Perspectives on Agriculture

Food Production in Ireland in the Period 2020-2050

A Response to Food Harvest 2020

Andy Wilson

The Sustainability Institute

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Discussion Document

Draft 1.0

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July 2012

Due to the fact the author was unaware, until a few days before the deadline, of the call by the Irish Department of Agriculture for submissions in relation to its publication *Food Harvest 2020*, this document was produced under very tight time constraints. It is therefore of an exploratory nature and does no more than outline some of the challenges posed to both Ireland and Irish agriculture by fossil fuel depletion. However, the author hopes the existence of this document will provoke the detailed discussion which is needed in order to begin to address these challenges, resulting in the allocation of financial resources to some of the many sectors within agriculture that need to be investigated and developed further.

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Experimental plot of spring wheat, Cooloughra, Co. Mayo, June 2012

"*It is evident that the fortunes of the world's human population, for better or for worse, are inextricably interrelated with the use that is made of energy resources*"

M. King Hubbert, 1969. Hubbert, a leading US oil geologist, is best known for accurately forecasting, back in 1956, that US oil production would peak in 1971. Modern peak oil theory is derived from Hubbert's pioneering work.

Perspectives on Agriculture

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1.0 Introduction to World Agriculture

The history of human civilisation is essentially a history of food. The rise of settled crop-growing communities in southwestern Asia and the Middle East c8500BC laid the foundations for the great ancient civilisations of Sumeria, Egypt, Greece, and Rome, while elsewhere, similar developments occurred in India, China and (more latterly) Central and South America. While individual civilisations rose and fell, a global civilisation built on grain production has endured to the present day. Even the relatively recent fashion, among wealthy countries, for diets that include a high proportion of meat and other livestock products, is predicated on grain for feedstocks. Without grain, human civilisation would quickly perish.

The earliest agricultural civilisations were largely self-reliant, producing most of what they needed to survive. Trade, where it occurred, tended to be very local, and was constrained by the limitations of the prevailing transport/freight infrastructure, whether of boats, pack animals or people. These in turn were influenced by local geography such as the proximity of navigable water or terrain accommodating to travel by animal or on foot. The downside of this enforced localisation was that communities were vulnerable to crop failures: shortfalls in harvests could only rarely be mitigated by emergency importation from other inhabited regions. One poor harvest could cause considerable hardship among the local population, while several poor harvests in succession nearly always meant famine.

The efforts of emerging civilisations to prevent famine developed in a number of different directions. Firstly, there were attempts to reduce the risk of crop shortfalls through better use of the land resource, through the implementation of more sustainable crop rotations, use of fertilisers, irrigation, the development of improved strains of crops, and the utilisation of slaves as an expendable labour force. Often the area of land under tillage would be expanded, though this was not always possible and sometimes it would end in failure, when the fertility of marginal land could not be maintained. The use of tillage land remote from the main population settlements was predicated on the availability of the means to transport the goods. In the Inca civilisation of the Andes, the wheel was never developed and there were no navigable rivers. As a consequence goods had to be carried by pack animal or slave.

Another strand of famine mitigation strategy went into the development of better food storage facilities. Over time these became both large and sophisticated. Ancient Egypt, and later, Rome, had vast grain stores capable of feeding the entire population for several years in the event of crop failures. However, the contents of grain stores were always at risk of spoilage through rot or destruction by vermin.

Militaristic civilisations could increase the area of tillage under their control by invading adjacent land and appropriating its productive resources. As water transport infrastructures developed, an increasing quantity of trade in foodstuff occurred between different regions. However, inter-regional trade was largely determined by the occurrence of favourable winds and sea currents and often was limited to certain seasons of the year. Trade was vulnerable to bad weather and also to the political allegiances prevailing at the time.

Another strategy, widely employed by human civilisations to ensure food security,, was population control. This could take many forms: infanticide, laws or civil codes that prevented certain sectors of the population (for example slaves or some other underclass) from marrying or having children, or that permitted the working to death of such groups, or that allowed the expulsion of undesirables. Such strategies were employed more vigorously when other options to relieve chronic food shortages were exhausted or not politically expedient.

In the worst of circumstances, when food supply was incapable of meeting demand, famine-stricken societies would sometimes resort to cannibalism. This is well documented in the case of Easter Island, where the land resource was degraded through bad practice and where fishing became curtailed by the destruction of the woods that provided materials for boats. However, cannibalism induced by famine is not a phenomena confined to the distant past. Cases of cannibalism were recorded in the famines of the 1930s in Stalin's Soviet Union, as well as in Mao Tse-tung's China in the 1960s. In both those instances, the famines were a consequence of political acts (forced collectivisation; adoption of inappropriate or unsustainable techniques of farming; repression of sectors of the population for ideological reasons; appropriation of crops and deliberate non-implementation of remedial measures).

The early agricultural societies relied on human labour, primitive implements, plants only recently domesticated from the wild, and production systems based on the premise that lands could be abandoned as they became degraded, and new ground cultivated instead. Soils could become depleted in as little as one season, depending on the soil, climate and type of crop. Moving to new land was an option whilst populations were low relative to the land available. Often, the degraded land would recover after a prolonged period of rest (often the period required to re-establish forest cover), and could be tilled on a cyclical basis of up to half a century in duration. As agricultural communities become more sophisticated, various practices were developed to maintain soil fertility for longer periods: the recycling of the nutrients contained in human and animal waste; the addition of nutrients through the capturing of seasonal silts from river flood waters (for example, in the case of the Nile civilisations); and the development of specialised crop rotations (including the use of green manure crops) that would permit the capture of nitrogen from the air (as in leguminous crops), access nutrients from sub-soils, or that would reduce nutrient losses occuring through leaching and erosion. The practice of *outgrazing* of livestock on *saltus* (pastureland unsuited to tillage), or in woodlands, allowed domestic animals to be used as mobile sources of nutrients. The livestock would graze in the *outlands* by day, while at nightfall they would be driven to the tillage land, where they would deposit their dung.

The system was not especially efficient, as some reverse transfer of nutrients also took place, and not all dung was deposited on the tillage land, but it enabled the tillage land to receive a modest and sometimes considerable nutrient subsidy from elsewhere. Other external additions or amendments to the land included lime produced from shells or lime-bearing rocks, wood ashes, powdered clays (rich in many nutrients) and seaweed. The development of the wheel for transport enabled many of these amendments to be transported more efficiently, over longer distances and in larger quantities.

The principal tillage tool was the *ard*, a device that scarifies the soil but which does not turn it. The early ards were operated by hand but later animal-drawn ards were used too. Ards are still used by some non-industrialised agricultural societies in the present day. Ards are limited in their capabilities. They are unsuitable for cultivating land that is vegetated. The only way to clear new land was through fire. Thus it was often easier to till land that was previously woodland, as this could be burnt, rather than grassland, which was more resistant to fire.

The development of the plough - an implement that could turn over the soil - from the early Middle Ages onwards permitted the cultivation of former grasslands. It also allowed better utilisation of the nutrient resource. While the burning of forest cover caused the loss of the greater part of the biological nutrient base, the ploughing in of grassland would return most nutrients directly to the soil.

The development of animal-drawn carts, which increased transportation options, facilitated the movement of animal feedstuffs. For the first time, it was possible to house livestock in one place, and transport bulk feedstuffs to them from another. This made it possible to utilise a much greater proportion of animal dung, as all the droppings of housed animals were deposited in one place, and were easily collected.

In all of the major civilisations and regional economic powers that existed prior to the twentieth century, the tillage crops, usually grain but occasionally other crops, provided the bulk of the food requirement for the population. Meat and other livestock products were generally of secondary importance, and typically would be raised mostly in areas unsuited to tillage. Except for short-lived periods in time of crop failure, the contribution from fish or other food collected from the wild was generally negligible. In general, tillage was practiced in three year rotation, with land set aside for fallowing for one long period (August till October of the following year) and one short period (August till March) in each cycle. The fallow period allowed the fertility of the soil to recover. Alternated between the two fallow periods, one winter grain and one spring grain would be grown. Sometimes a simpler, but inferior two year rotation would be practiced.

Agriculture in Europe suffered massive setbacks on occasion. The death of the regional superpower - the empire of Rome - in Europe in the early centuries of the Christian era precipitated a collapse in the European trading infrastructure that consigned much of European agriculture back to more primitive times. An emergence from this dark era only began in earnest around 1000AD. A further crisis, brought about by a combination over-population and a worsening climate, began in the early fourteenth century. The arrival in Europe of bubonic plague in 1347, and the Europe-wide epidemic that followed over the subsequent two to three years (the so-called *Black Death*), brought matters to a head, although it also solved the problem of over-population. Lesser crises, albeit ones sufficiently serious to cause local famines, were regular events. Famines would often occur several times within each generation. Sometimes population increases would put pressure on communities to till marginal land that would then quickly become exhausted, leading to a fall in agricultural output. A major limiting factor was the high level of dependency on large livestock populations in order to maintain soil fertility.

By the fifteenth century, the population of Europe had returned to the levels reached immediately prior to the Black Death. Around this time, the seeds of the late-medieval agricultural revolution were already being sown. A system of crop rotation that dispensed with fallowing but instead used green manures to recycle soil nutrients, began to be practised, first in Flanders, and soon after in England and Denmark. The preference for green manures over fallowing had a long pedigree in the ancient civilisations of Egypt, Central America and China, but the practice had not spread to pre-medieval Europe. The new use of green manures in crop rotations in late medieval Europe permitted a greater yield in crops, but also reduced the need to maintain such high populations of livestock, which in turn freed up grain for human consumption and made available land previously used for feedstock or grazing for tillage crops.

The selective breeding of crops and livestock had been practised to varying degrees since the earliest days of agriculture. By the eighteeenth century such practices had become more scientific in their approach. Many new breeds and varieties emerged. Livestock increased in size, and, in the case of dairy animals, milk production. Grains were developed with bigger yields, greater resistance to lodging or disease, and greater hardiness. Often developments were tailored to suit particular soils or climatic regimes.

The seventeenth and eighteenth centuries also saw considerable expansion of grain production in eastern Europe, in vast areas of land previously used for grazing. By the late eighteenth century, the increased production of grain for food had enabled Europe to support a population almost three times higher than the population of the early fourteenth century and four to five times the immediate post-Black Death population. This trend continued into the nineteenth century. However, by the second part of the nineteenth century, an emerging global food trade began to permit the movement of food between continents. The newly colonised lands of North America and Australia, with their low populations, vanquished indigenous peoples, and huge resources of potentially tillable soils, were ideally placed to produce food for European markets. Although the import of food into Europe from the territorial possessions of European imperial powers had already been taking place on an irregular basis for hundreds of years, it was the advent of steam ships with their greater reliability and speed compared to sail, combined with the massive increase in production capability of the new lands, that heralded the start of a new era in global food production, the era of food dependency on fossil fuels.

Fossil Fuels

The steam ships were powered by coal. Coal was the fuel that fired the world’s first industrial revolution, that of Britain (and subsequently other European powers and the United States) during the eighteenth and nineteenth centuries. It provided the heat energy needed for steel making and other emerging industrial processes, and through the development of the steam engine, revolutionised global transport infrastructures, both on water and on land. The simultaneous development of steam ships and rail transport opened up the vast prairies of the new lands for agricultural production, where economies of scale, combined often with more amenable soils and climates, ensured that production costs would be far lower than in the much smaller, and sometimes geographically constrained, farm holdings of Europe

This same industrial revolution also permitted the mass production of tools and other agricultural implements, the transportation of fertilisers such as guano and rock minerals from distant lands, and initiated the process of mechanisation in agriculture. A further significant development took place in the early twentieth century, when it became possible, for the first time, to manufacture artificial nitrogenous fertilisers on an industrial scale (from natural gas). The process, which is still used today, is named after its German pioneers, Fritz Haber and Karl Bosch.

Prior to the manufacture of nitrogenous fertilisers, the nitrogen available to crops was limited by the constraints of leguminous green manure nitrogen fixation, the availability of other biological sources of nitrogen such as other plant material, dung from livestock or people, and also the availability of mineral nitrate fertilisers or guano deposits excavated from tropical islands. In the nineteenth century, it had already been discovered that crop yields could be boosted by the application of supplementary nitrogen. Now, with the development of the Haber-Bosch process, nitrogen was available to agriculture as never before.

The first half of the twentieth century further consolidated the already dominant role of fossil fuels in the production of food. The processes of mechanisation and motorisation, that began with the use of steam engines for ploughing, threshing and other agricultural activities, was transformed with the development of the internal combustion engine fired by fuels derived from crude oil. By the beginning of final third of the twentieth century, a large proportion of global crop production was performed using tractors. The era of animal-drawn implements was over.

Another event of note, in terms of global food production, took place in the latter half of the twentieth century. Having access, as a result of the Haber Bosch process, to seemingly unlimited quantities of nitrogenous fertilisers, it was only logical that industrialised agriculture would seek to develop new crop varieties, particularly grain, that would convert these higher applications of fertilisers more efficiently into increased yields. This was achieved by breeding grain varieties with bigger heads, but simultaneously having shorter and tougher straw that could support the increased weight of the head. With the new short strawed varieties of grain, a smaller proportion of the nutrients used by the plant went into straw production and a higher proportion into the head of grain. The new varieties often did not perform well unless they received generous applications of fertilisers, thereby creating a potentially dangerous lock-in situation predicated on the availability of fossil fuels.

The industrialisation of agriculture, epitomised by its dependency on fossil fuels, had begun with the use of coal in the manufacture of agricultural implements and subsequently the transportation of food, animal feedstuffs, and fertilisers. Agriculture had then embraced gas derived from ancient geological deposits with the production of nitrogenous fertilisers. Finally, it had utilised the most versatile fossil fuel of all with the development of the internal combustion engine. Of course, the dependency of global agriculture on fossil fuels did not end there: fossil fuels also provided the energy to run the thermal power stations that generated the electricity used in food processing, refrigeration, packaging, and retailing. It provided the fuel used for the mining and processing of mineral phosphate and potash fertilisers, the fuel used to transport the consumer to the supermarket, the fuel for cooking, and the raw materials for the plastics used at almost every stage of the food production chain.

By the end of the twentieth century, the dependency of global agriculture on fossil fuels was complete. While fossil fuels have unquestionably transformed agriculture and permitted gross outputs that could only be dreamt of by eariler agricultural societies, the same fossil fuels have also created a false sense of security in relation to food production. Fossil fuels have enabled humanity to live in an unsustainable bubble. All the predictions of dramatic increases in future agricultural outputs are predicated upon ever-increasing quantities of fossil fuels being available. Yet, clearly, these resources are finite and already the signs are that their production is nearing a peak.

Now, in the twenty-first century, global agriculture is entering a new era, an era of diminishing availability of fossil fuels as finite geological deposits become depleted. There are no alternative fuels that can replace fossil fuels in the manner of usage to which humanity collectively has become accustomed. How this will play out will vary on many factors, not least of which is the adaptability of agriculture to methods that require smaller or zero inputs from fossil fuels.

There are a number of other significant and converging constraints and risks which will impact on future global agricultural output. These include:

- *The degradation of agriculture land as a consequence of unsustainable practices, such as excessive or inappropriate use of artificial fertilisers or other agro-chemicals, removal of hedges (thereby increasing the risk of wind-caused soil erosion), inappropriate use of machinery (causing impaction, waterlogging and damage to soil structure) and monocultural practices that cause the build-up of persistent crop diseases or which deplete the soil of vital nutritional elements.*

- *The degradation of the subterranean aquifers as a result of over-extraction and/or pollution. This is a major issue in India, Pakistan, China, Egypt, Mexico and parts of the United States, as well as in many other countries.*

- *The loss of agricultural land to non-agricultural uses, notably urbanisation*

- *The increasing loss of food-producing land to non-food crops, notably energy crops*

- *The loss of important genetic material as crop varieties suited to particular soils, climates and traditional methods of cultivation, are superseded by modern strains customised to respond to industrialised methods of production and which are often owned by large corporations. An alarming consequence of the dominance of these corporations is that ten companies now control the bulk of world seed production, and just three companies control almost fifty percent. A more insidious development, that of genetically engineered crops that will not reproduce, has not only created a further dependency among the world's farmers on expensive patented varieties under the complete control of large corporations, but also raises the spectre of the mutation of Frankenstein plants that will threaten entire species of food crop.*

- *The effects of climate change. These are very far-reaching and include: the loss of glaciers that currently provide seasonal meltwater for major river systems; the loss of land as a consequence inundation from flooding or elsewhere, from desertification; and the loss of crop-growing potential as climate changes occur that render specific crops non-viable.*

- *The collapse of the global economy. This is a very real risk as the global economic structure is predicated on continual and everlasting economic growth, itself predicated on ever-increasing availability of energy, simply an impossibility given the finite nature of fossil fuels and the constraints imposed on the so-called renewable energy technologies by the availability of fossil fuels. In macro-economic terms, there is no Plan B.*

Global economic growth, now no more than a clever sleight of hand achieved through the futurisation of debt (the postponement of debt repayments ever further into the future), is now in its terminal phase. The reality is that the increasing burden of debt, and the growing interest repayments on that debt, have now exceeded the future growth capacity of the global economy. The decline in global production of crude oil, now imminent, will only confirm what is already known, that the era of economic growth is over.

Where remedies have been proposed, they are of the *deckchair rearranging on the Titanic* variety: at best window dressing aimed at assuaging the rising fears of the citizenry, and at worst arrant dangerous nonsense. Such remedies are typically in the realm of pure science fiction. An example is the proposed genetic modification of food crops so that they might be grown on barren desert or in sea water, a proposal that ignores the energy inputs required to grow food crops in such locations and also the likely nutritional deficiencies of such crops. Upon examination, it appears that the development of genetically modified crops is little more than an elaborate con-trick aimed at boosting the profits of some of the world's largest agro-chemical-pharmaceutical companies. As noted above, the development of genetically engineered crops represents a major threat to the global gene pool of food crops. Nowhere, have genetically modified crops delivered in terms of achieving greater security and nor was this ever the objective.

The bottom line is there is no magic bullet that will simultaneously solve these converging constraints on food production. While there are too many variables involved to accurately pinpoint the impact and timing of particular constraints, one thing can be predicted with a high degree of confidence: world agricultural production will fall off a steep cliff during the twenty-first century, and many millions, billions most likely, of people will starve.

Fig 1 Gross World Product

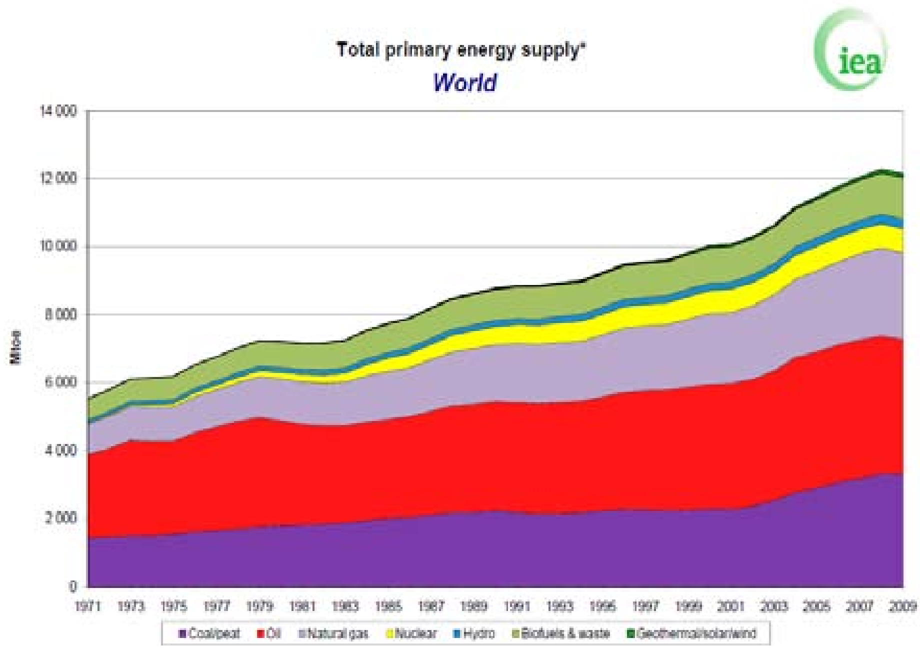

Fig 2 Total Primary Energy Supply

Figs 1 and 2 compare world gross product (GWP) with global total primary energy supply (TPES). As can be seen, the curves are almost identical, indicating a very strong correlation between the two. The kink at the right hand side of both graphs reflects the major upheaval in the global economy since 2008.
Sources: International Monetary Fund and International Energy Agency

"*We are trapped within growth economics. As our current economic crisis deepens, the strategies to manage it, through a 'new green deal' for example, all involve further debt, and the provision of such debt is itself a statement of faith in the resumption of economic growth. Yet we have seen that such growth cannot continue if our economies energy base is undermined by peak oil, natural gas supply risks, and peak gas. The result of such an energy withdrawal will profoundly effect food production, our financial and economic system, with follow-on consequences for the complex networks that support our modern civilisation.*

There is little chance that we can adapt our current system to perform a 'managed degrowth', if such a proposition was ever possible (due to the complexity of such a transition, short-termism, growth momentum, and the political risks for any government), it is too late now. Our civilisation will crash against the earth's resource limitations, the reverberations and feedbacks will bring in a period of serious multi-faceted strife. Even the best preparation now will not mean we avoid the coming crisis, at best it will limit the most severe risks."[1]

Economic Growth and its Future, Ch4 (*Framing Policy for De-growth*), David Korovicz, Feasta, 2008

2.0 Ireland

The island of Ireland has a land area of 83,000 km^2 and a population approaching 6.5 million. Five-sixths of the land mass is the sovereign territory of the Republic of Ireland, and is home for 4.6 million people. The balance of the land, known as Northern Ireland, has a population of 1.8 million people, and is part of the territory of the United Kingdom.

Ireland has a cool maritime temperate climate with generous rainfall and few extremes of weather. The majority of the land is low lying, being generally below 150m in altitude. The climate is very conducive to agriculture.

Local topography and soil, and sometimes the rainfall and exposure to winds, are limiting factors. The soils most suited to tillage lie mainly in the east and south. This region is also the warmest and driest part of Ireland, and generally, the region where most tillage takes place. However, some tillage can be found in all counties of Ireland.

In the west of the island, the greater proportion of land is given over to grazing or production of silage, and livestock farming predominates. Elsewhere, a mixture of livestock and tillage is more typical. Much of the tillage in Ireland is used to raise feed for livestock. Important livestock products include beef, milk and other dairy products, lamb, pork and poultry/eggs. The pork is produced in industrial units that have little connection to agricultural land, save as a repository for wastes. Beef and dairy cows are generally housed in the winter months. The duration of the period of housing has gradually increased over the last fifty years. Sheep farming utilises hardy breeds that can tolerate the tougher vegetation of the upland or more marginal areas, and lowland breeds that are raised on rich pastureland. Poultry is raised in industrial units.

A large proportion of animal-derived food products are exported. The methods used in the industrial production of animals for food have come in for increasing criticism in recent years, often on the basis of the perceived increasing risk to human health of such practices. The livestock industry in Ireland has been afflicted by several serious epidemics and other outbreaks of disease, notably *bovine spongiform encephalopathy* (*BSE* or *mad cow disease*), *foot and mouth disease*, *swine flu*, and *avian flu*.

This chapter will concern itself mainly with the Republic of Ireland. However, there are many close similarities in the agricultural practices, energy use, and social and economic structures of the Republic and of Northern Ireland.

Tillage Land

At present, Ireland has about 400,000 ha of tillage. The full breakdown of land in the Republic of Ireland is given below:

Agricultural land (hectares)

Tillage land:	400,000
Pasture, silage and hay:	3,400,000
Rough grazing:	500,000
Total agricultural land:	4,300,000

Non-agricultural land (hectares)

Forestry:	700,000
Built-on land:	150,000
Scrub:	150,000
Bog:	1,100,000
Mountain and other:	500,000
Total non-agricultural land:	2,600,000

The area of land tilled has varied considerably over the last 160 years. The area tilled in the 1850s exceeded regularly 1,300,000 ha, but by 1900 was down to about 700,000 ha. By 2007, the area tilled had fallen to an all time low of just 380,000 ha. During WW1 and WW2, Ireland had limited access to food imports and consequently the area under tillage was sharply ramped up in order to maintain food supplies. The total area occupied by crops, nurseries, and orchards combined reached 964,000 ha in 1918 and 1,039,000 ha in 1943. The bulk of this would have been tillage. Nurseries and orchards accounted for only 1-2 percent of the total. Following the end of WW2, the area of tillage remained above 900,000 ha until 1949. Socio-political and economic factors have often resulted in a significant proportion of the most fertile land being used for grazing rather than tillage.

The combined area of land used for hay, permanent pasture and (more recently) silage has also varied over time albeit to a much lesser extent than tillage. The maximum area utilised was 4,400,000 ha in 1905, and the minimum was 3,335,000 ha in 2008. As recently as 1990, the area used reached 4,265,000 ha.

Outputs

"*The food energy value of all crops, animal and dairy outputs suitable for human consumption is around 10,700 billion Calories per annum, slightly over twice Ireland's annual dietary intake. However... much of the tillage output is intended for animal feed. Therefore it is wrong to consider the gross figure as a true output, as the animal feed portion is really an input for the beef and dairy sectors.*

...A significant proportion of the grain crop is used in the industrial production of alcohol. Barley and oats - currently very minor components of the Irish diet but major sources of animal feed - collectively account for over 45 percent of the total agricultural calorific output. The dairy and meat sectors account for a further 25-30 percent, though the quantity produced exceeds the current domestic demand by more than a factor of three. The balance of 25-30 percent is made up of other tillage crops, most of which are consumed in Ireland.

An analysis of livestock and dairy production in Ireland suggests an [initial] *output of approximately 3800 billion Calories of edible product per annum, over 85 percent of which is from the dairy sector. However, the final calorific value of foodstuffs produced is significantly lower than this, as seven eighths of the raw milk yield is processed into other products, resulting in calorific losses of around 30 percent. The final usable calorific output is more like 2900 billion Calories. What actually gets eaten is somewhat less. Various studies in the UK have shown that up to one third of all food products end up as waste.*

To produce this quantity of [livestock-derived] *food, Ireland requires 1,100,000 hectares of silage, 240,000 ha of hay, 3,900,000 ha of pasture and 500,000 ha of rough grazing. Additionally, each year Ireland requires 3,600,000 tonnes of dried animal feedstuffs, 500,000 tonnes of beet, turnips and other fodder crops and 450,000 tonnes of imported artificial fertilisers. In 2008, the* [agriculture] *sector had an operating surplus of €2.3 Billion... Direct payments* [subsidies] *to the agriculture sector amount to €2 Billion per annum* [€2.9 Billion by 2010].

...The dry feedstuff figure mentioned above includes almost 1,600,000 tonnes of grain grown on Irish soil, with the balance of feedstuffs imported. Production of animal feedstuffs currently accounts for 70 percent of all tillage in Ireland. A further 500-600,000 ha of potential tillage land is used for silage, hay or pasture. Combining the actual and potential tillage land, we find that upwards of 85 percent of the total [potential tillage] *is used in the production of animal or dairy products.*

... The total fossil fuel[s]*... required to produce all of Ireland's agricultural fertilisers is not known but likely to fall between 300 and 600 KTOE - in other words up to twice as much energy as the 300 KTOE used by the entire agriculture sector within Ireland.*"

(From *The Demise of Irish Agriculture*, Andy Wilson, the Sustainability Institute, January 2010)

Elsewhere, the report calculates that livestock feedstuffs (manufactured feed and grazing inputs combined) amounting to approximately 130,000 billion Calories are required to deliver the useable food output of 2900-3000 billion Calories, giving a conversion of feed to food ratio of only 45:1. The energy value of the indigenous grain feedstuffs (grain grown specifically for animal feed) alone is about 5300 billion Calories, eighty percent higher than calorific value of the net food output of the entire livestock industry and more than twice the calorific value of food produced in Ireland for domestic consumption (estimated to be 2500 billion Calories).

The report estimated that proportion of food eaten in Ireland, that is actually produced in Ireland, is probably in the region of 32-38 percent.

Given that no official figures exist, the estimate provided by the Sustainability Institute is the only working estimate available. The corresponding figure for Britain - provided by the UK *Department of the Environment, Food and Rural Affairs* (*DEFRA*) is 49 percent.

In Ireland's case, the figure was calculated from the total production of food intended for the Irish market, and was based on an average per-capita intake of 3200 calories per day (downward revised from *World Health Organisation* (*WHO*) figures, which were felt to be too high). It was presumed that one quarter to one third of all indigenously produced food was lost as waste (this estimate corresponds with studies carried out in the UK that suggest that up to one third of all food is wasted).

The calculations inevitably involve an element of guesswork, particularly in terms of average per capita intake, and the proportion of food wasted at different points along the supply chain or after final point of purchase. In the event of the level of waste being underestimated, or per capita food intake being closer to the *WHO* estimate, then the total proportion of diet provided by indigenously-grown food falls.

In both the case of Britain and Ireland, the substitution of imports by indigenously produced food currently exported may increase the proportion of food provided by indigenous production to domestic needs. *DEFRA* estimates the revised figure for Britain to be 60 percent. The figure should be treated with some caution. It is not clear whether this revision simply swaps import and export tonnage, or if it attempts to directly match seasonal production with seasonal demand. For example, both Britain and Ireland import and export potatoes. But the bulk of the imports are early potatoes, grown in Mediterranean countries and available for consumption from early spring onwards (up to four months before the earliest locally grown potatoes are harvested), while the exports are main crops harvested in autumn. Clearly one cannot be substituted for the other.

There is also the question of whether dietary habits could change in order to avail more of indigenously produced food. For example, Ireland produces approximately 5500 billion Calories of food, of which 2500 Billion Calories are directed towards domestic consumption. Based on typical rates of wastage in the food supply chain, the actual intake of domestically produced food is estimated to be 1600-1900 Billion Calories. In the event of the global supply chain becoming compromised, as a consequence of energy scarcity or economic calamity, there is certainly room for many short term remedies that would make it possible for Ireland to continue feeding itself. Reducing waste levels in food already intended for domestic consumption to ten percent would make available 350-650 Billion Calories. The portion of agricultural production normally exported amounts to some 3000 Billion Calories, and this, added to the food already produced for the domesitic market, would provide Ireland with a slight surplus. It would create a diet very top heavy in dairy products, which might not be especially healthy for people with dairy intolerances, but the population would be fed. However, the solution, if one could call it that, would be very temporary. The same disruption to food supply chains would impact in the supply of feedstuffs, meaning that in a very short while animals would go unfed.

For the livestock population to be fed solely from indigenously produced feeds, livestock numbers would have to be significantly reduced. The problems wouldn't end there. Supply chain disruption would also end the importation of fertilisers, and without these the yield of both human food and animal feed will plumet. Animal numbers would have to be reduced further. Total production of food, that is, tillage and animal products combined, would fall far below a level capable of feeding the population. The only viable remedy would be to reduce the livestock even further, and re-allocate some of the land used to produce animal feedstuffs to growing food instead. This would permit a much more efficient use of the land resource. As noted earlier, the conversion of feedstuffs into meat or dairy products is an inherently inefficent process. Even in the most favourable conditions, the ratio is around twenty to one. From a grain only perspective, it takes roughly ten thousand Calories of grain to produce one thousand Calories of meat. The easiest way to increase food supply would be to increase the proportion of grain used for human food, and give less to livestock.
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The calorific value of indigenously produced grain currently used for fodder is around 5000 billion Calories, in other words almost as much as all 'food' products combined. However, it should not be presumed that all fodder grain grown for livestock could be used instead for human consumption, as a significant proportion is fed to livestock in a green (unripe) state. Also, very little of the fodder grain would be of a quality or type suitable for milling for bread-making purposes, though it may be entirely suitable for human consumption in whole grain or flaked form. It might be concluded, based on the bulk of the grain crop being used for human food, that Ireland could *easily* feed

itself should food imports no longer be available. Similar claims have been made for Britain by *DEFRA*. Unfortunately, such conclusions are predicated on the actual methods of agricultural production remaining unchanged. In an energy scarce future, this will not be the case. As noted, the lack of fertilisers will cause crop yields to fall very dramatically.

Ireland's agricultural output is utterly dependent on fossil fuels and the continued maintenance of the global supply chain, both for the running of agricultural machinery but also for the manufacture and supply of machinery, fertilisers and other additives, and the transportation, processing and storage of food. Without fossil fuels, Irish agriculture as it is currently configured will cease to exist.

The same economic or resource-related forces that might lead to a diminishment or cessation of food imports will undoubtedly lead to a corresponding reduction in imports of fertiliser, agro-chemicals, spare parts for agricultural and food-processing machinery and equipment, raw materials used for food packaging and storage, and the fuel required to run tractors and the many other vehicles associated with food production and distribution.

The more pessimistic scenario is one of chaos, of tractors idle in sheds for want of spare parts, of collapsing production, and of food spoiling for want of adequate storage or transport facilities. In this scenario the pool of surplus livestock is culled and eaten, with acute and then chronic food scarcity soon following. However, a more optimistic, but longer-term scenario is that after a period of 12-20 years, food production in Ireland could be raised to a level that would be capable of feeding the indigenous population (see Cuba scenario below).

So far, the discussion of prospects for Ireland outlined above has concentrated on the prospects for Ireland feeding itself. However, during Ireland's last major famine, that of 1845-51, food continued to be exported even though people were starving to death. Clearly, it is important that the production and distribution of food is not at the mercy of vested interest groups, in particular transnational corporations with no allegiance to Ireland, so that the needs of the population can be served ahead of any export considerations. However, it must also be acknowledged that following a lengthy period of adaptation and restructuring, Irish agriculture would have the potential to produce food in quantities in excess of the requirements of the indigenous population. This potential exportable surplus could be of major economic significance in the post-crash era, when Ireland will need something to sell in order to buy in the critical raw materials and manufactured products it is unable to produce itself.

The Cuba Scenario

Among the most plausible early crisis scenarios is one of increasing production costs (a consequence of rising fossil fuel prices) leading to market instability, collapse of exports, and possibly a short lived oversupply of meat and dairy products. Further difficulties caused by disruptions in global feedstuff and fertiliser supply chains are likely to result in the dairy and meat sectors quickly shrinking to less than one quarter of their current size.. Grain and other crops yields fall by approximately two thirds as the use of artificial fertiliser declines. The revised (transitional) output figures may look something like this:

	Billion Calories	
Dairy:	600	
Meat and eggs:	150	
Grain:	2500	(of which barley and oats 1200 billion)
Other crops:	150	
Total output:	3400	

Of this, a significant proportion (perhaps one third of the total tillage output) would still be needed for animal feed. The current dominance of the livestock sector is likely to prove a massive stumbling block to implementing the transition to a more sustainable reconfiguration of agriculture. The likely but mistaken perceived need to maintain animal numbers will unnecessarily prolong the unsustainable practice of using good tillage land for the production of animal feed, to the serious detriment of the national food supply.

In this revised transitional scenario, the combined output for human consumption is unlikely to exceed 2600 billion Calories, slightly over half what Ireland needs to feed itself. This would inevitably lead to further decimation of the livestock sector, to free up more tillage land for grain for human consumption. The second large culling of surplus livestock would provide a further short term boost to diet, and the grain freed up would add a further 700-800 Billion Calories to the domestic food supplies. However, without radical reform of the entire agriculture sector, annual food output will struggle to exceed 3400 billion Calories, resulting in a 30-35 percent shortfall in national food requirements. There is also the risk of a more serious collapse in domestic food production if the situation cannot be tightly managed. For a number of years, while agriculture is re-configured, it is possible people might have to manage on one third less food. This essentially is the Cuba scenario (see below).

2.1 Cuba's Economic Crisis

[At the end of the 1980s] "Cuba's economy was faced with the largest crisis of its history. Cuba's favourable rates of trade with the Council of Mutual Economic Assistance (CMEA), the international socialist marketplace, were abruptly terminated in 1989. In 1991, a year marked by the fall of the Berlin Wall, a rapid transition period began that culminated in the total disintegration of the Soviet Union and CMEA in 1991. This dissolution meant the loss of almost all of Cuba's import sources and markets, devastating its import based economy.

Cuba depended on CMEA for 85 percent of its trade; a far-reaching economic crisis was imminent. There ensued the "Special Period in Peacetime," commonly referred to as the Special Period, in which measures normally limited to wartime would be taken. The government instituted drastic measures such as planned blackouts, the use of bicycles for mass transportation, and the use of animals in the place of tractors to mitigate the effects of the crisis and help the island survive the oncoming shortages. Along with all other imports, Cuba lost access to its main sources of imported foodstuffs.

Food imports had supplied over half of the calories eaten in Cuba. Extensive food rationing was instituted to ensure equitable distribution in the difficult years to come. Where 19 items were rationed in the 1980s, by the early 1990s virtually all food items became scarce enough to warrant controlled distribution. Some imported goods that had been readily available before the crisis became unavailable. Overall caloric intake fell, and intake of fats and lipids fell even more dramatically. The decrease in caloric and nutrient intake was accompanied by a rise in energy consuming activities such as walking and bicycle riding. Along with other factors, this sudden drop in vitamins and minerals caused several health problems, the worst of which was an eye disorder causing temporary blindness.

Accompanying the loss of food imports was the loss of agricultural inputs such as pesticides, fertilizers, and spare parts. Annual petroleum imports fell from 13 million tons to under seven million tons in only three years, vastly inadequate to run industry and meet the high requirements of tractors, ploughs, and other agricultural equipment. There was not enough fuel to run irrigation pumps and harvest combines.

Domestic food production plummeted. Other services crucial to food supply, such as storage, refrigeration, and distribution networks, also dependent on petroleum, nearly ground to a halt. Without enough fuel to ship food into the cities where it was most needed, some of the remaining harvest spoiled before it could reach consumers. The food crisis was felt across the island, and cities were the most affected, especially the capital city of Havana.

At this moment of crisis, the United States passed the Torricelli Bill (1992), tightening the already existing economic blockade against Cuba, and further damaging the Cuban economy. The Torricelli Bill banned all foreign subsidiaries of U.S. companies from trading with Cuba. Seventy percent of this trade had been in food and medicines. This bill also banned all sea vessels that had been to Cuba from docking in the US within six months, punishable by confiscation. The U.S. placed several conditions on Russia and the newly independent states as they scrambled for U.S. aid, one of which was to end all trade with Cuba"

Extract from *Cultivating Havana: Urban Agriculture and Food Security in the Years of Crisis* by Catherine Murphy, Food First, 1999

2.2 Contemporary Food and Animal Feedstock Production in Ireland

Livestock feedstuffs (billion Calories)

Processed feedstuffs:	11,900 (very conservative figure)
Silage:	38,700
Hay:	7,000
Grazing of pasture:	67,000
Rough grazing:	2,100
Other fodder crops:	120
Total:	127,900

Utilisable yield from meat and dairy (human food): 2860 billion Calories
Ratio of input to output: 45:1 (conversion rate of 2.2 percent)

Food produced in Ireland for domestic markets (billion Calories)

Milk incl. skimmed: 593,000 tonnes ≈ 575,000,000 litres@ 570 Calories/litre:	328
Milk powder: 16,000 tonnes@ 4000 Calories/kg:	64
Cream: 21,000 tonnes@ 3700 Calories/kg:	78
Butter: 16,000 tonnes@ 7370 Calories/kg:	118
Cheese: 22,000 tonnes@ 4290 Calories/kg:	94
Total dairy:	682
Beef: 68,000 tonnes. Food component: 18,100 tonnes@ 1550 Calories/kg:	28
Lamb: 30,000 tonnes. Food component: 8,000 tonnes@ 2000 Calories/kg:	16
Pork: 150,000 tonnes. Food component: 39,600 tonnes@ 2250 Calories/kg:	89
Total meat (excl. poultry):	133
Poultry meat: 33,000 tonnes@ 1100 calories:	36
Eggs: 426 million @ 65 calories:	28
Total poultry:	64
Total meat, poultry and dairy:	879
Grain: 364 tonnes @ 3300 Calories/kg:	1200
Potatoes: 455,000 tonnes (2000) @ 770 Calories/kg:	350
Other crops:	100 (maximum)
Total crops:	1650
Total crops and animal outputs for domestic consumption:	2530
Portion eaten (65-75 percent):	1600-1900

Estimated food consumed in Ireland: 3200 calories per day x 4,300,000 people x 365 days ≈ 5000 billion Calories per annum. Hence only 32-38 percent of the food eaten in Ireland is produced in Ireland.

Calculations based on data from the Irish *Central Statistics Office* for agricultural output and population data for the years 2002-2007. By 2012, the Irish population had grown to 4,500,000, while the gross contribution of Irish agriculture to demestic food supply had remained static. This suggests its proportional contribution to domestic food requirements may have fallen in the last 5 years.

Tipping point (definition) *- the moment of critical mass; the threshold; the point of no return; the point at which the momentum for change becomes unstoppable.*

"The uncomfortable reality is that we find ourselves faced with the imminent end of the era of cheap oil, the prospect of steadily rising commodity prices, the degradation of air, water and soil, conflicts over land use, resource use, water use, forestry and fishing rights, and the enormous task of stabilising the global climate. And we face these tasks with an economy that is fundamentally broken..."

Prosperity without Growth, Tim Jackson, UK Sustainable Development Commission 2009.

3.0 Peak Oil and Energy Return Over Energy Invested

Peak Oil is the term given to the peaking of global crude oil production. This event was widely believed to have occurred during the summer of 2008 following a production plateau of about three years in duration. However, it now appears that another, slightly higher peak occurred in December 2010. On the limited data available, it appears the trend since then has been of declining production. However, the longer term trend may not become apparent for some time.

The basic theory of peak oil is based upon the geological reality that there is only a finite amount of oil beneath the earth's surface. It argues that the exploitation of the resource traces a very predictable path beginning with exploration and development, followed by peaking of production and ultimately by resource depletion.

One of the earliest peak oil theorists was the geologist M. King Hubbert, who in 1956 forecast that US oil production would peak around 1971. Hubbert argued that oil discovery - when plotted against time on a graph - showed a bell shaped curve. The middle of the curve represented the half way point of discovery. Hubbert surmised all the biggest fields were found during the middle of the discovery phase, and that the later discoveries would become successively smaller. Hubbert predicted that that the exploitation of the resource would follow a similar path to discovery, albeit with a time lag of about 30 years. Although Hubbert was widely ridiculed in 1956, he was later vindicated when it became clear that US oil production had in fact peaked in 1971 as he had forecast.

In 1969, Hubbert made a second forecast: that global production of oil would peak around 2000. Had it not been for the global oil crises of the 1970s, which saw the price of crude oil rise by a factor of twelve in only seven years, and which resulted in a significant fall in global demand, Hubbert's estimate may have proved very close. However, global oil production continued to rise significantly until 2005.

In March of that year, conventional production of oil (crude oil plus distillates) reached a high of 74,270,000 barrels of oil per day. For the next three years it looked as if global production might have peaked. Although global demand for oil grew consistently during the period 2005-2008, no corresponding increase in supply was forthcoming.

Attention was beginning to focus on the giant Ghawar oil field in Saudi Arabia, which alone supplied six percent of global supply and which acted as a regulator in balancing global oil supply and demand. The official Saudi line was that there were decades of oil left in Ghawar. However, this claim was being increasingly questioned by independent oil analysts, who argued that Garwal was coming very close to the end of its life. In the latter camp was Matt Simmons, an investment banker who also sat on the *US Petroleum Council*. Simmons also believed any decline in output from Ghawar would soon be followed by a permanent decline in global crude output.

Simmonds was far from alone in his conviction that both Saudi and global oil production were about to peak. The failure of oil producers to respond to the narrowing gap between supply and demand - by ramping up production - stoked fears in international markets that oil supply might not be able to keep up with demand much longer. This perceived scarcity caused the price of oil to rise dramatically during 2007 and even more spectacularly in the spring of 2008.

From a temporary low of around $55 a barrel at the start of 2007, oil reached $96 by the end of that year and went on to climb to a high of $147 by June 2008. In May 2008, investment bankers *Goldman Sachs* - one of the world's biggest energy derivatives traders at the time – forecast oil would rise to $200 a barrel within a few years.

Prior to the price peak of 2008, there were growing concerns that the economies of many oil importing countries would not survive any further rises in the price of oil. Consequently, immense political pressure was brought to bear on the oil producers. The result was that a few extra barrels of oil were squeezed out of the world's oil fields. Production reached a new peak of about 74,730,000 (initially reported as 75,000,000) barrels a day in July 2008, thus exceeding the previous 2005 high by a barely discernable 0.6 percent.

Oil Production Post-2008

The spike in the price of oil in 2008 also caused a corresponding spike in prices of all the major commodities including other fossil fuels, agricultural fertilisers, food commodities, and metals. and did, as predicted, impact severely on the global economy. Collectively these events were a major contributory factor to the global economic crisis that unfolded immediately afterwards. Although the cause of this crisis is frequently cited as one of excessive speculation, fuelled by cheap credit, and the subsequent debt default, the macro-economic climate was largely shaped by the erroneous belief that economic growth could continue indefinitely. However, by comparing the curves of global gross domestic peroduct (GDP) with global energy and raw materials consumption, it can be shown that economic growth is closely linked to the availability of energy and essential raw materials (themselves predicated upon energy availability). The almost continuous period of economic growth that has been a distinctive feature of the fossil fuel era, will come to an end with the decline of those same fossil fuels.

As the global economy entered a deepening crisis during the latter part of 2008, the oil price fell back dramatically, at one time falling as low as $33 a barrel in early 2009. As demand for oil fell, production of crude oil fell back to 71,600,000 barrel a day. Since then production of crude oil has fluctuated within a range of about 3.5 million barrels per day. This fluctuation may not appear much when compared to total production but infact it is as much as the daily oil requirements of *Britain and France combined, and more oil than is used daily by the whole of Africa*. By comparison, Ireland uses about 140,000 barrels of oil per day.

Although the root causes of the 2008 crisis were far from being addressed, the global economy regained some forward momentum from late 2009 onwards and even grew a little over the period 2009-2011, thereby further increasing demand for oil. Perliminary data suggests a new peak in production of 75,300,000 barrels a day may have been reached in January 2011. However, early estimates of global production are often subject to subsequent revision - mostly in a downwards direction - as more accurate data is made available by producer countries. The estimated average production for the twelve month period July 2010 to June 2011 is 74,120,000 barrel a day. The lowest output during this period occurred during March-May 2011. Data is not available after June 2011. The expectation is that production of crude has remained flat or has fallen since mid 2011, and any shortfall in supply has been met by increased production of liquid fuels from natural gas.

A random trawl of opinions among oil company executives, energy strategists and other independent analysts reveals a wide disparity in predictions for the date of peak oil. The estimates from the oil companies tend to be the most optimistic, and in some cases border on the ludicrous. Most of the independent forecasts are for peak oil to occur by 2012, or soon after.

An authoritative 100 page study published by the Germany-based *Energy Watch Group* in 2007 concluded that global oil production would fall by 29 percent between 2006 and 2020. However, other reports suggest production may fall even faster. In November 2008, a leaked report from the International Energy Agency suggested that post-peak, global production of crude fall at between 6.4 and 9.1 percent per annum. This would cause a 50-63 percent reduction in supply within twelve years. Chronic under-investment in the oil industry from1990 onwards, which had resulted in missed oportunities to maximise the ultimate output achievable from major global oil fields, was cited as a major contributary factor.

Ireland is not an oil producer. There may be some oil deposits in the sub-sea rock strata off the west and south coasts but the viability of such deposits, if they exist, is questionable. Hence Ireland is at the mercy of the global market. It is not solely a matter of oil being available on these markets: the means to transport it and refine it must also exist, and also the money to pay for it. In order to have money to pay for oil imports, Ireland must have something of worth to export. Moreover, scarcity on world markets will inevitably provoke a bidding war, in which the winners will be those with the most money to spend. In some cases, it can be expected that nations with military muscle will seize oil resources.

In spite of the very poor future global outlook for production, the general expectation is for oil demand to continue increasing, particularly in developing countries where per capita use is only a small fraction of the usage in the wealthier nations, and where industrialisation is seen as a solution to endemic poverty.

However, this expectation is hardly going to be met. As world population continues to rise, the energy available per capita is already falling. Global oil production per capita peaked back in 1979 and by 2008 has declined by 15 percent.

Energy return on energy invested

A further consideration is the *energy return on energy invested* (*eroei*). In the early days of development of an oil field, the oil often is forced from the ground by its own pressure, and little energy is required to obtain it. But as a field becomes depleted, ever more complex techniques must be employed to extract the oil. Consequently, over the lifetome of an oil field time it takes progressively more energy to obtain a given amount of oil, so eroei falls. Eventually, the return becomes so low that it is no longer worthwhile continuing to extract oil.

The historical development of oil fields shows a similar profile. In the early days, oil production was exclusively from easily accessible, high quality oil fields situated underneath land. As these fields became depleted, or demand exceeded their output, production turned to more inaccessible fields, often deep down, or below the sea bed, or in political unstable locations, or in remote or geographically challenging environments. As these more difficult locations begin to supply an increasingly dominant proportion of the total oil produced, the average eroei for producing oil fields falls.

Identical trends occur with the other fossil fuels, namely coal and gas, and also the uranium ore used in nuclear power stations. As geological deposits become depleted, or extraction moves to fields that are more inaccessible or more difficult to develop, eroei falls.

A consequence of a falling eroei is that it accelerates the impact of falling levels of gross production. Not only is output less, but a higher proportion of this output must be reinvested in further energy production. This leads to a much greater fall in the net energy available to society. An additional consideration is that oil producing nations are likely to allocate an increasing percentage of their own production for domestic use, further reducing the availability of oil on global markets.

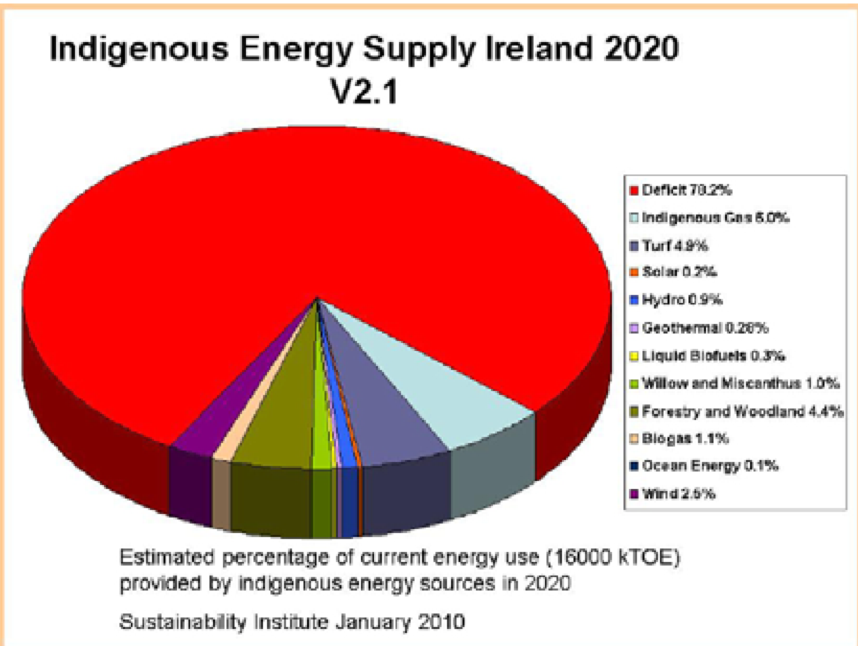
The return of energy over energy invested is also the determining factor in the viability of alternative sources of energy. Some biofuels (ethanol from maize in the United States for example) have such a low eroei that they are effectively *net energy losers* - they take more energy to produce than they can deliver. The production of such fuels is only made possible through energy subsidisation (in this instance from generous US Department of Agriculture subsidies aimed at supporting particular sectors within agriculture).

Using food crops to produce energy also reduces the food available on world markets, causes shortages in food supply and spikes in food prices. The diversion of food crops into the production of biofuels has been cited as a major factor in rises in the price of main food commodities worldwide.

For a civilisation to exist, there has to be some spare energy in order to develop infrastructure: build schools and hospitals, develop transport and industry. An eroei of 1:1 would allow no surplus - all the energy would be used to get more energy. In such circumstances, infrastructure would become degraded, and eventually fail. The evidence is that it takes an average eroei of between 3:1 and 5:1 to run a complex society, what we might term civilisation.

The eroei of energy crops is typically in the range 0.7:1 to 3:1. The use of energy crops can only be justified when the energy provided is of high strategic value, or when it can be obtained through the utilisation of an inferior energy source.

However, in post-oil Ireland, certain energy crops with an energy return towards the higher end of the range may have considerable strategic value, by providing fuel for agricultural machinery and the transportation of food.



Indigenous Energy Supply Ireland 2020 (best-case scenario)

Indigenous Energy Supply Ireland 2020

Official energy forecasts are predicated on a perceived increase in energy demand, not the realities of supply. The pie chart opposite takes a different approach - it looks at the potential for indigenous supply if energy demand remained at 2008 levels. This 2010 assessment takes into consideration the likely level of development in renewable energy technologies, given the various technological, economic and infrastructural constraints. The assessment assumed new indigenous gas resources would come on stream. It was an optimistic scenario in that it assumed that appropriate decisions were taken to maximise indigenous energy production, and rapidly implemented. Even so, energy deficit (based on 2008 levels of energy demand) remained close to 78 percent, while all the renewable energy sectors combined accounted for only about 11 percent of energy needs. A preliminary but more realistic assessment, carried out early in 2012, suggests Ireland’s future energy deficit will be even greater.

"*There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we now know we don't know. But there are also unknown unknowns. These are things we do not know we don't know*."
Former United States Secretary of Defence Donald Rumsfeld at a press briefing on Afghanistan

There are also things that are known that people pretend not to know, for fear this might compromise their preferred vision of the future. We might call these the *not-wanted-to-know knowns*. Many of these particular knowns are relevant to Irish agriculture, for they demolish the business-as-usual notion that all can continue as before.

4.0 Constraints on Future Food Production in Ireland

These are many, and varied in their impacts. The list below is by no means complete. Some of the categories are overlapping (for example, 'energy' could also include work animals, though these is dealt with separately).

Energy

Energy is used for all aspects of the food production chain. It is used for production, transportation (both primary transportation of food and distribution of food to consumers), processing and storage. Currently, in excess of 98 percent of this energy is provided by fossil fuels. The limited availability of fossil fuel energy in the future will require food production to become much more energy-efficient, in other words, to achieve the required dietary outputs with much lower energy inputs. As it requires on average, only one tenth as much energy to produce grain for food as it does to produce meat or dairy products, much of the change to energy-efficient food production will be predicated on changes in diet. However, the production of meat and other livestock products will still make good sense on land unsuited to tillage and also may be ingrated with tillage crops in certain circumstances (for example small farms of mixed land).

Food production will also need to become more energy-diverse, and be reconfigured to utilise energy derived from non-fossil fuel sources. Alternative sources of energy include liquid biofuels from tillage crops, biogas from anaerobic digestion, and woody biofuels. Some of these sources (wood for example) may have limited direct application in agricultural production but may be used for related activities for example generating electricity, production of charcoal for biochar or steel-making, and providing heat energy for food processing and other crop-processing activities (including production of liquid biofuels).

Facilities

As the need to produce a greater proportion of domestic food requirements within Ireland rises, there will be a corresponding increase in the demand for storage facilities for raw food commodities. In order to provide security against poor harvests, storage facilities will need to be large enough to hold at least eighteen months supply of food. Also, additional processing facilities will be needed. However, many existing buildings could be adapted to these purposes. The type of preparation required to deal with fossil fuel depletion is very similar to the preparation needed for dealing with other long-term crises such as war or natural disasters. The main difference is that wars and natural disasters eventually come to an end. Fossil fuel depletion is permanent.

Transport infrastructure

There will be a need for a freight transport infrastructure especially geared to the needs of food production, processing and distribution. As energy (of all kinds) will be scarce, a system of triage may have to be employed, to ensure vital services and essential production are maintained.

Nutrients

Irish agriculture currently relies very heavily on manufactured fertilisers, which themselves require considerable quantities of fossil fuels (as great as or greater than the quantity used to run all Ireland's agricultural machinery) in their production and transportation. These fertilisers will not be available in the future, or will only be available in much smaller quantities. Alternative methods of maintaining soil nutrient levels will have to be developed, for example the more efficient recycling of nutrients in waste (perhaps in conjunction with anaerobic digestion), the intelligent use of green manure crops, and the adoptation of production systems that utilise more marginal resources. In post-fossil fuel agriculture, it is likely that yields per unit area of land will be considerably lower, and allowances must be made for this.

Organic inputs

Many tilled soils in Ireland contain relatively low levels of organic material. As has been long recognised, all worked soils will experience falling levels of organic material unless strenuous efforts are made to replace what is lost through crop extraction and the oxidising processes of tillage. The addition of organic matter to increase the organic content, and specifically the humus content, of soils will be an essential strand of soil fertility, and will enable improved up-take of nutrients through increased cation exchange capacity (CEC), as well as directly providing the bulk of the nutrients required by crops. However, the building up of humus will be a slow incremental process that will only show results over timespans runing into decades. It will be essential to return the greater proportion of organic waste to the soil.

Feedstocks

The importation of bulky, relatively low-value feedstuffs for livestock will not be an option in the future. Equally, proportionately less tillage land will be available for production of animal feedstuffs as it will be needed for food crops instead, in particular for grain. It is likely livestock numbers will have to be eventually reduced by 75-85 percent (even further in the case of pigs and poultry raised in industrial units). However, given Ireland's current very large over-production of livestock products (relative to domestic demand), the curtailed output of animal products does not necessarily compromise Ireland's ability to meet domestic dietary requirements for the proteins, essential fats, vitamins and micro-nutrients associated with meat and dairy products. In order to maintain even reduced livestock numbers however, it will still be necessary to provide winter feed. The production and distribution of this feed, with only limited availability of fossil fuels. will present challenges.
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Machinery

It is debatable whether the manufacture of new agricultural machinery will take place in an energy-scarce future, when the far greater concern will be obtaining sufficient fuel to run the macinery that already exists. Even if manufacture does continue somewhere, the supply chains are likely to be both fragile and unpredictable. Demand is likely to be low, as very few farmers will have the spare capital or be willing to risk investment in a machine that might lie idle for want of fuel. However, while fuel does exist, or while it can be produced locally from crops, it will be logical to continue using at least some of the existing fleet of agricultural machinery. The challenge, therefore, will be in maintaining this machinery, so that it might be kept operational for tillage. The greater bulk of all non-tillage activities should be considered of secondary importance.

Livestock

Ireland has large numbers of livestock, but the breeds most common are those that are most suited to the prevailing regimes of production, which includes long-term housing and high levels of imported feedstocks. In the future, very different breeds may be needed. For example, smaller, hardier breeds of cattle that can forage on poorer land may be preferable to larger and less hardy breeds. Preference may be given to milk cows that produce milk with high cream content. Milk sheep and goats may become of greater importance. However, the ramping up of numbers is likely to take many years.

Work animals

In the pre-tractor era, work animals were the mainstay not only of tillage, but of transportation and forestry work too. In the period between the two world wars, the population of working animals in Ireland frequently exceeded half a million. Work animals will probably include horses, mules and oxen (and to a lesser extent donkeys) - all would have a valuable role to play in post-oil agriculture. However, there are almost no work animals in Ireland at the present time, not even sufficient numbers to initiate a breeding programme. This is likely to be a major constraint.

Seeds

Changing circumstances (food crop requirements, different methods of production, climate change) will require changes in the type of crops grown, and also in the varieties of those crops. For example, wheat varieties suitable for bread-making, which are currently grown on only a very small scale in Ireland, will be needed in much greater quantities. The barley and oats varieties currently grown for livestock feed are not necessarily the ones most suited to human consumption. *Naked oats*, a type of oats that is easy to de-husk, and which is largely absent in Ireland, may become an important grain for small scale production and localised milling. Other useful grains, currently not grown in Ireland, include rye and *spelt*.

Many of these new (to Ireland) varieties will become progressively hard to obtain onn global markets, even in the smaller quantities required for seedstock. There is a need for Ireland to build up strategic seed repositories of all potentially useful varieties of grain and open-pollinating varieties of vegetables suitable for the Irish climate, and ensure that each year sufficient quantities are grown and saved to maintain stocks at levels sufficient to cope with emergency situations, when the quantities sown may suddenly have to be ramped up. The seed repositories should also include seeds of fibre plants such as flax and hemp, medicinal herbs and other plants that have a strategic value. The lack of a nationwide network of seed repositories would have major consequences for food production.

Nursery Stock

Future food production will require a much greater diversity of crops produced. While the main preoccupation might be intake of calories, a balanced and attractive diet is also important. Many times, history has demonstrated that a diet has to have more than the bare minimum required to maintain life. The need to rise above the bare necessities should be the basis of future agriculture in Ireland. Ireland has the possibility of growing apples, plums, cherries, pears, a wide variety of soft fruit (including ones used mainly for processing such as sea buckthorn), cultivated forms of the hazel, sweet chestnut and walnut.

All of these fruits and nuts are grown Ireland at present, but with the exception of apples and some soft fruit, on a tiny scale. It is noted that some countries with far more challenging climates and/or limited land resources grow a much more diverse range of fruit than Ireland. Norway, Sweden and Finland, in spite of their short growing seasons (and in the case of western Norway, high rainfall and small area of suitable land) succeed in growing cherries, plums and pears on a commercial scale. This gives some idea of what is possible in Ireland. However, a massive constraint will be the lack of nursery stock of the most suitable fruit and nut varieties. This deficiency includes rootstocks and scion wood, grafted trees, and also seed-raised trees. As in the case of livestock, the lead time is long. Although propagation can be done in laboratories by means of tissue culture, the traditional time-tested methods of propagation namely budding, grafting, layering and stooling, and growing stock from seed, are the methods that provide the bulk of orchard material worldwide, and are the methods which are most likely to prevail in Ireland.

Forestry

Post-oil Ireland will need trees. In particular it will require deciduous woodlands, some of which will be coppiced on a medium to long term basis (8-20 years). These medium or long term coppiced woodlands represent of one the best options for long term woodfuel production in Ireland. Unlike hybrid biomass willows, they do not require the most fertile land or large supplements of nitrogen, or specialist machinery for harvesting. Woodlands will also provide a multitude of other useful products, including livestock fodder, and have potential for low level grazing. However, deciduous woodland currently exists on only a very limited scale in Ireland, in spite of a million or so hectares of land being suitable. Again the lead time is long.

Research facilities

Ireland will need an integrated countrywide network of research facilities, focussed on research into the performance (especially disease resistance and reliability) of different varieties of grain, vegetables, green manures, fibre crops, and fruit and nut crops. Research will also be required into new breeds of livestock more suited to new emerging methods of agricultural production, into woodland crops (perhaps especially into deciduous trees suitable for nutrient harvesting on very wet land) and also into biochar (charcoal used as a soil improver) and other soil amendments. Facilities do not necessarily have to be elaborate or cover a multitude of difference activities - greatest efficiency will probably be achieved through some degree of specialisation. Venues should be sited so that they cover all the principal soil types and regional climatic zones found in Ireland. It would be of very limited value if all the research into a particular aspect of agriculture or horticulture (for example top fruit) were carried out at one location. The absense of such facilities, specifically geared to the needs of post fossil fuel agriculture would be a constraint on the long term development of agriculture, and would impact on future food-producing capability.

Labour

Food production in Ireland will require a large labour force. It is likely upwards of thirty percent of the entire working population will be involved in work on the land, or in related activities such as food processing. It may be the case that other employment opportunities will be very limited. While the numbers of people required for agricultural and forestry will exist on paper, they may not necessarily be living in the right locations. For example, many contemporary rural populations are too low to support a labour-intensive system of agriculture.

Skills

There will be an acute and possibly chronic deficiency in skills in the new, massively enlarged, agricultural workforce that will only be remedied over a very prolonged period of time, probably running into decades.

Educational

It is likely that there will be a chronic deficiency in educational possibilities with regard to agricultural science and horticulture geared specifically towards the new systems and crops employed in agriculture. The deficiency is likely to be greatest at second level education, where food production is completely off the radar of current school curricula.

Future curricula will have to reflect long-term educational requirements in relation to food production. Possibly, the whole educational system will require restructuring. This will require considerable political will and vision. The lead time will be long.

It will be necessary for post-second level education in agricultural science, animal husbandry and horticulture to be be closely integrated with employment. This will only occur gradually, as new educational and training structures emerge.

Knowledge

When agricultural systems remain unchanged for long periods of time, there is a build up of a wealth of knowledge that offers strategies for dealing with the varying and sometimes challenging conditions of weather, incidence of disease, and other factors. Such knowledge is often passed on in successive generations and offers considerable security against unexpected calamity. There will be a acute deficiency in such knowledge in relation to many of the breeds, varieties and production techniques required for the Ireland's new agriculture, particularly with regard to their performance or viability in varying Irish conditions. The acquisition of such knowledge will only be gained incrementally through experience (and hence the important of research), most likely over a period spanning decades. This absense of knowledge will be a major limiting factor.

Psychological constraints

This must be considered one of the most formidable barriers to the radical reconfiguration of Irish agriculture necessary in order for Ireland to meet its future needs. At all levels: policy making, administrative, production, and employment, there isc likely to be considerable resistance to change. Frequently, this resistance reaches a level that might be regarded as denial or even delusion. Examples abound: denial of fossil fuel depletion, in spite of its absolute geological certainty; the obsessive insistence in pursuing flawed business-as-usual economic models; the inability of global leaders to agree on mitigation strategies for dealing with potentially catastrophic climate change; the supremacy of short term policial expediency over the bigger picture; and the pervasive, but horribly constraining sense of entitlement to things that are at best, temporary. The situation is probably made more serious through the complicity of the media in wilfully promoting a dumbed-down, make-believe world in which human worth is assessed largely on the acquisition of material goods or consumer experiences. The alternative vision, offered here, is for a more mindful, more aware, possibly more spiritually-guided, and ultimately more satisfying mode of existence for humanity. If there is to be anything in the future that we might term an *intelligent agriculture*, it will be one based on these principles.

Access to land

The structure of land ownership and tenureship in Ireland has both positive and negative attributes. Ownership can often promote innovation, although the opposite can be said for ownership when burdened by debt. Debt often causes lock-in, and stifles changes, even when the changes would make good long-term sense. Ownership where free of debt provides a freedom to innovate and improve rarely found in tenancies and leases.

The contemporary practise of one year leases, that encourage no long-term nurturing of the land and negate the possibility of implementing proper crop rotation, can be considered highly detrimental to the development of sustainable agriculture. In order for tillage land to be managed sustainably, the period of lease must be at least as long as the minimum period required for one full cycle of a carefully balanced crop rotation that will maintain soil fertility (5-9 years). However, even this period is insufficent to encourage long-term improvements, this requires leases of 20 years duration or more. Such lease arrangements are very rare in Ireland.

It is also a concern that a large number of people who might make a major contribution to future food production, would have no easy access to land. In past periods of food-related crisis in Ireland, legislation existed to empower local authorities to compulsorily purchase or lease under-utilised land, and make this land available to farmers, smallholders or allotment holders. Wartime legislation required farmers to allocate a specified minimum proportion of tillage land to grain crops. Such legislation, although potentially open to political abuse, could be of immense value in a future Ireland striving to make the most of its land resource. However, the absence of legislation of this type, or its non-implementation on the ground, would impact negatively on future food production.

Finance

Ireland has external debts so large that the repayments of the primary (initial debt) and interest combined exceed anything that the country could conceivably earn in income derived from either exports or sale of fixed assets. Essentially Ireland is bankrupt. A private company in such circumstances would quickly find itself in receivership. Without some degree of default or write-off, it is difficult to see how this debt can ever be resolved. Ireland's ability to continue functioning economically depends firstly, on the pretence that it is still a viable economic entity, and secondly, on the availability of additional bailout money received in the form of loans from the European Union (EU), European Central Bank (ECB), and International Monetary Fund (IMF). It is noted that the EU itself is in an extremely precarious financial position, and from *its* perspective, Ireland is only one of a number of states requiring financial bailout. To say the outlook is poor is something of an understatement.

Nevertheless, funding is required for a wide range of projects and initiatives relevant to future food security, some of which are outlined later in this document. In the longer term it can be assumed the funding available for these initiatives will fall to very low levels and this will be a major constraint. In the short term however, it is noted that Ireland receives approximately €2 billion per annum from the EU in the form of grants. Strenuous efforts should be made to re-allocate this funding - which may dry up with little prior warning - to long-term strategic ends, particularly in relation to food security.

Land, soils and topography

The land available for agricultural purposes is finite. However, calculations elsewhere suggest the available area of land, properly utilised, is adequate to feed the population. Possibly, it could provide a small surplus for external trade to nearby regions of the UK. To a large extent, the type of soil and local topography dictate the various purposes for which land can be used. However, it is noted that many agricultural and forestry activities are causing or have caused degradation of the land resource through soil erosion, loss of nutrients, compaction, destruction of beneficial soil flora and fauna, removal of hedgerows, and the spread of invasive species (for example the New Zealand Flatworm and Japanese Knotweed). In other cases, the land resource has become degraded through neglect and abandonment, particularly with respect to drainage. Further degradation of the resource would impact on future food production capability and is highly undesirable.

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Climate change

The world's climates are not static but follow long-term cyclic patterns typically on time-scales running into tens of thousands of years. Humanity has also impacted upon the global climate, through activities that add gasses and particles of solid matter to the atmosphere. The latter may sometimes have a cooling effect, through the blocking out of solar radiation while the former - collectively known as *greenhouse gasses* - absorb long wave radiation emitted from the earth and cause warming. In the last half century, the massive increase in greenhouse gas emissions arising from the burning of fossil fuels and also from agriculture and deforestation has caused atmospheric concentrations to rise very significantly, in turn increasing the absorption of long wave radiation. The net effect is global warming.

Global warming massive implications for global food production, not simply because of the warming, but also as a consequence of other related climatic changes such as increases or falls in precipitation (depending on the region) and the increase in frequency of extreme weather events, and also secondary events such as the melting of glaciers (some of which supply the water for irrigation in major food-producing regions) and, eventually, rising sea levels. There are other very serious implications too, including the destruction of the planet's most important ecosystems, the rainforests. Anthropogenic global warming probably represents the biggest challenge facing the human species in the last 10,000 years.

As a consequence of changing climates, many key food growing regions may become non-viable for the crops currently grown, and in some cases crop-production may cease completely. Climate modelling based on ice core samples and recent historical data suggests global temperatures will rise by 2-6 degrees Celsius this century, with the greatest likelihood of a rise towards the upper end of this range. While global temperatures are expected to peak within several hundred years, the longer-term effects on global climate are predicted to persist for thousands or even tens of thousands of years. Seven years ago, James Hanson, Director, NASA Institute of Space Studies and one of the world's leading experts on climate change, warned that "*we are on the precipice of climate tipping points beyond which there is no redemption*". Since then greenhouse gas emissions have continued to increase, while the so-called mitigation measures have amounted to no more than window dressing. The evidence suggests humanity has already passed those tipping points, and there is no way back.

In Ireland there are also implications for agriculture, albeit not catastrophic. There may be some modest benefits. Climate modelling suggests the winters will become much milder and generally wetter, with the greatest increase in precipitation to occur in the north and west. The summers are predicted to get slightly warmer, and generally drier. This may favour fruit and nut crops, some of which are currently regarded as marginal in Ireland.

Parts of the south and east are likely experience a greater incidence of soil water deficiency during the summer months, especially during late summer. This could impact negatively on tillage crops and reduce yields. The increased precipitation in winter is likely to result in wetter soils during the springtime, which could also impact on tillage. Overall, the warmer and wetter winters are likely to favour the spread of crop diseases, particularly fungal diseases. However, the outcomes are far from clear. In addition to experiencing changes in temperature and precipitation, Ireland may experience a greater frequency of extreme weather events such as storms that could impact severely on crops.

A further possible consequence of global climate change for Ireland is a greater degree of variation and unpredictability in seasonal weather patterns. This may already be occuring. The first six months of 2012 exhibited many characteristics that diverged from seasonal norms: mild yet dry weather during the first three months; exceptionally warm during March; cold in April and May; and unusually wet during May and June. At some locations more frosts were experienced during April than in January, February and March combined. Although it is too early to determine whether these untypical conditions represent a random, one-off climatic variation or are part of an emerging long-term trend towards highly variable seasons, there is a concern it could be the latter. Agriculture will need to think on its feet, and be flexible in changing conditions.

Trial orchard of sweet chestnut. Hardy hybrids of the European and Japanese chesnut have the potential to perform well in Irish conditions and begin producing nuts from about six years. The trees do best in a deep, moist and slightly to moderately acid soil rich in organic material. Nut potential is likely to improve further as the climate warms.

"*If you are planning for a year, sow rice; if you are planning for a decade, plant trees; if you are planning for a lifetime, educate people* " (Chinese Proverb)

5.0 Responses and mitigation strategies - drawing up a comprehensive strategy for feeding Ireland post 2020 and developing other aspects of the land resource

Without such a strategy, Ireland's ability to feed itself in the future will be massively compromised. Possible templates for action may be derived from the experiences of other countries and regions that have suffered severe constraints on energy and food supply, in particular Cuba during the ten year period immediately after the break up of the Soviet Union, post-Soviet Russia, and Argentina during the financial crisis of 1999-2002. The experience of both Britain and Ireland during and immediately after both world wars is also of relevance. However, one important distinction is that all these crises were of a relatively temporary nature, and were resolved (with varying degrees of success) once a business-as-usual situation returned. The post-fossil fuel crisis will be of an entirely different nature, in that it will be on-going for decades, and possibly indefinitely. There will be no help forthcoming in the form of foreign aid, multinational investment, or the resumption of conventional energy supplies.

Unlikely as it may appear to many who are struggling to survive, Ireland will be in a privileged and even enviable position when considered in a global context. Ireland has a good land resource at its disposal - relative to its population size - and potentially at least, has better long term prospects than many other European countries. However, much will depend on the degree of preparation for the crisis. Some specific actions that should be initiated in the immediate future, that will assist in the drawing up of a comprehensive food security strategy and its subsequent implementation, are listed below.

Undertaking of detailed audit of land resource

Although there have been many assessments carried out of the land resource in Ireland in the past, there is a pressing need for detailed up-to-date information regarding the state of the resource. The envisaged survey would require the resources of a state agency, though possibly the work itself could be put out to tender. Of particular importance would be a re-assessment of the tillage resource, possibly using the original grading system but perhaps looking more realistically at the grade 3 and 4 tillage categories, which appear to have been under-stated in earlier studies. Also of strategic importance would be an assessment of the land considered below tillage standard for its suitability for various forms of sustainable woodland, including orchards (this does not imply orchards should be excluded from tillage-grade land) and wetland woods with potential for nutrient accumulation, carbon sequestration or other strategic purposes.

Review of educational curricula from a food security perspective

The incorporation of horticulture and agricultural science into educational curricula - particularly at second level - to a much greater degree than occurs at present time will be an essential strand of future food security. Such curricula should include a significant component of practical work: some of this could take the form of school orchards or small plots of tillage. A small number of schools have already initiated projects of this type under the *Green Schools* scheme. However, there is massive scope for increasing horticultural activities in schools.

At the present time, food growing initiatives undertaken as part of the *Green Schools* scheme usually are considered as part of the biodiversity element of the scheme. It may be more appropriate to consider food growing as a separate category, different from but complementary to biodiversity.

The re-focussing of the *Green School* scheme towards food-related projects, although potentially of considerable benefit, should not distract from the need for a more comprehensive and structured horticultural component in school curricula, begining at primary level and then continuing right through secondary education. In order to reflect the varying resources available to secondary schools, it may be may be advantageous for schools within a particular locality to share land resources, and also for some degree of specialisation to occur. There is also an argument for re-structuring the school calender, to reduce the duration of the long summer recess in order that the school year is more compatible with horticultural activities.

Education in horticultural practices should continue at post-second level. Many school premises would be suitable venues for post-second level horticultural training.

Obligatory planting of fruit and nut trees on municipal and other public land, and land owned by state institutions

The obvious example here is schools (see above) but such planting could take place at many other types of educational instructions (particularly large third-level campuses), on municipal land allocated for recreational purposes, along footpaths, and in many other open areas. The costs involved are miniscule when compared to contemporary local authority budgets. In many cases, the work could be carried out by voluntary groups or under community employment schemes. From many perspectives - social, economic and educational to name but three - the planting of fruit or nut trees by people employed under such schemes is preferable to unemployment.

Anecdotal evidence from projects of this nature undertaken on a voluntary basis on public land in several towns in Mayo suggests that local authorities are sometimes lacking in the expertise necessary to make good calls on this type of project, and sometimes allocate inappropriate land where the orchard trees are compromised by soil conditions or by other activities undertaken in the same general area by the authority. It is strongly recommended that measures are taken to inform local authorities of good practice, and to provide training for personnel (planners, engineers, local authority horticultural staff and other manual workers) where appropriate.

Minimum targets for trees planted should be set. This could be done on a town by town basis, with the target figure proportional to the population. For example, an annual target might be a number of trees equivalent to five percent of the municipal population.

School orchard project, St Joseph's Secondary School, Castlebar, Co. Mayo.
The orchard contains varieties of nut trees, apples, plums and damsons.

Support for training programme to re-skill the workforce in activities related to food security

This closely ties in with the educational and municipal planting initiatives outlined above. It should focus on innovational or specialised aspects of food production not covered by existing training aimed at mainstream agricultural activities. The long lead times associated with orchards, and long period required to become familiar with the processes involved in orchard development and maintenance, make training in this area a high priority. Given the extremely low knowledge base in Ireland, it may be necessary for an initial cohort of trainers to be sent overseas in order to gain from the experience of regions with climates similar to Ireland where fruit and/or nut growing is more developed. An example would the fjordland of western Norway, which produces plums and cherries on a commercial scale. Ireland may also learn from the practices of regions elsewhere in Europe that have greater experience of organic methods, or that still use work animals.

Financial incentives for landowners to plant orchards

This initiative would have considerable strategic value, particularly on land considered marginal for regular tillage but with a potential fertility adequate for orchard trees. The resultant increase in the number of orchards in Ireland, of apples but also of cherries, plums, pears, cultivated strains of hazelnut, walnut and sweet chestnut (none of which have much tradition of cultivation in Ireland) would do much to raise the level of collective knowledge, thereby enabling growers to pool expertise, equipment and other resources. In turn this would encourage more orchards to be planted.

Some care would be required in the configuration and awarding of grants, in order to ensure appropriate varieties were chosen and that trees were adequately maintained. Possibly, a level of prior training would be obligatory where previous relevant experience could not be demonstrated. Possible mechanisms for administrating this type of funding are already in place under the *Scheme of Investment Aid for the Development of the Commercial Horticulture Sector* (part of the *Irish National Development Plan 2007-2013*) and, possibly to a lesser extent, under *Rural Environmental Scheme*/*Agri-Environmental Options Scheme* (*REPS*/*AEOS*). However, the emphasis of any new funding should be on long-term production viability, rather than commercial criteria based on contemporary market conditions (as required under the current horticulture scheme).

A criticism of the current funding for the establishment of *traditional* apple orchards is the requirement that exclusively 'Irish' varieties are used - including varieties that have little history of usage in orchards with quite limited production potential - a somewhat arbitrary distinction as all the varieties designated as 'Irish' were originally developed (often accidentally) from varieties brought into Ireland from abroad. The historical evidence is that the bulk of apples produced in Ireland in the eighteenth, nineteenth and early twentieth centuries would have been of varieties introduced from England, where the culture of apple growing was much more established and where the development of new, improved varieties was practicised on an on-going basis at many of the larger nurseries.

As an interim measure it is recommended that the varieties approved under the *AEOS* is expanded to include 'heritage' varieties commonly planted in Ireland in the past, but that originated abroad.

Lease or lease purchase arrangements to make land available to people who have no access to land but who wish to farm

Such arrangement have existed in various places in the past, including Ireland and the UK. There is a considerable resource of under-utilised land in Ireland. The resource includes properties formerly held by property speculators and developers that are now in receivership or under the administration of the *National Asset Management Agency* (*NAMA*), derelict land not recently used for agriculture but that has some agricultural or forestry potential, and abandoned or otherwise badly neglected holdings held by absentee owners. As noted, Ireland previously had legislation to compulsorily lease or purchase land in order to make it available for farming or horticultural purposes. Some of this legislation was repealed in the 1990s, while other legislation (for example the *Derelict Sites Act* and also the *Allotments Act*) is still in force. The criteria of who would qualify for such land should include a clear demonstration by the applicant of a minimal level of prior experience or training.

Funding of agricultural/horticultural research and establishment of research facilities

Plenty of agricultural research takes places in Ireland, only it is predominantly the wrong type. Certainly, it has the wrong focus, namely selling product to the globalised market - a market with extremely limited future prospects. Arguably much of the research is also carried out by the wrong organisations: corporate bodies with their own particular allegiances and agendas. It would be fair to say none of this research - which is entirely based on the premise that business-as-usual (epitomised by the mantra of *lowest costs*, *maximum profits*) will prevail indefinitely - has much relevance to future food security in Ireland. By necessity, future agriculture in Ireland will be small scale, low energy, self-sustaining, and very diverse, serving firstly local markets and secondly the immediate region beyond.

The extent of the changes required is such that there is scarcely one single variety grown at the present time, of any crop, that will automatically be guaranteed a place in Ireland's agriculture of the future. In essence, research will be starting from scratch, from first principles. While this may appear daunting, it actually presents an opportunity to relocate research where it needs to be, namely in the hands of the new agricultural pioneers who will be tasked with feeding Ireland. The Irish state can facilitate this process, by providing limited capital funding to community-owned agricultural cooperatives and other non-governmental organisations engaged in useful research work. The money involved is tiny when viewed against the annual subsidy of around €2.5 billion that currently is used to keep Irish agriculture afloat.

Initiation of breeding programmes for work animals, including horses, mules and oxen

Future agriculture will be powered from a very diverse range of sources, including animals. Animals may be particularly suited to working in areas of marginal land, where their 'fuel' of hay or turnips can be grown in locally in fields unsuited to the production of biofuel crops for fuelling tractors. Crucially, the use of animals *increases the range of options*. As already noted, a major constraint regarding the use of work animals will be their very low numbers. At the very least, there should be a network of small stud or breeding farms dedicated to raising suitable breeds and maintaining a breeding population of stallions and bulls. Funding could be provided under the auspices of an expanded *AEOS* (which already promotes the raising of limited numbers of the *Dexter* and *Kerry* cows, *Irish Draught Horse* and several other Irish breeds) and/or under a new scheme set up specifically for this purpose, possibly under the *Rural Development Programme* (*RDP*). The amount of money required to undertake this proposed breeding programme is small. It is noted that grant aid is currently available under the *RDP* to the Irish sport horse industry, which has a very limited strategic value.

Utilisation of state-owned land for strategic purposes

The Irish state is a major owner of land. Much of this land is held by semi-state companies, for example *Coillte* and *Bord na Mona*. Proposals have been mooted by the Irish government in recent times for the Irish state to sell off these land assets for the purpose of relieving burgeoning state debts. Such a move would be a huge mistake. The state-owned land is too important a resource to sell off to pay outstanding debts (and in any case the impact on the total debt would be very small). Specifically, the bulk of this land has potential for sustainable forestry or woodland, much of it for long-term deciduous woodland, useful for a variety of purposes and activities: carbon sink; bio-reserve; nutrient accumulation for agricultural purposes; biomass and/or charcoal production; production of lumber for construction purposes; and low density grazing to name but some.

However, it is questionable whether the semi-state bodies that nominally own the land have the capability or aptitude to manage such a diverse range of activities and uses. In some cases, it may be appropriate for the land to be leased on a long term basis to community-owned cooperatives and other community organisations. One potentially important use of the drier soils is medium term rotation coppicing, which would coppice trees on an eight to twenty year cycle for biomass production. Naturally, much production would be focussed on local requirements, including small-scale industry. However some products, for example charcoal and construction-grade timber, would be valuable as a tradeable commodity.

“ *There is no solution, though there are some paths that are better and wiser than others. This is a societal issue, there is no other to blame, but the responsibility belongs to us all. What we require is rapid emergency planning coupled with a plan for longer-term adaptation.”*

David Korovicz, *Tipping Point,* 2010

6.0 Conclusions

That there is a need for a comprehensive national strategy for agriculture that both acknowledges and addresses the critical issues listed here can hardly be overstated. Ireland is stuck in an outdated, inappropriate mindset belonging to a era characterised by energy abundance and global economic stability. That era, although still in its death throes, is to all intends and purposes over.

The new era will be characterised by economic crisis, collapsing supply chains, and chronic energy scarcity. It will be an emergency, but unlike previous emergencies, it will be one with no clear end. Priority will be survival, beginning with basic principles: food and water supplies, shelter, healthcare and the maintenance of an infrastructure that will make these things possible.

Contemporary agriculture meets, at best, only slightly more than one third of indigenous food requirements. Although the justification for its high orientation towards exports is the alleged economic return, agriculture as a sector requires direct financial subsidies to the tune of over €2 billion per annum - an amount roughly equivalent to its annual operating surplus - just to maintain its position. From an economic perspective alone, Irish agriculture as currently configured is not sustainable.

The elephants in the room however, are fossil fuels, particularly oil. Fossils fuels run contemporary agriculture. They are finite resources, laid down by geological processes millions of years ago, and ones which are becoming depleted, globally, at ever increasing rates. There are no alternative sources of energy that will match the versatility and sheer quantity of the energy provided by fossil fuels. The future, inevitably, will be energy-lean. There will be critical shortages of energy throughout the supply chain. However, outcomes will be considerably more positive if preparations for energy scarcity are made in advance of.

Agriculture will have a critical role to play, in providing most if not all of Ireland’s food, as well as fibre and fuel. If the land resource is developed to its full potential, there may be a small surplus of goods to trade overseas.

The lead time for many of the initiatives needed is long. From a standing start, it will take eight to twelve years to reconfigure agriculture, and then a further two to three decades to fine tune and optimise output.

The new agriculture will be characterised by a shift in orientation away from exports towards fully meeting indigenous food demand, from livestock towards crops, from animal feed to food for humans. However, it will be required to utilise marginal land resources for livestock production, while simultaneously developing orchards for fruit and nut production, and woodlands for fuel and a range of other useful outputs.

Whereas, contemporary agriculture is hugely inefficient, requiring massive external inputs for the outputs achieved, the new agriculture, by necessity, will be tightly run on minimal external inputs.

The new agriculture will entail lower levels of motorisation but much higher intensity of labour, the recycling of nutrients, great diversity of outputs, micro-utilisation of land, and an intelligent mindful approach that permits long-term nurturing of resources. It will be not so much ‘smart’, with all the implied connotations of spin and trickery, but *wise*.

“*Time is short. At best Ireland has a few years in which to take decisive action that will put in place the essential infrastructure and to develop the skills, resource bases and supporting grass-roots organisations that will enable society to survive the extremely difficult transition period. By way of comparison, the recent economic downturn and associated credit crisis, so called, may be considered a minor sneezing fit while a case of life-threatening pneumonia awaits around the corner. The process of adaptation and mitigation will draw heavily from the concept on triage used by emergency response teams dealing with natural disasters of a magnitude that threaten to overwhelm the resources available - namely to concentrate resources on saving those that can be saved. The process of triage must be applied to employment, business, manufacturing capability, utilisation and development of natural resources, and to the provision of food, energy and essential services. While this diagnosis may seem alarmist, it is one that will be ignored at society’s peril.*”

Taken from: *Renewable Energy in Post-Tipping Point Ireland* (Submission to Draft National Renewable Energy Action Plan), Andy Wilson, Sustainability Institute, 2010

7.0 Appendices

7.1 The area of land available for tillage in the future

From the figures presented earlier, it is possible to estimate the area of land that is potentially available for tillage in the future. The tillage areas from the mid-nineteenth century are an unreliable indicator, as some of this would be in areas now depopulated, or would be extremely marginal land on bogs or steep hillsides. However, it is acknowledged that other areas with tillage potential were not tilled during this period. The area of tillage achieved in 1943 - just over 1,000,000 ha - may be used as a starting point for estimating future tillage potential.

From this base figure we must subtract all the land that has been built on, or which has been lost to other uses. We must also deduct land that will no longer be available for tillage owing to the increased precipitation and flooding that are consequences of global warming triggered climate change. Finally, we must deduct tillage land that will be lost to other purposes in the future. This could include tillage land close to farmsteads that for strategic reasons is used for coppicing plantations, or land that is planted in orchards.

Finally, we should add land that was not used for tillage in 1943, but which had tillage potential. It is estimated that since 1950, some 75,000 ha of tillage land ha has been built on, or has otherwise become unavailable because of building-related activities.

A further 75,000 ha may be regarded as potentially unavailable owing to the effects of climate change, in particular increased levels of soil moisture or risk of seasonal flooding. Some of this land may be suitable for biomass production (trees grown for biomass). A further 100,000-150,000 ha of potential tillage land may be lost in the future, owing to the establishment of orchards and coppicing plantations. The total loss is estimated to be 250,000-300,000 ha.

However, approximately 200,000-250,000 ha of land not utilised for tillage in 1943 could be brought into productivity. This would mainly be land unsuited for large machinery, where tillage would be best accomplished by hand. This gives a final figure of 900,000 - 950,000 ha of potential tillage land.

However, not all this land would be tilled in any one year, as aproportion of the land would be under green manures or used for grazing purposes. The tillage area potentially available for crops in any given year can be assumed to be 675,000-750,000 ha. This represents a 70-90 percent increase in tillage from contemporary levels.

7.2 Land-based Biofuels

These fall into the following categories:

Biofuels from tillage crops
Other biofuels requiring tillage-quality land
Biofuels from poorer land (tillage grade 4 or land considered unsuitable for tillage)

General principles

Food crops will have to take priority in post-tipping point Ireland. Ireland currently produces only one third of the food it eats, and will only achieve food autonomy in the post fossil fuel era with a massive coordinated effort. Except in special circumstances, it will not be possible to use tillage land for non-food crops. Exceptions might include specific fibre crops or biofuels for tractors or essential (non-private) transport. Therefore, the area of tillage land allocated to biofuels will be low. Crops such as biomass willow or Miscanthus that require tillage grade land, but which are extremely difficult to adapt for use as vehicle fuels, will be a particularly low priority. However, silage may become an important energy crop as this can be digested anaerobically to produce biogas - a versatile fuel suitable for use in transport, heating, and the generation of electricity (including CHP) - and can be grown on land considered marginal for tillage.

On other marginal land, in particular dry grassland unsuited to tillage, there is considerable potential for biomass production from sustainable deciduous forestry. Although these forests have yet to be planted, the potential long term energy yield is possibly greater than all the other biofuel sectors combined. The most sustainable method of production would involve medium term rotation coppicing (sometimes called short term forestry) whereby trees are coppiced on 8-30 year cycles. As coppicing plantations live for centuries, this system would entail planting the trees just once - an important consideration when resources are scarce. Sustainable forestry may also be appropriate on some of the wetter grassland areas. The resulting fuel crop would be very suitable for heating (both domestic and commericial/industrial) and may have applications in the generation of electricity, especially CHP.

Existing coniferous forestry plantations are also an important energy resource, even though it can be considered a finite resource in the sense once the trees are cut down the resource is gone. While replanting can be carried out, there is a long lead time. Also, many coniferous forestry methods are clearly unsustainable, and are known to contribute to greenhouse gas emissions, soil erosion, water pollution and loss of biodiversity. For these reasons, new coniferous plantations should not be considered on bog, nor anywhere else where clear-felling is regarded as the only viable method of harvesting.

The principal land-based biofuel sectors are as follows:

Liquid biofuels from tillage crops

Solid biofuels from perennial crops grown on tillage land

Silage

Solid biofuels produced from sustainable forestry (including medium term rotation coppicing)

Solid biofuels from coniferous plantations

Taken from: *Renewable Energy in Post-Tipping Point Ireland* (Submission to Draft National Renewable Energy Action Plan), Andy Wilson, Sustainability Institute, 2010

7.3 Particulars of Land-based Biofuels

7.3.1 Liquid biofuels from tillage crops

As indicated above, the development of this resource is inevitably constrained by the need to prioritise the use of good tillage land for food production. Further, the energy return over energy invested is known to be extremely low with liquid biofuels, and possible under break-even point in some cases. Given these constraints and limitations, the Sustainability Institute estimates the viable resource to be 30-50 ktoe in2020, possibly rising gradually to 80 ktoe in 2030

7.3.2 Solid biofuels from perennial crops grown on tillage land

This sector includes biomass willow and Miscanthus. Both require tillage-grade land, industrial scale production or processing, and specialist harvesting machinery. In spite of the potentially large yield per hectare when compared to other energy crops, the contribution to future energy needs will have a definite upper ceiling. Possibly there will be a big push in this sector in the next few years, followed by a gradual tailing off as more tillage land is returned to food production. The Sustainability Institute estimates the viable resource to be 50-160 ktoe in 2020, but falling back to around 135 ktoe by 2030.

7.3.3 Silage

Silage has great potential as a feedstock for biogas production from anaerobic digestion. Given there is approximately 1,000,000 ha of land used for silage production at present, and much of this will be surplus to animal feed requirements in post-tipping point Ireland (when livestock numbers will be much reduced), it can be deduced that many thousands of hectares of land could be committed to silage for biogas production. However, it is acknowledged that few real world trials of silage for biogas have taken place to date, and many questions remain unanswered in relation to the long term maintenance of soil fertility, Expectations must be tempered with some caution. Given the probable slow development of this sector, the Sustainability Institute estimates the viable resource to be up to 50 ktoe in 2020, but possibly rising to 500 ktoe by 2030. The 2030 figure is predicated on approximately 10 million tonnes of feedstock, or about 40 percent of the current national silage crop.

7.3.4 Biomass from Existing Coniferous Forestry

It is assumed that in post-tipping point Ireland, much of the coniferous forestry resource will be available for energy purposes. The viable annual yield is estimated to be 500 ktoe, possibly rising as high as 700 ktoe. The higher the yield, the sooner the resource becomes depleted. This is a valuable resource, albeit one that should be used judiciously.

7.3.5 Biomass from New Coniferous Forests

This potential resource has a long lead time, with the first harvests from new (yet to be planted) coniferous plantations coming on line no sooner than 2030. The potential energy yield in 2030 is about 80 ktoe.

7.3.6 Biomass from Medium Term Rotation Coppicing

Medium Term Rotation Coppicing (MTRC) was identified in the Mayo Energy Audit as potentially a very important timber resource, being particularly suited to farm and local community scale production as well as industrial scale operations. Ireland has approximately 1.5 million hectares of land suited to MTRC. The main limiting factor is the time needed to ramp up planting, and the relatively long lead time (upwards of 8 years) to the first harvests. The Sustainability Institute estimates that if aggressive planting programmes begin immediately annual yields from newly planted coppices or from coppicing existing deciduous woodland could reach 40 ktoe by 2020 and 380 ktoe in 2030. The potential yield in 2040 would be 500-1500 ktoe, depending on the area planted and the ability to utilise the resource. In order to reduce transport requirements to the absolute minimum, it would be vital that production is localised.

7.3.7 Biomass from Other Broadleaved Forestry and Woodland

This resource includes existing broadleaved woodland including scrub. In energy terms it could yield up to 130 ktoe per annum by 2020, rising to 180 ktoe in 2030.

Taken from: *Renewable Energy in Post-Tipping Point Ireland* (Submission to Draft National Renewable Energy Action Plan), Andy Wilson, Sustainability Institute, 2010. Owing to lack of progrss in developing the biomass resource in the intervening two years, these figures require significant downward revision.

7.4 The Utilisation of Waste for Energy using Anaerobic Digestion

The main waste streams suitable for anaerobic digestion are as follows:

Municipal waste

Sewage

Abattoir Waste

Slurry

7.4.1 Biogas from Municipal Waste

The utilisable resource is estimated as 3-5 ktoe per annum by 2020 but falling to 0.5 ktoe by 2030 as waste streams diminish.

Other Benefits

The used digestate, once pasteurised, could provide a very high quality fertiliser or compost.

Constraints

Contaminents in residues. This difficulty should be surmountable with greater controls over waste inputs

7.4.2 Biogas from Sewage

The utilisable resource is estimated at 4-6 ktoe per annum by 2020, but potentially increasing to 12 ktoe by 2030 as the resource is better utilised

Other Benefits

The digestate, once properly processed, could provide a very high quality fertiliser or compost. Additional benefits lie in reducing current sewage processing-related financial and energy costs.

Constraints

Heavy metal content in residues. This difficulty should be surmountable with greater controls over waste inputs

7.4.3 Biogas from Abattoir Waste

The utilisable resource is estimated as 3-4 ktoe per annum by 2020 but falling to 0.5 ktoe by 2030 as waste streams diminish owing to reduction in livestock numbers and greater emphasis on tillage for food crops.

Other Benefits

Additional benefits lie in the reduction of otherwise problematic waste (and associated financial and energy costs). Also, the digestate, if treated properly, has the potential to be used as fertiliser.

Constraints

Health risks from poor procedures

7.4.4 Biogas from Slurry

The utilisable resource is estimated as 12-36 ktoe per annum by 2020 but potentially rising to 72 ktoe by 2030 as better use is made of the resource.

Other Benefits

The resulting digestate is far less polluting than the original raw material and far less harmful to worm populations. Also there is a much higher accessibility of nutrients to crops. Thus soil fertility can be improved, worm populations encouraged, dependency of artificial fertilisers reduced. These 'other' benefits are so great that it is desirable to anaerobically digest slurry for these outcomes alone, irrespective of the energy benefits.

7.4.5 Other sources of biogas from waste

Biogas can also be derived from exising landfill sites. The potential resource is estimated at 25 ktoe in 2020, peaking at around 35 ktoe in 2030.

Updated from: *Renewable Energy in Post-Tipping Point Ireland* (Submission to Draft National Renewable Energy Action Plan), Andy Wilson, Sustainability Institute, 2010. The original estimates have been revised downwards, in some cases significantly.

7.5 Economic Growth and its Future*

“The last two hundred years have seen an extraordinary growth in human population, urbanization, societal complexity, and wealth. This has required, and been facilitated by, ever more resources for our primary needs: food, water, shelter, waste disposal, and energy; and for our secondary needs such as the resources for discretionary consumption and for the operation of the complex bureaucratic and infrastructural aspects of our civilisation. The conventional wisdom assumes that this growth will continue.
Climatic change, oil and gas depletion, biodiversity loss, water and top-soil loss are among an array of threats that can be situated as a singular consequence of a massively consuming and growing population in a finite global ecosystem. We are in effect trapped within economic and social systems that require the growth in throughput of finite resources to maintain those same social and economic systems. And because of growing resource constraints, our relationship with such systems may be about to rupture.

The UN has estimated that by 2050, 9 billion people may live on earth, and that continued economic growth will allow billions of people to have a western level of consumption. This implies yet more resources, energy and food will be accessible in a relatively stable climate. Not only do our assumptions intuitively accept this, many of our personal and social systems depend upon it. The Irish government urges the public to get a pension, and while warned that ‘past history is not a guide to future performance’, or ‘prices may rise as well as fall’, the background acceptance of continuing economic growth, is never questioned. The governments’ investments in infrastructure, education, and state pensions are also framed within the assumption of growth. It is seen to have in this sense a historical inevitability.

That conventional wisdom is rarely charged with analytically justifying this assumption, despite the levels of resources we bet upon it, should be a warning. When attempts are made to justify the continuance of economic growth, it is principally through the lens of conventional economic theory, with little reference to the actual quality of human eco-systems. It is not surprising that such theory can assure us that growth can in effect continue indefinitely.

Our economy is in essence a materials and energy processing system. The earth’s material resources are transformed using high quality energy into goods and services, and in the process low quality energy is dispersed into the environment along with waste. This process is subject to the laws of thermodynamics. And because they are laws of nature, all human activities are subject to them.

Our economy grows exponentially, meaning each years’ 3% growth is bigger than the previous years. This means that each years’ demands upon energy, resources, and the earth’s capacity to absorb waste, is growing bigger. At such a growth rate, the size of the global economy would double in only 24 years. We could try and run these processes more efficiently, that is doing more for less. However, efficiency gains will always be limited by the laws of thermodynamics, while we expect economic growth to continue ad infinitum. Others suggest science and technology will allow us to escape the bounds of resource limitations. But science and technology are themselves energy and resource intensive, and often end up just displacing problems in time and space

Awareness has grown, particularly over the last thirty years that the path we were on is unsustainable. Indeed one is likely to find that many people would agree that ‘we are fishing unsustainably’, or ‘our increasing greenhouse gas emissions are unsustainable’. Virtually every indicator measuring our ecosystems health has got progressively worse. In response governments and wider society have laid out targets, signed treaties, passed laws, invested in research & development, agitated, and cajoled to reverse human impact. Yet despite this, growing damage to our ecosystem has consistently far outweighed our limited successes. In order to explain our failure we might consider that we are attempting to solve these problems within a system which is itself causing the problem, and our efforts are therefore doomed to failure. And if our economic system makes such growing demands upon our ecosystem then that system must itself, be unsustainable.

The economist Hermann Daly called this an impossibility theorem, the idea of infinite growth on a finite planet. A growing number of experts are warning that we are indeed reaching the limits of how much growth can be sustained. It is argued that the energy that sustains our complex world and drives its growth is on the cusp of decline; that our food production cannot sustain the multiple risks to its productivity even as population rises; that increasing biodiversity loss is presenting serious risks on many fronts; and that our climate system may have passed tipping points that ensure that no matter what we do with our emissions, we will face severe consequences.”

*David Karovicz, from *Economic Growth and Its Future*, Feasta, December 2008

7.6 References and Further Reading

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