over 10 years hence 0.73t/ha/yr CO_2-e x 603 kha =0.44 Mt CO_2-e/yr). Set against this increased carbon cost is the atmospheric carbon and other nutrients gained by the soil during the two green manures years. With so many different permutations of green manure species, cultivation and incorporation methods, it is difficult to put precise figures on these benefits. The literature gives a range of 0.32-3.34t soil organic carbon/ha/yr. A compromise figure of 1t C/ha/yr (3.7 t CO_2-e/ha/yr) is used here. Multiplied by the 320 kha allocated to green manure crops this gives a carbon reduction of 1.18 Mt CO_2-e/yr. The final calculation is 2.91+0.44-1.18 = 2.17 Mt CO_2-e/yr.

[4] Total emissions from crops (2.81 Mt CO_2-e/yr) plus total carbon and nitrous oxide losses from the conversion of 283 kha of grassland to crops amortised over 30 years. These are 2t/ha CO_2-e carbon and 5.3t/ha CO_2-e nitrous oxide = 7.3t/ha CO_2-e over 30 years hence 0.24t/ha/yr CO_2e x 283 kha = 0.07 Mt CO_2-e/yr. The final calculation is 2.81+0.07 = 2.88 Mt CO_2-e/yr.

[5] Total emissions from crops (3.03 Mt CO_2-e/yr) plus total soil carbon and nitrous oxide losses from the conversion of 603 kha of grassland to crops amortised over 30 years. These are 2t/ha CO_2-e carbon and 5.3t/ha CO_2-e nitrous oxide = 7.3t CO_2-e over 30 years total hence 0.24t/ha/yr CO_2-e x 603 kha = 0.14 mt CO_2-e yr.. Set against this increased carbon cost is the atmospheric carbon and other nutrients gained by the soil during the two green manures years. As above, the compromise figure of 1 t C/ha/yr (3.7 t CO_2-e/ha/yr) is used here. Multiplied by the 320 kha allocated to green manure crops this gives a carbon reduction of 1.18 Mt CO_2-e/yr. The final calculation is 3.03+0.14-1.18 = 1.99 Mt CO_2-e/yr.

[6] Any new woodland or forestry planted between 2020 and 2030 would be too young to have any net carbon sequestration benefit. In the early years of new forestry, the emissions cost of land use change and planting cancel out any carbon sequestered.

[7]In the 2050 scenarios, the first tranche of new broadleaved woodland (656 000 ha) planted prior to 2030 is presumed to be sequestering carbon at the rate of 1.7t C/ha/yr (6.3t CO_2-e/ha/yr).

[8] In the 2050 scenarios, the second tranche of new broadleaved woodland (696 000 ha) planted prior between 2030 and 2050 is presumed to be sequestering carbon at the rate of 0.42t C/ha/yr (1.55t CO_2-e/ha/yr).

[9] Any carbon sequestered by existing set aside grassland would have already been accounted for in the overall emisions figure for Business-as-Usual agriculture. No additional land for set aside was allocated

[10] The sequestration figures for set aside assume a modest soil carbon gain of 0.38 t C/ha/yr (1.41t/ha.yr CO_2-e). Many studies have demonstrated that much higher rates of carbon sequestration are possible.

[11] Many additional measures were listed in the government proposals. These range from the reasonably credible to deckchair rearranging exercises and the highly marginal, and are listed below:

a) Improved beef genetics (maternal traits and liveweight gain)
b) Extended grazing
c) Improved nitrogen (N) use efficiency
d) Clover
e) Altered fertiliser formulation
f) Improved animal health
g) Altered crude protein in pig diets
h) Altered slurry spreading techniques
i) Use of slurry amendments during storage
j) Use of sexed semen
k) Drainage of impeded mineral soils
l) Pasture nutrient management (optimising pH, fertilisation, etc.)
m) Cover crops and straw incorporation in tillage
n) Water table manipulation in organic soils

The figure used in the tables here (1.85 Mt CO_2 -e/yr) is the median figure provided in the government document, which is the midway point between best case scenario and zero. The author notes that the historical record shows that government policy documents - particularly on energy use and greenhouse gas emissions - frequently paint an unduly rosy picture of the likely outcomes of said policy, and particularly where the required outcomes are presumed to be market-led.
(example '*Delivering a Sustainable Energy Future for Ireland*' Irish government white paper of March 2007. Almost all of the targets and aspirations outlined in this document were missed by a wide margin)

Food Security Scenarios

Shortcomings in calculations

1 Incorrect or misrepresented scenarios

The data for the BAU scenarios has been extracted from the Irish government's 2019 Climate Change Action Plan, which was published in June 2019. It has to be said that this is not an easy document to decipher. The effort to reduce greenhouse gas emissions in Ireland is frequently couched in terms of international obligations and permitted offsetting of Ireland's massive per capita GHG burden through clever accountancy tricks, rather than the non-negotiable imperative to prevent irrevisible climate change, and is also framed in Business-as-Usual economic terms which completely discount the future costs of not doing enough.

That said, the author has made a determined effort - through the BAU scenarios depicted here - to accurately represent the government position and it is hoped that any oversights or accidental omissions are small. One deliberate omission was the BAU scenario extended to 2050 but unfortunately the government plan did not provide adequate detail as to what would happen after 2030.

2 Insufficient data

The dearth of detailed information in relation to the origin of food eaten in Ireland inevitably resulted in a certain amount of guesswork, hence the figures for food self sufficiency under the BAU scenarios should be viewed as ball park rather than absolute truths.

The carbon costs attributed to food for the Low Carbon scenarios - by virtue of their origin in research undertaken outside of Ireland and in differences in methods of crop husbandry and greenhouse gas accounting - are inevitably only indicative. In most cases the author has erred on the side of caution and taken the higher figures for carbon costs and the lower ones for offsets.

3 Omissions and errors in calculation

For future reference, the author would be very grateful if anyglaring errors or omissions are pointed out! However, the gap between the BAU and Low Carbon scenarios in terms of emissions' costs, carbon sequestration and net carbon balance is too large to be significantly reduced by any small errors in calculation.

4 Downstream food emissions not included

The greenhouse gas emissions associated with food production do not end at farm gate but also include bulk transportation, storage, food processing, retailing, transportation of the finished product from shop to home and the emissions attributable to food preparation and cooking. Estimates are hard to find but total emissions cost for the UK has been estimated of 66.3 x Mt CO_2-e/ yr or approximately 1.1 t Mt CO_2-e/ per capita/ yr. Of this approximately 79 percent of emissions were associated with eating at home with the balance from eating out. These figures only included emissions downstream of regional distribution centres. Given Ireland's much lower population density it would be reasonable to conclude that per capita emissions associated with food processing and transport would be at least as high as in the UK. Also the downstream emissions will vary considerably according to the type of food. Approximately two thirds of downstream emissions are associated with processing, food storage and cooking (in roughly equal proportions).[1]

[1]*How low can we go? An assessment of greenhouse gas emissions from the UK foodsystem and the scope to reduce them by 2050.* WWF-UK.Audsley, E., Brander, M., Chatterton, J., Murphy-Bokern, D., Webster, C., and Williams, A.(2009).

Calculations used in low carbon scenarios

CO_2 emissions per kg/produce at farm gate and total scenario emissions

Crop	kg CO_2-e/kg crop at farm gate[1]	Total tonnes (000s)	Total CO_2-e (000 tonnes)	
			Conventional	Organic
Sugar beet	0.1	not included in scenarios		
Wheat	0.52	1152	599.0	
Oats	0.38	1152	437.8	
Faba beans, dry	0.61	288	175.7	
Peas, dry	0.51	280	142.8	
Potatoes	0.26	1500	390.0	
Linseed	2.20[2]	36	79.2	
Hemp seed	2.20[2]	60	132.0	
Oilseed Rape	2.09[3]	192	401.3	
Carrots	0.35	250	87.5	
Kale	0.22	8	1.8	
Broccoli	1.94	6	11.9	
Squash	2.22	20	44.4	
Total excluding berries			**2503.4**	**2753.7**
Aronia	0.84[4]	50	42.0	
Sea buckthorn	0.84[4]	5	4.2	
Blackberries	0.84	32	26.9	
Cranberries	1.39	40	55.6	
Blueberries	1.39	30	41.7	
Total berries			**170.4**	**153.4**
Total CO_2-e (all field crops)			**2673.8**	**2907.1**
Apples	0.32	400	128.0	115.2
Hazelnuts (cobnuts)	0.43[5]	15	6.5	5.9
Total CO_2-e (all orchard crops)			134.5	121.1
Total CO_2-e (all crops)			**2808.3**	**3028.2**

Source of data: *How low can we go? An assessment ofgreenhouse gas emissions from the UK food system and the scope to reduce them by 2050. WWF-UK.* Audsley, E., Brander, M., Chatterton, J., Murphy-Bokern, D., Webster, C., and Williams, A. (2009). Most figures are for UK production.

Notes

[1] Figures for conventional production (not organic). However, an extrapolation has been made for organic production, using the following convertion factors:
Annual tillage crops: Conventional x 1.1
Berries: Conventional x 0.9
Orchards: Conventional x 0.9
The higher figure for annual tillage crops relates mainly to the higher level of soil cultivation needed in weed control.

[2]The figures for hemp and linseed are taken from '*Misc Oilseed*' in the study above and relate to production outside the UK. In the author's view these figures would be very high for hemp seed or linseed grown in Ireland.

[3]The figure for oilseed rape seems high (elsewhere in the UK this is given as 0.539 kg CO_2-e/kg)

[4] No information available for these crops so the figure for blackberries is used instead

[5]The hazelnut data is based on production elsewhere in Europe and in the author's view is an overestimate of the footprint in UK or Irish conditions (hazelnuts grown in southern Europe have a considerable water footprint)

Commentary

As mentioned, this is not a blueprint for post climate change agriculture but an indicative model. A true blueprint would include all the crops Ireland might need. Notable omissions here include sugarbeet and crops for making alcohol - both for human consumption and for vehicle fuel - and readers conversant with the threat posed by irreversible climate change may feel that by 2030 these would be crops of some importance, and especially by 2050. However, it would be a simple matter to incorporate these additional crops into the mix. Given the massive calorific surplus in the crop combination outlined in the low carbon scenarios, a proportion of these crops could be used for ethanol production without any loss in food security. And some of the oat crop could be replaced with malting barley and sugar beet. These are but minor details. In any case, the optimum mix of crops would not be written in stone but would evolve over time according to society's needs.

Nuts

The envisaged 2050 hazelnut harvest of c30 000t is approximately 5 times greater than Ireland's annual tree nut imports (2018). A crop of this magnitude, in combination with relatively low supply chain costs allows the possibility of nuts evolving from a relatively luxury product into a mainstream staple food. Nuts also have great potential for use in many added value products: for example nut oils and butters. In addition to hazelnuts, there are many other species of nut that could produce viable crops in Ireland. Owing to the long lead time it is a matter of some urgency that all viable nut species be trialled on a small commercial scale. Species with good nut yielding potential include juglans (walnuts and heartnuts), castanea (chestnut), pinus (pinenuts) and araucaria (Monkey Puzzle).

Livestock

Although the exclusion of livestock from the low carbon food scenarios was deliberate, this document is not intended as a treatise against animal husbandry. Rather, its intention is to show that livestock isn't actually needed, and that the system of livestock-free agriculture outlined here not only can easily feed Ireland's population and even provide a surplus for export but can also be an impressive carbon sink with which to offset a significant proportions of Ireland's non-agricultural greenhouse gas emissions.

Radical as this may seem, a low or zero animal agriculture is far from being a new idea. In their groundbreaking study of UK food production and consumption *How low can we go? An assessment of greenhouse gas emissions from the UK food system and the scope to reduce them by 2050*, the authors considered many different scenarios for future food production in the UK, including ones with low or zero meat and zero dairy[1]. And food activist Simon Fairlie, in his 2007 article *Can Britain Feed Itself?* also considered the vegan option.[2]

However, it should be emphasised that within the framework of the scenarios offered there is considerable potential to incorporate livestock, ideally on a low-intensity basis that would enhance the options for sustainable agriculture rather than work against them. In an idealised diverse and mixed agriculture the best land would be mainly reserved for tillage, and the livestock eventually being downsized considerably from present numbers - perhaps by 80-90 percent - and allocated mainly to the land unsuited to field crops or to agroforestry situations involving orchard trees (for example nuts) or low density woodland for carbon sequestration.

[1] Audsley, E., Brander, M., Chatterton, J., Murphy-Bokern, D., Webster, C., and Williams, A.(2009). *How low can we go? An assessment of greenhouse gas emissions from the UK food system and the scope to reduce them by 2050. WWF-UK*.
This study was conducted for WWF-UK and the Food Climate Research Network.

[2] Simon Fairlie *Can Britain Feed Itself?* The Land 4 Winter 2007/08

The Old and New Emergencies

The Emergency was the name given by Ireland to the period 1939-1948, when the supply of essential imports was severely curtailed by World War Two and its aftermath. At the outbreak of war, approximately forty five percent of the Irish diet - including most of its wheat and sugar - was derived from imports, the lion's portion from Britain or its former colonies. Additionally, Ireland was also dependent on Britain for its supplies of motor fuel, gas, most of its coal and agricultural fertiliser.

Although the Irish government had begun as early as 1935 considering the implications of Britain becoming embroiled in a war with Nazi Germany, it had been lulled into a false sense of security by Britain's apparent unwillingness to enter into hostilities , culminating in Chamberlain's agreement with Hitler in 1938, which effectively ceded the Sudetenland region of Czechoslovakia to Germany.

Even after it became clear that conflict was inevitable, denial of the realities of war was endemic. The prevailing opinion both in Ireland and Britain was that Hitler would easily be defeated, that the war would be a brief one with only short-lived disruptions to international trade. It would be something of an understatement to say that Ireland was very poorly prepared for a long conflict and in particular one that brought Britain - the principal supplier of Ireland's food imports - to its knees.

The subsequent attempts to ramp up food production in Ireland were severely hampered by a chronic shortage of tractors and also of fuel. Nevertheless the tillage area allocated to wheat was increased from 89 000 hectares in 1937 to 260 000 hectares by1944. During the same period, the tillage area of oats - the principal animal feed (both for work animals and livestock) - was increased from 226 000 to 383 000 hectares. Needless to say the push for greater food self sufficiency was not left to chance or market forces but was driven by strong government intervention and support. Government measures included the Compulsory Tillage Scheme - which obliged all farmers with tillage quality land to allocate a proportion of their land to grain - and tight rationing of flour, butter and other essential food items to circumvent hoarding and ensure that society's most needy did not starve.

The New Emergency

The *New Emergency* is global warming - or more specifically irreversible climate change - and unlike Britain's war with Hitler it will not be over in a matter of a few years but will continue for the lifetime of everyone alive today and for many generations to come. Dealing with *this* emergency will require a complete transformation in how we live and in particular a reconfiguration of how we do food. It will require facing down the climate deniers, who by virtue of their refusal to accept incontrovertible facts are impeding action and thereby making an already bad situation worse.

Irreversible climate change is not a game in which the major decisions can be left to the market - the companies which trade in food and other essential commodities and their shareholders and CEOs - but must be driven by the bigger picture analysis and the need to minimise the permanent damage to the ecosystem and the threats to our and other species. And governments must step up to the table and show leadership and direction. In the words of the climate protesters who recently have taken to the streets, it will require governments to begin *telling the truth*. Although the United Nations has recently stated that the world must reduce net greenhouse gas emissions to zero by 2050 - a minimum objective that Ireland has yet to endorse at national level - there is very little small print about how such an objective could be achieved. Given this date is still quite distant, it is easy to dismiss calls for action on the basis that there is still *plenty of time*, but for the world to achieve zero net emissions three decades from now would be such an enormous undertaking that concrete measures towards achieving that aim must begin now. Not in five or ten years time, not even next year, but *now*. And just as in Ireland in 1937, there is no place for denial.

Achieving that aim also means challenging some of the perceived truths concerning the place of export-driven livestock-based agriculture in Ireland. Some of these are listed overleaf:

Myths of Contemporary Agriculture

1 This is how agriculture always has been

This is not the case. Cattle, cow and pig numbers are close to all times highs. Although Ireland has long produced livestock, historically it has also been a major producer of grain for food. In recent years however, more than 90% of grain production has been for animal feed, with three quarters of the balance for alcohol production. An examination of historical numbers (see tables below) reveals that the respective fortunes of different agricultural products have ebbed and flowed over time, often in response to market quirks and demands but in the case of the Second World War years entirely directed to meet national nutritional needs.

Crop areas 1861-2018

Crop	Hectares (thousands) by selected year[1]										
	1861	1881	1901	1931	1939	1944	1961	1976	1996	2010	2018
Wheat	133	47	13	8	103[2]	260[2]	140	50	86	78	58
Barley	78	83	64	47	30	68	146	259	181	175	166
Oats	574	378	293	252	217	383	149	40	21	20	22
Potatoes	349	257	186	140	128	167	86	47	24	12	8
Sugar Beet	0	0	0	2	17	33	32	35	32	10	0
Flax	19	16	5	0	2	12	0	0	0	0	0
Total Crops	1306	926	721	577	604	1039	678	476	406	354	357

Source: CSO

Notes

[1] This does not neccessily reflect output (which per hectare has increased considerably over time) but rather the relative importance of different crops

[2] Production of wheat (for bread) was ramped up massively during the war years. WW2 also gave a major boost to the emerging Irish sugar beet industry (which went into terminal decline after 2006 when the last Irish sugar plant closed).

Livestock numbers 1861-2018

Animal	Stock numbers (thousands) by selected year										
	1861	1881	1901	1931	1939	1944	1961	1976	1996	2010	2018
Total Cattle	2803	3268	3868	4029	4057	4246	4713	6954	7423	6606	6994
Cows	1208	1104	1178	1222	1260	1218	1291	2047	2413	2229	2351
Total Sheep	3358	3051	3981	3575	3048	2663	4528	3475	7934	4745	3744
Ewes	1436	1249	1525	1507	1298	1079	1927	1603	4405	2450	2622
Pigs	932	924	1015	1227	931	381	1056	925	1621	1516	1572
Poultry	8468	11013	14084	22782	19551	18330	12843	9531	13170	10925	n/a[1]
Goats	167	223	265	153	95	79	0[2]	0[2]	15	10	9[3]

Source: CSO

Notes

[1] No figures available for 2018

[2] Almost certainly under reported

[3] Figures for 2014 (later figures not available)

2 A rapid transformation of agriculture would not be possible

The historical record (above) suggests otherwise. When the situation warranted it, production could be reconfigured very quickly, for example during the Second World War when food imports reduced to a bare trickle and Ireland had to quickly face up to the challenge of feeding itself or starve. The area of wheat was ramped up from 103 000 hectares in 1939 to 260 000 hectares in 1944 and the total area of tillage reached levels not seen since the early 1870s. The transformation of Irish agriculture during this period was all the more remarkable for the limitations imposed by the numbers of available tractors and work animals.

A ten year lead time during peacetime conditions - a period both more generous and more condusive to change than the tight imperatives of the Second World War years - would easily provide sufficient time for major reallignments in agriculture towards addressing long term national food security needs.

Myths of contemporary agriculture cont...

3 Irish agriculture is too important economicially to be changed

Irish agriculture enjoys massive subsidies (both from Ireland and the EU), currently totalling in the region of €3 billion per annum, and which account for almost 50% of total farm income. The greater part of the value attributed to the Irish agri-food sector comes downstream of the farms, in the food processing and alcohol production sectors. If provided with a similar level of financial and other supports that Irish agriculture currently enjoys, a reconfigured agriculture with priorities similar to those outlined here would provide a more secure long term financial return than a system predicated on uncertain export markets. In any case. the imperative of food security, does not allow the luxury of continuing with the system we have.

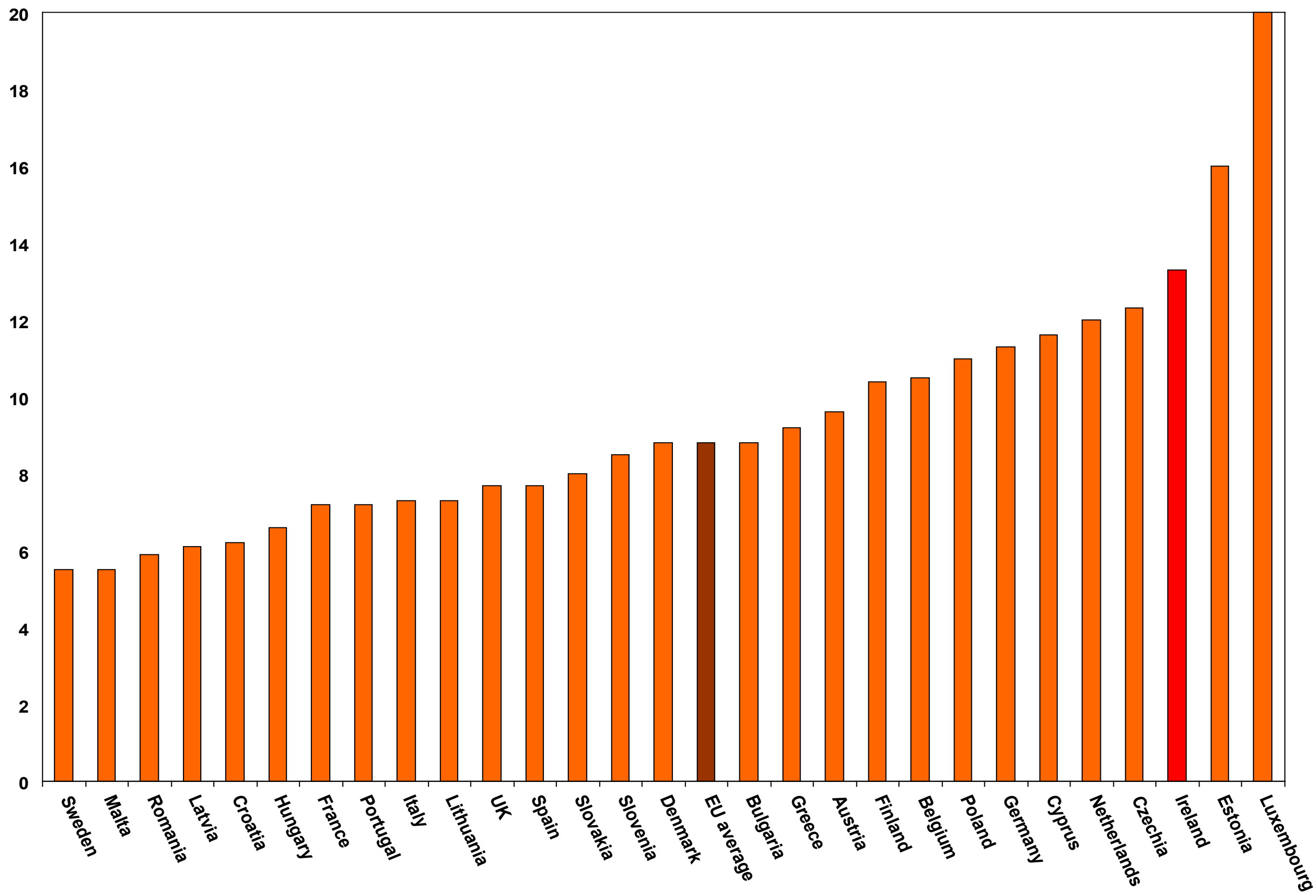
4 Irish agriculture creates jobs

This is a non argument really as the jobs without the subsidies contemporary agriculture would not exist. A more diverse and labour-intensive agriculture would create many more jobs.

5 Irish agriculture is entitled to special dispensation (to emit greenhouse gases)

This is a variation on the poor mouth theme: in this particular instance being based on the assumption that poor hard-done-by Ireland has no choice but to engage in intensive beef and dairy production aimed at distant export markets. But as indicated in this document, Ireland has every reason to do something different and not only has the option of moving towards greater food security but could even become a leader in agricultural greenhouse gas emission reduction, instead of being Europe's laggard.

EU greenhouse gas emissions, per capita (tonnes/yr CO_2-e)



Source: Eurostat

Myths of contemporary agriculture continued...

6 Contemporary agriculture is green(er)

This is far from being the case, as the table below shows:

CO_2 Emissions in Food

Output	Greenhouse gas emissions	
	kg CO_2-e per 1000 Calories	kg CO_2-e/ kg Protein
Beef[1]	7.06	73.1
Chicken[2]	1.98	13.2
Eggs[3]	1.96	22.5
Milk[4]	1.90	28.6
Pork[5]	1.62	17.8
Potatoes, maincrop[6]	0.34	13.0
Wheat[7]	0.16	4.1
Peas, dry[8]	0.15	2.1
Oats[9]	0.10	2.2
Hazelnuts[10]	0.07	3.1

Notes

The above figures relate solely to production (including imported feeds and fertilisers) and exclude emissions associated with downstream transportation, food processing and storage.

[1] Based on 19 CO_2-e per kg beef at farm gate at 26% protein and 2500 kcal/kg

[2] Based on 3.3 CO_2-e per kg chicken at farm gate at 25% protein and 1670 kcal/kg

[3] Based on 2.5 CO_2-e per kg eggs at farm gate at 11% shell weight, and of edible portion12.5% protein and 1430 kcal/kg

[4] Based on 1.14 kg CO_2-e per kg milk at farm gate. at 3.5% protein and 600 kcal/kg. The figures for skimmed milk would be higher.

[5] Based on 4.8 CO_2-e per kg pork at farm gate at 27% protein and 2970 kcal/kg

Source of CO_2-e data: *Evaluation of the livestock sector contribution to the EU Greenhouse Gas Emissions*, EU Joint Research Centre

[6] Based on 0.260 kg CO_2-e per kg, 2.0% protein and 770 kcal/kg

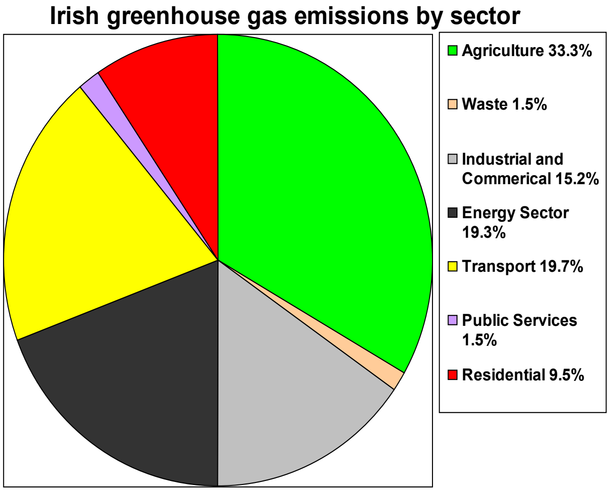
[7] Based on 0.520 kg CO_2-e per kg, 12.6% protein and 3270 kcal/kg

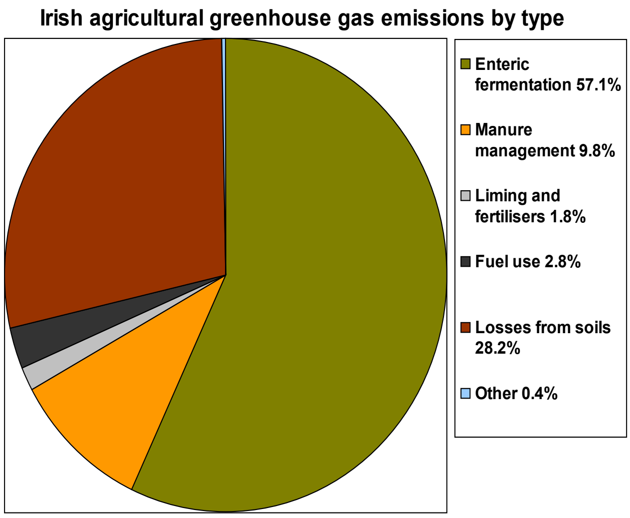
[8] Based on 0.520 kg CO_2-e per kg, 24.9% protein and 3410 kcal/kg

[9] Based on 0.380 kg CO_2-e per kg,16.9% protein and 3890 kcal/kg

[10]Based on 0.430 kg CO2-e per kg, 14.1% protein and 6500 kcal/kg

Source of CO2-e data: *How low can we go? An assessment of greenhouse gas emissions from the UK food system and the scope to reduce them by 2050. WWF-UK.* Audsley, E., Brander, M., Chatterton, J., Murphy-Bokern, D., Webster, C., and Williams, A. (2009). Except for hazelnuts, all figures are for UK production. The hazelnut data is based on production elsewhere in Europe and may be an overestimate (hazelnuts grown in southern Europe have a considerable water footprint).





Source of data: EPA 2018

Livestock and associated land use accounts for aaround 96% of all agricultural emissions, hence approximately 32% of Ireland's total greenhouse gas emissions, and all of this to produce less than one quarter of Ireland's food.

Myths of contemporary agriculture continued...

7 Agriculture aids food security in recipient countries

It doesn't. Compared to grains or pulses, using land for meat or dairy production is an incredibly inefficient means of producing calories or protein: in the case of dairy only 41% of the protein and 31% of the calories of the tillage crops outlined below. With beef the proportions are even lower: 7% of the protein and just 2.5% of the calories. Even hazelnuts compare favourably to beef. The continued promotion by market interests of a diet heavy in meat and dairy products flies in the face of considerable scientific evidence that the domination of global agriculture by livestock farming is not a sustainable use of land.

Land Use, protein and calorific output

Output	Land use			
	Beef[1]	Milk[2]	Hazelnuts[3]	Tillage crops[4]
Protein (kg/ha/yr)	38	233	106	561
Calories (000s kcals/ha/yr)	365	4533	4875	14483

Notes

[1] Based on total land required to support one beef cow, inclusive of all land required for feed. For a modern beef cow this is determined to be 1ha. Output is based on 146 kg/yr of edible product at 26% protein and 2500 kcal/kg

[2] Based on total land required to support one milking cow, inclusive of all imported feed provided. For a modern milk cow this is determined to be 0.75ha. Output is based on 5000l/yr of milk at 3.5% protein and 680 kcal/l

[3] Based on yield of 0.75t/ha, 14% protein, 6500 kcal/kg

[4] Based on 6 year organic rotation system of wheat, oats, pulses and potatoes with 2 years of green manures. Yields/ha as follows: wheat 7.2t, oats 7.2t, pulses (dry weight) 3.6t, potatoes 30t

All calculations by the author

8 Coniferous forestry offsets more carbon than broadleaved trees

By virtue of presumed faster rates of growth, it has long been claimed by forestry bodies - including state organisations - that coniferous forestry offsets more carbon than the equivalent area in broadleaved trees. While it is true that the biomass gain (per hectare) of plantation species such as Sitka spruce is generally higher than the gain of high-value broadleaved trees such as oak or beech, a crucial detail omitted is the respective *albedo* of different types of ground cover.

Albedo is the term given to the reflectivity of a particular type of ground cover. In the natural world it is highest for fresh snow and lowest for open water. Of different type of vegetation cover, the albedo of coniferous forest is the lowest.

Albedo of different land surfaces

Surface	Albedo	
	Min	Max
Open ocean	0.06	
Evergreen conifers	0.079	0.105
Deciduous conifers (larch)	0.127	0.145
Broadleaved deciduous (mean of oak and beech)	0.145	0.152
Crops	0.178	0.193
Grassland	0.181	0.209
Ocean ice	0.5	0.7
Fresh snow	0.8	

Source: *Albedo estimates for land surface models and support for a new paradigm based on foliage nitrogen concentration* D . Y. Hollinger, S . V. Ollinger, A. D. Richardson, T. P. Meyers, D. B. Dail, M. E . Martin , N. A. Scott, T. J . Arkebauer, D. D. Baldocchi, K. L. Clark, P. S . Curtis, K. J. Davis, A. R. Desai, D. Dragoni, M. L. Goulden, L . Gu , G. G. Katul, S. G. Pallardy, K. T. Paw U , H. P. Schmid, P. C . Stoy, A. E. Suyker and S . B . Verma

Studies show that the albedo differences between different types of tree cover *are* significant, and effectively cancel out any benefits of increased biomass gain from conifers[3]. And from an ecological perspective, broadleaved trees enhance biodiversity while coniferous plantations do enormous damage.

[3] *The functions and sizes of the five carbon sinks on planet Earth and their relative to climate change. Part 2 Coniferous forests - Do they warm or cool the climate?* David L Frape, World Agriculture 2017

Crop data calculations used in scenarios

Crop	k ha	t/ha[1]	total tonnes	kcal/kg	protein g/kg	fat/g/kg	vit A mcg/100g	vit C mg/kg	total 10^9kcal	total protein 10^9g	total fat 10^9g	total vit A[2] 10^9mcg	total vit C 10^9mg
Oats	160	7.2	1152	3890	139	37			4485	160.1	42.6		
Wheat	160	7.2	1152	3270	126	22			3767	145.2	25.3		
Fava Beans (drying)	80	3.6	288	3410	260	12			982	74.9	3.5		
Peas (drying)	80	3.5	280	3410	249	13			955	67.9	3.6		
Potatoes	50	30.0	1500	770	20	4		130	1155	30.0	6.0		195.0
Flaxseed	24	2.5	60	5350	183	400			321	10.9	24.0		
Hempseed	24	1.5	36	5550	320	350			200	11.5	12.6		
Oilseed Rape	48	4.0	192	4550	220	450			874	42.2	86.4		
Carrots	10	20.0	200	440	9	2	15000[3]	36	88.0	1.8	0.9	30000	7.2
Kale	1	8.0	8	49	33	1	590	410	0.4	0.3	-	47	3.3
Broccoli	1	6.0	6	31	23	1	360	640	0.3	0.1	-	22	3.8
Squash	2	10.0	20	300	10	-	3100	150	6.0	0.1	-	620	4.5
Total tillage	**640**								**12833.7**	**545.0**	**204.9**	**30689**	**210.8**
Blackberries	4	8.0	32	430	14	5	128	210	13.7	0.4	0.2	41	6.7
Aronia	5	10.0	50	470	14	5	770	210	23.5	0.7	0.3	385	10.5
Sea Buckthorn	1	5.0	5	740	10	42	3000	2000	3.7	-	0.2	150	10.0
Cranberries	5	8.0	40	460	4	1		140	18.4	0.2	-		5.6
Blueberries	5	6.0	30	570	7	3		97	17.1	0.2	0.1		2.9
Total berries	**20**								**76.4**	**1.5**	**0.8**	**576**	**35.7**
Total field crops 2030	**660**								**12910.1**	**546.5**	**205.7**	**31265**	**246.5**
Total 2030 -20% waste									**10326.1**	**437.2**	**164.6**	**25012**	**197.2**
National Nutrition Requirements 2030 (population 5.5 million)[4]									**5620**	**185**	**160**	**19300**	**181**
% National Nutrition Requirements 20303									**184**	**236**	**102**	**130**	**109**
Apples 2050	20	20.0	400	500	3	1		40	200	1.2	0.4		16.0
Hazelnuts 2050	20	0.75	15	6500	141	610			97.5	2.1	9.2		
Total tree crops 2050	**40**								**297.5**	**3.3**	**9.6**		**16.0**
Total 2050	**1000**								**13207.6**	**549.8**	**215.3**	**31265**	**262.5**
Total 2050 -20% waste									**10566.1**	**439.8**	**172.2**	**25012**	**210.0**
National Nutrition Requirements 2050 (population 6 million)[3]									**6130**	**209**	**176**	**21055**	**197**
% National Nutrition Requirements 2050									**172**	**218**	**98**	**119**	**107**

Notes

[1] Tonnes per hectare

[2] Micro grammes beta carotene.

[3] Mainstream carrot varieties contain approx 8-9000 mcg/100g beta carotene. Some specialist varieties contain 4 times this.

[4] Per capita intake: Calories 2800/day, protein 92g/day (both same as for modern day Japan, the country with the world's highest life expectancy. Fat = 80g day

Implications of climate change within Ireland

So far the discussion has concentrated on two distinct but inter-related goals: the first to enable Ireland to fulfil international obligations on greenhouse gas emission reduction and achieve net zero emissions by 2050 or earlier, and the second to climate proof Ireland's future food security by achieving close to 100% self sufficiency with food production within Ireland. This second objective does not preclude international trade, but provides insurance against food imports not being available.

An additional but equally important strand of this discussion is the implication of climate change on Irish agriculture, not only for business-as-usual agriculture but also for low carbon alternatives of the type outlined here. Compared to many countries Ireland is fortunate in that its vulnerability to climate change is relatively low. It does not lie on the track of hurricanes or typhoons and the occasional tailend of a hurricane that does reach Ireland is in no way comparable to a Category 5 blasting its way across the Caribbean. Ireland does not suffer extreme heat or draught, and even the rainfall that those who live in Ireland might complain about is never on the scale seen in other parts of the world, that might wash away entire towns overnight. And unlike coastal Bangladesh or Vietnam or some of the islands in the Pacific and Indian Oceans, most of Ireland is well above sea level and not under imminent threat of inundation by sea rise caused by melting icecaps.

Ireland lies at the interface between conflicting climate systems, the first the continental climate to the east and the second the maritime climate of the Atlantic to the west. In its purest form the former is characterised for hot dry summers and cold winters, with long periods of stable anticyclonic weather and strong temperature differences not just between summer and winter but also between day and night. The latter is typified by cool rainy summers and mild but wet winters, modest maximum daytime temperatures and relative high night-time minimums, changeable and unpredicable weather which although never extreme brings its own particular set of challenges to agriculture.

And precisely because Ireland is at that interface between maritime and continental, the two sides of the country experience significantly different climates: the east relatively dry and settled and the west much wetter and more changable.

Climate change modelling

For the regions with strong continental climates, global warming brings the likelihood of even hotter summers, reduced summer rainfall yet increased evaporation - thereby increasing water losses from soils - in some cases to the point where agriculture is no longer possible or temperatures are too extreme for people to survive. In the mountainous regions of central Asia the warmer winters - which might be thought to be a blessing - can bring a new tranche of problems arising from increased rainfall (at a time of year when the demand for irrigation is zero) at the expense of the snow previously relied on for meltwater during late spring and early summer, when demand for irrigation is often at its highest.

In response to global warming, oceans heat much more slowly than land hence summer temperature increases in maritime regions - which are strongly influenced by nearby sea temperature - will be less pronounced. The opposite is true in winter, when oceans are generally much warmer than land and this difference will be amplified by any temperature increase arising from global warming.

Global warming also means more water evaporating off the oceans, and this has significant implications for maritime regions where moisture-saturated oceanic air is driven onto land by prevailing winds. Impacts are likely to be highest during winter, when land masses are cooler than the sea and more likely to cause water vapour to condense into rain.

Higher temperatures in maritime regions in winter - although potentially extending the growing season - may also cause problems by providing more favourable conditions for disease, particular where the higher temperatures are accompanied by increased precipitation. Higher temperatures in the oceans also add energy to oceanic storm systems, potentially creating storms of greater violence and destructive power.

Some of the potential outcomes of climate change for Irish agriculture - both positive and negative - are listed in the following pages.

Climate change outcomes Ireland[1]

Criteria	Region of Ireland and potential climate change outcome			
	East		West	
	Best	Worst	Best	Worst
Summer rainfall	Slightly drier	Slightly wetter	Slightly wetter	Significantly wetter
Winter rainfall	Slightly wetter	Significantly wetter	Significantly wetter	Much wetter
Summer temperatures	Much warmer	Significantly warmer	Significantly warmer	Slightly warmer
Winter temperatures[2]	Slightly warmer	Little change	Much warmer	Significantly warmer

[1] Author's assessment based on EU climate change models

[2] Here warmer winter temperatures are given as a positive outcome, however depending on the agricultural output this may not be the case

Some potential climate change impacts Ireland (positive)

Criteria	Impacts	Region of Ireland			
		East		West	
		Best	Worst	Best	Worst
Summer rainfall		Slightly drier	Slightly wetter	Slightly wetter	Significantly wetter
	Livestock	reduced damage from grazing	in the driest locations, increased yield of grass/crops	no obvious benefits	no obvious benefits
	Tillage	improved access improved ripening			
	Berries	reduced spoilage improved ripening			
	Tree crops	improved ripening			
Winter rainfall		Slightly wetter	Significantly wetter	Significantly wetter	Much wetter
	Livestock	no obvious benefits	no obvious benefits	no obvious benefits	no obvious benefits
	Tillage				
	Berries				
	Tree crops				
Summer temperatures		Much warmer	Significantly warmer	Significantly warmer	Slightly warmer
	Livestock	increased grass growth	increased grass growth	increased grass growth	no obvious benefits
	Tillage	increased crop yields/faster ripening improved quality of harvest	increased crop yields/faster ripening improved quality of harvest	increased crop yields/faster ripening improved quality of harvest	no obvious benefits
	Berries	faster ripening improved quality of harvest	faster ripening improved quality of harvest	faster ripening improved quality of harvest	no obvious benefits
	Tree crops	faster ripening improved quality of harvest	faster ripening improved quality of harvest	faster ripening improved quality of harvest	no obvious benefits
Winter temperatures		Slightly warmer	Little change	Much warmer	Significantly warmer
	Livestock	longer growing season for grass reduced feed requirements	no clear outcomes	longer growing season for grass reduced feed requirements	longer growing season for grass reduced feed requirements
	Tillage	longer growing season		longer growing season	longer growing season
	Berries	no obvious benefits		no obvious benefits	no obvious benefits
	Tree crops				

Some potential climate change impacts Ireland (negative)

Criteria	Impacts	Region of Ireland			
		East		West	
		Best	Worst	Best	Worst
Summer rainfall		**Slightly drier**	**Slightly wetter**	**Slightly wetter**	**Significantly wetter**
	Livestock	reduced grass growth	no clear negative consequences	reduced grazing season increased risk of disease	reduced grazing season increased risk of disease
	Tillage	reduced yield	reduced access increased crop spoilage	reduced access increased crop spoilage	reduced access risk of total crop failure
	Berries	reduced yield	increased crop spoilage	increased crop spoilage increased risk of disease	increased risk of disease risk of total crop failure
	Tree crops	**reduced yield**	**increased risk of disease**	**increased risk of disease**	**increased risk of disease**
Winter rainfall		**Slightly wetter**	**Significantly wetter**	**Significantly wetter**	**Much wetter**
	Livestock	reduced grazing season	reduced grazing season increased risk of disease	reduced grazing season increased risk of disease	reduced grazing season increased risk of disease
	Tillage	reduced access increased crop spoilage	reduced access increased crop spoilage	reduced access risk of total crop failure	reduced access risk of total crop failure
	Berries	increased risk of disease	increased risk of disease	increased risk of disease	increased risk of disease
	Tree crops	increased risk of disease	increased risk of disease	increased risk of disease	increased risk of disease
Summer temperatures		**Much warmer[1]**	**Significantly warmer[1]**	**Significantly warmer[1]**	**Slightly warmer**
	Livestock	increased water demand increased risk of disease	increased water demand	increased water demand	
	Tillage	increased risk of disease			
	Berries	increased risk of disease			
	Tree crops	increased risk of disease			
Winter temperatures		**Slightly warmer**	**Little change**	**Much warmer[1]**	**Significantly warmer[1]**
	Livestock	no clear negative consequences	no clear outcomes	increased risk of disease	increased risk of disease
	Tillage			increased risk of disease	increased risk of disease
	Berries	shorter dormancy period		increased risk of disease shorter dormancy period	increased risk of disease shorter dormancy period
	Tree crops	shorter dormancy period		increased risk of disease shorter dormancy period	increased risk of disease shorter dormancy period

[1]In all of these scenarios there is an increased risk from extreme weather events

Where do we go from here?

This document has highlighted some of the rather serious limitations of business-as-usual agriculture, both in terms of greenhouse gas mitigation and in meeting Ireland's future food needs in the event of global warming triggered crops failures in the countries that supply the bulk of Ireland's food imports.

The alternative offered here - a zero livestock based agriculture - was chosen deliberately in raise awareness of the huge potential for feeding a population when diets do not include meat or dairy. However in Ireland's case, there is considerable land that is unsuited for crop production and here there will always be some potential for animal husbandry, thereby offering an additional food stream to complement the food crops grown on the land most suited to tillage.

The objective:

To reconfigure Irish agriculture to deliver a diverse, nutritious, wholesome and ecologically sustainable diet *that will feed the population of Ireland*, and specifically:

1: *Carbon neutrality (zero net emissions from agriculture) by 2030*

2: *80% self sufficiency in staple foods by 2035*

3: *100% self sufficiency in staple foods by 2050*

4: Unambiguous intermediate targets for each 5 year period from 2025 to 2050

Programme for Action

1 Commissioning of Land Resource Audit

Objective: To quantify all land in terms of its potential contribution to food security. The first part of this task would entail classifying land according to its potential for all conceivable food outputs, for example: high carbohydrate tillage crops, high protein tillage crops, oil producing tillage crops, tree fruit, nuts (here a separate rating should be given for each species), beef, mutton, pork, fowl, dairy plus all non-food agricultural outputs deemed as important.

Almost all the necessary information can be extrapolated from existing land classification data; past and present land usage data, climate data, soil and topographical maps, and would be well within the capability of a small dedicated research team, perhaps financially supported by a state body.

The second part would involve matching specific crops/outputs to specific classes of land, and allocating a given acreage to each of these outputs. Given the large number of variables, a number of different scenarios could be presented, including one - if the land resource provided this - that allowed for a modest degree of agricultural export (to help finance essential imports).

Timetable: To commence as soon as parameters are properly clarified

Time to completion: 6-9 months

Cost: Minisule, when compared to the current annual budget of the Department of Agriculture, which in 2019 is €1.6 billion. Irish agriculture also receives a further €1.2 billion per annum from the EU.

2 Drawing up schedule for implementation

By necessity, full implementation would have to be phased over several decades. Irish agriculture as currently configured cannot suddenly be switched over to something else. The reducing of stock numbers to sustainable levels would take (at best) 10-12 years. Also, a new sustainable agriculture will require new players, new skillsets, new knowledge: things that require wholesale changes in the how food security is perceived and in particular in the role of education as a tool for achieving these aims. Such things will not happen overnight. Moreover, the precise end destination in terms of the mix of crops, livestock and other land uses is unknowable at this point in time, and will be guided/informed by the unfolding situation as regards climate change and also by on-going research on the ground. That all said, much could be accomplised n the first ten years.

2 Drawing up schedule for implementation continued

A further consideration - albeit one only relevant to the longer term self sufficiency objectives - is the long lead time to developing key aspects of the new agriculture - for example the propagation and establishment of the 8 million hazelnut trees needed for planting up 20 000 ha of nut orchards. Unlike forestry species, which are largely propagated from seed or cutting, hazel for nut production is propagated by stooling or grafting, which takes longer and requires more infrastrucure, a greater degree of expertise and more hands-on skills. At present, a few thousand nut trees are planted in Ireland each year. Over the next two decades, this needs to be ramped up to hundreds of thousands.However, with appropriate state supports, an implementation period of 20 years is achievable.

The changes outlined here are ambitious but not without historical precedent. Numerous other dramatic transformations have occured in Irish agriculture during the previous 170 years. The transition from horse-powered agriculture to tractors took less than one generation. Even more dramatic (and far reaching) perhaps has been the consolidation during the tractor era of land and capital in the hands of industrial-scale agricultural enterprises, at the expense of the small farmers; and the new dominance of the dairy and beef industries. More recently still has been the arrival of all year round animal housing and feedlot meat production (which in only one decade has risen from nothing to now comprising ten percent of all beef produced in Ireland). None of the changes occuring in Irish agriculture in the last 40 years can be regarded as accidental, but the direct result of economic and agricultural policies, boosted with generous grants and subsidies.

3 Agriculture and Land reform

This would be an essential pillar of implementation. Among the measures needed would be the following:

1 Phasing out of all state agricultural subsidies that do not have a clearly defined food security benefit. Ideally all EU agricultural subsidies that do not meet this criteria would be phased out too.

2 Introduction of a land value tax

Taken together, these two measures would swiftly end the hoarding of land resources solely for subsidies or for land speculation purposes. It would return the price of agricultural land back into the real world and would free up underutilised land for new entrants into agriculture, younger people with fresh ideas and a climate science informed vision of where agriculture needs to go.

The rate of tax on land would need to be sufficiently high to discourage hoarding or speculation (perhaps 2-3%). In Denmark, land is taxed at 1.6-3.4% of its value, while in Estonia it is taxed at various rates up to 2.5%. In both cases the revenue goes to fund local government.

Other recommended measures include the following:

3 Introduction of a carbon tax on agricultural products. The carbon assessment would take into consideration not just the carbon emissions occuring in Ireland but also the external carbon footprint of imported feedstuffs and fertilisers, thereby penalising the most heavily the least sustainable agricultural practices.

4 Parachute subsidy scheme of up to 20 years in duration for younger farmers wishing to transition to sustainable farming. Such a scheme would have to be carefully monitored.

5 Buy-out scheme for existing farmers wishing to get out of agriculture. This would help free up land for a dynamic new generation of farmers, and would take the form of offering a guaranteed minimum price for land (perhaps one third of current market prices). Such a scheme would help avoid a complete collapse in the price of land which although seemingly attractive for new entrants, would also attract speculative interests too.

6 Generous finance supports for new entrants who embrace the new agricultural vision

7 Compulsory purchase of all derelict land by local authorities and reallocation for food security purposes (the legal means to do this already exists)

Programme for Action continued

4 Education system fit for purpose

Adapting to climate change will require a new mindset, something akin to being on a permanent war footing. And to help implement that, the education system will need to be completely reconfigured, with priority given to food and energy security, and a secondary role allocated to everything else.

Over the top? Not really. When imported food supplies begin to dry up as a consequence of climate change caused crop failure, it will be 20 years too late to develop alternative supply chains on the scale required at home.

Some of the requirements of a climate change configured education system are listed below:

1 Horticulture/agriculture and climate change studies to be taught as mandatory subjects in schools, with considerable emphasis on practical skills

2 Substantial recruitment of new teachers possessing the appropriate knowledge of agriculture/horticulture and climate science

3 Immediate establishment of food security focused third level courses to train up the new generation of education professionals

4 Establishment of specialist agriculture schools with intake at senior cycle level (year 4). These schools would adopt a new calendar of four terms/semesters of equal length, each approximating to a calendar season. Thus the long summer break currently in the school calendar - which is not compatible with the teaching or learning of food production skills - would become the new summer term and the school holidays would take the form of four shorter holiday periods between the terms.

A similar timetable is proposed for all post-leaving certificate or third level courses covering horticulture or agriculture.

Final Comment

This draft will be updated in the near future. Revised versions will be published at http://www.sustainability.ie/foodsecurityscenarios.html. Feedback and comments most welcome. The author can be contacted at andi@sustainability.ie

Andi Wilson, October 2019

Greenhouse gas emissions in the agriculture, forestry and fishing sectors

Source of emission	CO_2-e kt/yr[1]	% emissions per sector[2]				CO_2-e kt/yr livestock[2]
		% fishing	% food production	% forestry	% livestock	
Enteric fermentation	11542		0	0	100	11542
Manure application	1971		2	0	98	1932
Emissions from soils	5700		8	2	90	5130
Liming	333		2	<1	97	323
Fertiliser application	35		3	<1	96	34
Fuel	560		4	<1	95	532
Fishing industry	71	100	0	0	0	0
Total emissions	20213					19493
% agricultural emissions attributable to livestock and associated land use						**96.4**

Notes

[1] Figures for 2017 (from EPA 2019). Quantities in thousand tonnes per annum

[2] Author's estimates based on current land use

Data used in the food self sufficiency calculations for Ireland (2018)

Calories, protein and fat consumed, from grains produced in Ireland (2017)												
	total tonnes (000s)[1]	% for animal feed[2]	Food or alcohol									
			% for alcohol[2]	% for food[2]	% home market[2]	tonnes home market[2]	kcal /kg	total kcal 10^9	kg protein /tonne	total protein 10^9 kg	kg fat /tonne	total fat 10^9kg
Winter wheat	484.6	100	0	0	0	0						
Spring wheat	22.2	94		6	100	1.3	3270	4.2	126	0.16	22	0.03
Winter barley	508.1	100	0	0	0	0						
Spring barley	716.1	87	13	0	33	31.0	3600	111.6[3]	n/a[4]			
Winter oats	80.1	80	0	25	20	16.0	3890	62.2	139	2.22	37	0.59
Spring oats	42.2	80	0	25	20	8.4	3890	32.7	139	1.17	37	0.31
Total grain								**210.7**		**3.55**		**0.93**

Notes

1 From CSO data 2017

2 Author's estimates derived from Teagasc data 2017

3 Based on conversion of carbohydrates in grain to calories in alcohol being approximately 1:1 (it is probably less than this)

4 The protein and fat components in the barley used in fermentation is left behind in the mash

Calories, protein, fat. vitamins A and C consumed, from fruit and vegetables produced in Ireland (2017)														
	ha[5]	total tonnes (000s)[6]	% for home market[7]	tonnes home market[7]	kcal kg	total kcal 10^9	kg protein tonne	total protein 10^9g	kg fat tonne	total fat 10^9g	Vit A mcg/ 100g	total Vit A 10^9 mcg	Vit C mg/ kg	total Vit C 10^9mg
Potatoes		273.0	99	270.3	770	208.1	20	5.41	4	1.08	-	-	130	35.14
Carrots, main	564	16.9	100	16.9	440	7.4	9	0.15	2	0.04	8000	1352	36	0.61
Carrots, early	117	1.2	100	1.2	440	0.5	9	0.01	2	-	9000	108	50	0.06
Parsnips	367	5.5	100	5.5	750	4.1	12	0.07	5	0.02	-	-	130	0.72
Swedes	505	20.2	100	20.2	280	5.7	9	0.18	1	0.02	-	-	115	2.32
Onions/leeks	367	5.5	100	5.5	400	2.2	13	0.07	1	-	-	-	70	0.39
Broccoli	643	5.1	100	5.1	310	1.6	23	0.12	1	-	360	18	640	3.26
Cauliflower	413	4.1	100	4.1	310	1.3	20	0.08	1	-			440	1.80
Cabbage	918	27.5	100	27.5	310	8.5	31	0.85	1	0.03	420	116	370	10.18
Other bras.	183	1.5	100	1.5	310	0.5	30	0.05	1	-	590	9	410	0.62
Salad veg	275	1.7	100	1.7	170	0.3	12	0.02	-	-	-	-	90	0.15
Other veg	230	1.4	100	1.4	310	0.4	20	0.03	1	-	-	-	100	0.14
Total veg						**240.6**		**7.04**		**1.19**		**1603**		**55.39**
Rapeseed oil		2.0	100	2.0	8750	17.5	0	0	990	1.98	0	0	0	0
Strawberries		7.0	100	7.0	320	2.2	7	0.05	4	0.03	70	5	580	4.06
Other berries		0.5	100	0.5	430	0.2	10	0.01	4	-	128	1	210	0.11
Apples		17.7	100	17.7	500	8.9	3	0.35[8]	1	0.01[8]	-	-	40	0.48[8]
Total fruit						**11.3**		**0.41**		**0.04**		**6**		**4.65**
Total grains (from above)						210.7		3.55		0.93				
Total crops						**480.1**		**11.00**		**4.14**		**1609**		**60.04**
mcg beta carotene equivalent in mcg RAE												**134**		

5 From CSO data 2018

6 Potato data from CSO 2018. Other tonnages author's estimates based on area planted

7 Potato data from CSO 2018. For other vegetables all the crop is presumed to be for Irish market

8 Presumes one third of apples used in cider production and that this portion of protein, fat and vitamin C are lost

Data used in the food self sufficiency calculations for Ireland (2018) cont...

Calories, protein and fat consumed from Irish produced meat and eggs (2017)												
	Irish production (10^3 tonnes)[1]	Imports (10^3 tonnes)[1]	Exports (10^3 tonnes)[1]	Irish demand (10^3 tonnes)[1]	Irish supplied (10^3 tonnes)[2]		kcal/ kg	total kcal 10^9	protein g/kg	total protein 10^9 kg	fat g/kg	total fat 10^9 kg
Beef	617	41	565	94	Min	52	2170	112.8	232	12.06	28	1.46
					Max	94		204.0		21.81		2.43
Sheep	67	6	57	16	Min	10	2580	25.8	215	2.15	47	0.47
					Max	16		41.3		3.44		0.75
Pork	294	115	271	139	Min	23	2970	68.3	200	4.60	365	8.40
					Max	139		412.0		27.80		50.74
Poultry	152	137	126	163	Min	26	2160	56.2	200	5.20	9	0.23
					Max	126		352.1		32.60		1.47
Total meat					**Min**			**263.1**		**24.01**		**10.56**
					Max			**1009.4**		**85.65**		**55.39**
	millions of eggs						kcal/ egg		protein g/egg		fat g/egg	
Eggs	**1066**			**1066**		**1066**	**78**	**83.1**	**7**	**7.46**	**5**	**5.33**
Total meat and eggs					**Min**			**346.2**		**31.47**		**15.89**
					Max			**1092.5**		**93.11**		**60.72**

Notes

[1] From CSO data 2017

[2] The minimum figures assumes maximum proportion of Irish produced livestock exported while the maximum figures assumes domestic demand met entirely by Irish produced meat, with all imported meat reprocessed for export (a highly unlikely scenario)

Calories, protein, fat and vitamin A consumed from Irish produced milk (2017)														
	Irish production (10^6 litres)[3]	Imports (10^6 litres)[3]	Total (10^6 litres)[3]	Irish demand (10^6 litres)[3]	Irish supplied (10^6 litres)[4]		kcal/ litre	total kcal 10^9	protein g/ litre	total protein 10^9 kg	fat g/ litre	total fat 10^9kg	Vit A (mcg RAE) litre	Total 10^9 mcg RAE
Total milk	7585	810.9	9395.9	536.7	Min	484.6								
					Max	536.7								
Whole milk					Min	296.0	680	201.3	34	10.06	35	10.37	470	139
					Max	327.8		222.9		11.15		11.47		154
Skimmed and semi skimmed					Min	188.6	410	77.3	23	4.34	9	1.70	300[5]	57
					Max	208.9		85.6		4.81		1.88		63
Skimmed					Min	21.0	350	7.7	10	0.21	3	0.06	300[5]	6
					Max	23.3		8.2		0.23		0.07		7
Semi skimmed					Min	167.6	470	78.8	36	6.03	15	2.51	300[5]	37
					Max	185.6		87.2		6.68		2.78		41
Total milk					**Min**			**365.1**		**20.64**		**14.64**		**239**
					Max			**403.9**		**22.87**		**16.20**		**265**

Notes

[3] From CSO data 2017

[4] The minimum figures assumes maximum proportion of imported milk used for domestic market while the maximum figures assumes domestic demand met entirely by Irish produced milk, with all imported milk processed into other products

[5] Wide variation in different milk products. Some semi skimmed and skimmed milk products have added vitamin A

Data used in the food self sufficiency calculations for Ireland (2018) cont...

Calories, protein, fat and vitamin A consumed from Irish produced dairy products (2017)											
	Irish production for home market (10^3 tonnes)[1]	Production from Irish produced milk (10^3 tonnes)[1]		kcal/kg	total kcal 10^9	protein g/kg	total protein 10^9 kg	fat g/kg	total fat 10^9 kg	Vit A (mcg RAE/kg)	total Vit A 10^9 mcg RAE
Butter	14.0	Min	12.6	7300	92.0	9	0.11	810	10.21	6840	86
		Max	14.0		102.0		0.13		11.34		96
Cheese	31.0	Min	28.0	4030	112.8	220	6.16	330	9.27	2940	82
		Max	31.0		124.9		6.82		10.26		91
Cream for retail	10.0	Min	9.0	3450	31.1	21	0.19	152	1.37	4100	37
		Max	10.0		34.5		0.21		1.52		41
Cream for food industry	15.0		13.5	3450	46.6	21	0.28	152	2.06	0[2]	
			15.0		51.8		0.32		2.28		
Total dairy excluding milk				**Max**	**282.5**		**6.74**		**22.91**		**205**
				Min	**313.2**		**7.48**		**25.40**		**228**

Notes

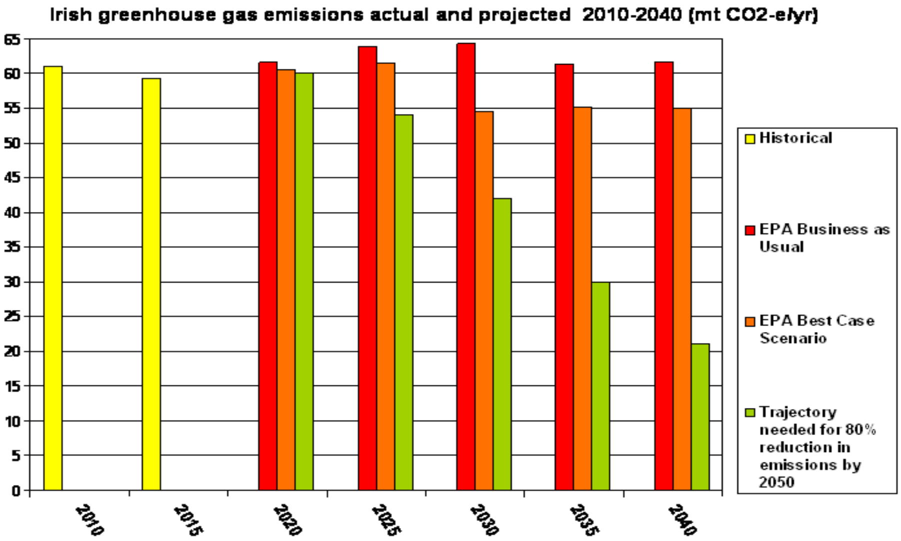
[1] Data extrapolated from CSO figures 2005-2011

[2] Vitamin A presumed destroyed by processing. A significant proportion of this cream would be destined for Irish cream liquers.

Food Totals						
		total kcal 10^9	**total protein 10^9 kg**	**total fat 10^9 kg**	**total Vitamin A 10^9 mcg RAE[3]**	**total Vitamin C 10^9g**
Total dairy excluding milk	**Max**	**282.5**	**6.74**	**22.91**	**205**	
	Min	**313.2**	**7.48**	**25.40**	**228**	
Total milk	**Max**	**365.1**	**20.64**	**14.64**	**239**	
	Min	**403.9**	**22.87**	**16.20**	**265**	
Total meat and eggs	**Max**	**340.2**	**31.47**	**15.89**		
	Min	**1092.5**	**93.11**	**60.72**		
Total crops		**480.1**	**11.00**	**4.14**	**134**	**60.0**
Total production for Irish consumption	**Min**	**1467.9**	**69.85**	**57.58**	**573**	**60.0**
	Max	**2289.7**	**134.46**	**106.46**	**855**	
Total production for Irish consumption adjusted for food waste (33.3%)	**Min**	**979**	**46.6**	**38.4**	**382**	**40**
	Max	**1526**	**89.6**	**71.0**	**570**	
Irish total food consumption 2017		**6368**	**195.1**	**223.5**	**1419**	**160**
Proportion of food consumed in Ireland produced in Ireland (%)	**Min**	**15.4**	**23.9**	**17.2**	**26.9**	**25**
	Max	**24.0**	**45.9**	**31.8**	**40.2**	
	Ave	**19.7**	**34.9**	**24.5**	**33.5**	

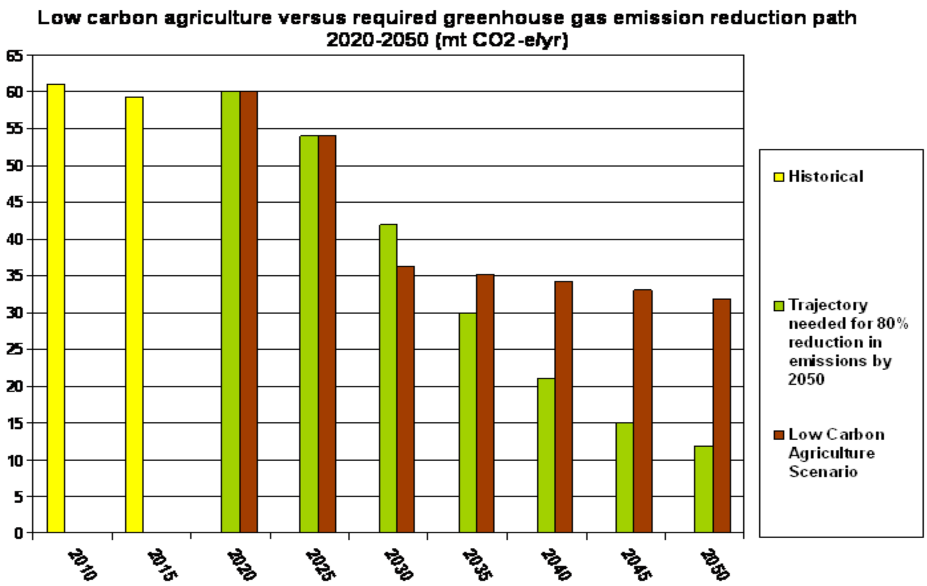
[3] Crop figures converted from mcg beta carotene to mcg RAE (retinol activity equivalents). The conversion ratio used was 12:1

The Emission Reduction Reality Gap



The reality gap: actual and projected greenhouse gas emissions 2010-2040

The projected emissions are estimates made by the Environmental Protection Agency (EPA October 2019). The B*usiness as Usual* scenario assumes a trajectory based on current trends (for example continued expansion of the dairy sector) while the *Best Case Scenario* is essentially a modified business-as-usual with a few extra wind turbines. The third set of bars depict the probable emission reduction path required in order to achieve an 80 percent reduction in greenhouse gas emissions by 2050 (an objective to which Ireland is allegedly committed). To some extent the steepness of this path could be mitigated through carbon sequestration. However the problem here is that business-as-usual agriculture offers only very limited opportunities for sequestration.



Comparison of projected national emissions with low carbon agriculture and the required emission reduction path to achieve 80% emission reduction by 2050

Here we can see the contribution made by the alternative low carbon agriculture - as outlined in this document - towards meeting Ireland's stated emission reduction targets. If the steps towards implementing low carbon agriculture are initiated immediately, considerable emissions reductions are achievable by 2030. However, additional emissions reductions achieved by during the period 2030-2050 period - namely those predicated upon the expansion of and accelerated uptake of carbon by broadleaved woodland - are relatively minor. Agriculture alone cannot provide the pathway to meeting the emissions reduction target: there must also be a sharp reduction in emissions in all other sectors and in particular in transport. It is noted that the 80% reduction target set by Ireland is at odds with the 2050 target of net zero emissions sought by the EU and by the United Nations.