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Gut feelings and possible tomorrows: (where) does animal farming fit?

Photo: the Argument by Design

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Introduction

The 'future of food' problem is an industry in its own right. It is its very own subsector of the new green economy, spawning innumerable high level conferences, power dinners, 'ground breaking' reports, multiply-referenced analyses, think tanks, dedicated academic journals and a proliferation of NGO campaigns and food industry roundtables – all seeking to 'address' the variously termed twin challenges, wicked problems and perfect storms that the food system engenders.

While their activities may be legion, most analyses converge on a few simple and generally accepted descriptions of what the problem actually *is* – namely that more people, with different levels of access, want more and different food, from fewer and poorer resources. The consequences are environmental damage, the depletion of essential but finite resources and an ongoing failure to address the problems of hunger and malnutrition even while large sections of the global population grow sick from eating too much. As such the human species faces a difficult and uncertain future.

We all know – and agree – therefore, that we have a problem, we agree on what the main problems *are*, and that something needs to be done. And yet food related greenhouse gas (GHG) emissions keep rising and forests cleared, and people remain badly fed – the malnourished, sick and hungry now morphing seamlessly into the malnourished, the sick and the obese.

The difficulty is that there is less unanimity as to what causes the problem, on what or who is to blame and why. This matters because our views about what drives a problem shape our assessment of what constitutes a solution. We make sense of the world by constructing or relying on pre-constructed narratives of cause and effect.

While the stories we tell ourselves about how and why things are, may be necessary if we are not to wallow in atomised and disembodied information, the risk is that facts are squeezed and edited and shaved to fit the desired or assumed narrative. And those with most power tend to determine which narrative dominates.

One particular issue exemplifies both the complexities of the food problem, and the different and contested narratives that interest groups (stakeholders), present. This is the 'meat question' – for the purposes of this paper meat serving as a shorthand for animal products of all types. It is now largely undisputed that the rearing of animals uses a great deal of our finite land and resources, and contributes to a great many environmental problems. What is much more contested, however, is whether these problems are tractable, how the costs of livestock weigh up against the various benefits they provide, how 'beneficial' these benefits truly are and – on the basis of all

this – what kinds of solution are necessary, desirable, inevitable or possible. In short, different beliefs and values about meat give rise to different diagnoses of the real underlying problems, and these in turn shape different visions of what 'good' actually looks like.

The purpose of this paper is to look at the different narratives that people construct about the food – and specifically the meat – 'problem,' explore the values and beliefs that underpin them, and show why we need to pay more attention to these same values and beliefs.

It is divided into three parts. Part One asks who the stakeholders are in discussions about meat, and what stories they tell about the problem – what lies at its root and who and what is to blame.

Part two looks at solutions. It explores the visions of 'good' – the sustainable livestock futures – that can be inferred from looking at the way in which stakeholders define the problems. These visions are sketched out as scenarios and a little life breathed into them. What might happen if the world were really like this? How is success defined in these futures, what sort of dynamic tensions might start to manifest themselves, and what new problems might emerge?

Of course, having drafted a set of scenarios, the obvious question that arises is 'so what?' Visions of the future are ten a penny and scenario construction a whole micro-industry in itself. Is there anything to be gained from exploring the values that different people bring to the issues, and where their ideals might lead, if followed through to their logical and extreme conclusions? The final part of the paper focuses on this "so what?" question and makes the case for more self-critical, exploratory approaches to research, policy and advocacy.

1. The problem with food: three stories

We all have a very tangible interest in food: everyone eats. We are all 'stakeholders' by virtue of our metabolisms. And we all influence and are influenced by the complex processes through which food is produced, distributed and delivered to us. These determine what we eat and how much – but our act of eating also influences those self same processes.

Of course while we are all stakeholders, some have more of a stake. A subset of us – more than a third of the world's population – is also involved in growing, rearing, capturing, distributing and purveying food. As provisioners, these people influence and are influenced by the food system in ways that may reinforce or contradict the responses they make as eaters. Some of them may carry particularly strong political or economic weight – for example commercial agribusiness companies, traders and distributers, manufacturers, retailers and caterers.

An additional group of stakeholders has interests in food that go beyond, or are in addition to, metabolism or money, and could be seen as ideological. These include civil society organisations who want to reinforce or change aspects of the food system's impacts on health and nutrition, environmental protection, power relations and poverty, or animal rights or welfare. National and international policy makers and the academic community present themselves as neutral – or at least evidence based – but they too are inevitably buffeted by the competing narratives and analyses of these sometimes powerful and vocal stakeholders, as well as by their own private ideologies.

These multiple stakes give rise to multiple views – some virtually unheard, others overwhelmingly influential, some shouty and simplistic and others finely layered and nuanced. But within this diversity and beneath the complexity, three broad-brush accounts of what is wrong, and therefore what should be done about the food system can be discerned. It would be simplistic to assign stakeholders entirely to one narrative over another – a point discussed later on in this paper – but there are certainly differences of emphasis: stakeholders tend to feel more comfortable with one framing of the problem over the other, and this shapes their arguments for action.

Their divergent emphases reflect contrasting beliefs about the role of technology and the potential it holds to address the problems we face; the extent to which it is possible to alter human behaviours; and the malleability of global political and economic institutions. More fundamentally, however, the narrative that resonates most with stakeholders will be the one that reflects their deeper ethical and aesthetic convictions about our role in the natural world, the nature of human progress, definitions of freedom and ultimately what constitutes the 'good life'.

These are the three stories.

1.a. Story One: Not enough food

The story runs as follows. The population is growing, and our demand for food – particularly for milk, meat, eggs and fish is rising. Eight hundred million people in the world are still chronically hungry. The imperative is therefore to increase production. But since current methods generate unsustainable and ultimately untenable environmental costs, we need to develop production methods that are more resource-, carbon- and water efficient. The grand challenge is thus to deliver more food – and more of the foods we want – in ways that generate fewer environmental problems.

Efficiency is therefore key – of production, delivery and supply. This can be achieved first by carefully measuring current impacts, since 'if you can't measure it, you can't manage it.' Environmental life cycle assessment (LCA), with its structured approach is brought into service here. The insights it provides, combined with those from the natural and agricultural sciences and from business thinking can help us develop more efficient systems of production while simultaneously increasing productivities. Since agriculture additionally contributes to CO_2 release by driving land use change,[1,2] the need to raise productivity to 'spare' land from agricultural encroachment is all the more critical, adding further impetus to arguments for 'sustainable intensification.'

This 'more for less' narrative of sustainable intensification dominates the discourse on food sustainability. It is the story told by the mainstream and more commercial parts of the food industry such as agricultural input businesses, farming unions, manufacturers and retailers.[3,4] It resonates with policy makers since it is consistent with the larger narrative of economic growth as the indispensable handmaiden of human progress,[5] and the belief that, thanks to human ingenuity, growth can be decoupled from environmental impact. It is also consistent with the dominant political emphasis on the primacy of consumer choice, manifested through the workings of the market. Consumers are rational beings who can make decisions by weighting their different preferences. The problems of obesity and overconsumption are very real, but they are best addressed not through radical changes in consumption patterns but through product reformulations and consumer education. Our choices should not be proscribed by 'nanny statist' regulations or hammered into submission by blunt, heavy handed measures such as taxation. Consumer choice, freedom and progress are in fact coterminous – and history bears this out.

Advocates of this narrative see themselves as optimists – our problems can be solved – but optimists grounded in psychological pragmatism – perhaps in some cases even pessimism. Technology needs to improve because our natures cannot. We are creatures of desire and generally, our desires are materialistic. Wealthier people have always consumed more resource intensively than poor people and since the world is (on the whole) growing richer, it follows that demand for resource intensive products,

1 Burney J.A., Davis S.J., Lobell D.B. (2010). Greenhouse gas mitigation by agricultural Intensification, *PNAS*, www.pnas.org/cgi/doi/10.1073/pnas.0914216107

2 FAO (2006). *Livestock's Long Shadow*. Food and Agriculture Organisation, Rome.

3 Bayer Crop Sciences, undated http://www.bayercropscience.com/bcsweb/cropprotection.nsf/id/EN_Producing_good_quality_and_abundant_food?open

4 Syngenta (undated), Sustainable Agriculture http://www.syngenta.com/country/ca/en/corporate-responsibility/Pages/SustainableAgriculture.aspx

5 Defra (2012). *Green Food Project Conclusions*, Defra, UK.

such as meat, will increase[6] however much we my wring our hands. Where both demand and income co-exist, supply will follow.

This is where technology comes in since it can help deliver this supply in ways that do less damage. For some, efforts to moderate demand may even pose a threat, given the economic importance of the livestock and their nutritional value. [7,8]

Interestingly one logical consequence of this technologically optimistic approach is to bypass livestock altogether by developing artificial or *in-vitro* meat – an approach which has already won the support of some archetypal technophiles.[9] Here the prospect of increased animal production is tempered by the development of lower impact alternatives – a kind of dematerialisation through rematerialisation.

1.b. Story Two: Too much greed

In a second framing of the challenge, the problem shifts to the demand side. The consumer becomes the focus of concern and locus of change. Our consumption patterns are catastrophically resource intensive and they make us fat and sick. We must change them.

This story has also been strongly influenced by LCA and related approaches.[10,11,12] But where the tellers of the first narrative use LCA to identify opportunities for optimising *production*, the emphasis in this second shifts to the *consumption* habits that ultimately drive production of resource intensive foods. The metrics used to measure progress are absolute rather than relative: these story tellers are not interested in relative improvements in GHG efficiency (more with less impact) but in achieving absolute cuts,[13] that require us to consume less.

Moreover, eating meat is not just environmentally damaging, it is also cruel, either (depending on standpoint) because of the systems in which animals are reared or because eating sentient beings is simply wrong. It is inefficient and unjust too: more food is obtained from a given area of land if we consume plants directly rather than pass them through an animal first. In a world where land is constrained and the

6 FAO (2012). *World agriculture towards 2030/2050: The 2012 Revision*, Food and Agriculture Organisation, Rome.

7 IDF (2009). *A global dairy agenda for action – climate change*, International Dairy Federation, World Dairy Summit, Berlin

8 IMS (undated). 800 Participants attended the 19th IMS World Meat Congress in Paris, International Meat Secretariat http://www.meat-ims.org/the-19th-ims-world-meat-congress-2

9 http://www.gatesnotes.com/About-Bill-Gates/Future-of-Food

10 Pelletier N. and Tyedmers P. (2010). Forecasting potential global environmental costs of livestock production 2000–2050, *PNAS* 107 (43) 18371-18374.

11 EC (2006). Environmental impact of products. Analysis of the life cycle environmental impacts related to the total final consumption of the EU25 (EIPRO), *European Commission Technical Report EUR 22284 EN*, Brussels, Belgium

12 Weber, C., & Matthews, H. (2008). Food-Miles and the Relative Climate Impacts of Food Choices in the United States. *Environmental Science & Technology*, 42,10: 3508-3513.

13 FAO (2013). *Tackling Climate Change Through Livestock: a global assessment of emissions and mitigation opportunities*, Food and Agriculture Organisation, Rome.

human population is growing, 40% of arable crops are fed to animals – food for the rich – when this food could instead be consumed directly, efficiently and affordably by humans. In short, poor people starve because the rich eat meat. Counterfactuals – what ifs – are often woven into this narrative: for example 70% of agricultural land currently used for livestock could – if we ate differently – be used for something else, perhaps nature conservation or bioenergy production.[14] Humans need to 'get out of nature' by reducing the space they take up on this planet. Alternatively by producing less food we can afford more extensive, wildlife-friendly forms of agriculture that allow for a more harmonious integration of people and nature.

This broad perspective encompasses many slants on the whole idea of demand restraint (how much reduction and of what kind), many interest groups, and diverse underlying motivations. Its most extreme advocates are the vegan and animal rights organisations – but the 'less meat' position is also held by many environmental NGOs and by a growing number of environment-oriented academics.

In this story, technological improvements cannot sufficiently address the problems we have caused, and may even exacerbate them. They can, for example, be 'unnatural,' as in the case of GM, and risk generating irreversible health or environmental problems. They may be seen as entrenching already unequal power relations. Worse still, technological fixes may perpetuate and strengthen the underlying disease: our insatiable rapacity.

The meat issue is in fact just a theme in a bigger story, one in which human greed – our desire for stuff in general – sits at the heart of our environmental crisis. Our urge to consume is humanity's original sin. For some this sin is inherent in the individual; for others she is a hapless victim, at the mercy of manipulative commercial interests. Food is not the only issue of course, but it has especial and symbolic resonance since, by eating, we quite literally take part of the planet into our bodies.

To really address the problem we must curb this demand, so saving us from ourselves and, in the process, the planet. There are biophysical limits to growth: ongoing, green and environmentally decoupled economic development is an idea up for challenge. Environmental limits are rigid and absolute and so humanity has to fit inside them. The happy ending in this story is a world of 'less but better,' of 'voluntary simplicity'[15,16] where freedom is defined as liberation from the entrapments of consumption and value resides not in things but in justice, equality and spiritual wellbeing.

But some renditions of this narrative hint at the possibility that demand restraint will not be possible or achieved to a sufficient degree, meaning that a technologically derived pressure valve might just need to be on hand. Since intensive livestock systems are anathema, that pressure valve is artificial meat and other novel proteins, both plant and (in the case of insects) animal based. Thus we find an organisation such as PETA (the animal rights, pro-vegan organisation) funding a $1 million prize for the commercialisation of artificial meat; a solution they unexpectedly share with some advocates of supply chain efficiency, the narrators of Story Number One.

14 Schmidinger, K, Stehfest, E. (2-12). (2012): Including CO_2 implications of land occupation in LCAs-method and example for livestock products, *Int J Life Cycle Ass.*; 17(8): 962-972

15 http://simplicitycollective.com/start-here/what-is-voluntary-simplicity

16 http://www.nytimes.com/2008/05/18/world/americas/18iht-simplicity.1.12981659.html?pagewanted=all&_r=0

1.c. Story Three: Too much inequality

The third narrative talks less about producers and production, or consumers and demand, and more about imbalanced relationships. Systemic inequities are the main concern. They give rise to the twin problems of excess and insufficiency that play out both in the environment (over and under-use of agricultural inputs); and in our bodies – in the form of obesity and malnutrition. The solution is not necessarily to produce more or less but rather to rebalance the system: we need to reconfigure relationships within and among different actors in the supply chain, and with the natural world. Issues of injustice already touched upon in Story Number 2 assume a central place here. Hunger is not a problem of insufficient supply but of insufficient *access*.

There are many variants of this story line, some more radical than others in their analysis of the problems and their vision of the solutions, and in the emphasis they place on environmental as opposed to socio-economic aspects of the imbalance. For all, though, the central argument is that the problems we face are relational rather than technical or the result of individual decisions.

The more environmentally-focused often call for a relocalisation of production, for an increase in the number of people in farming and for ways of living and producing food that lead to a greater integration of human activity into the natural world; approaches such as organic farming, agro ecology or permaculture indicate not just a set of agronomic techniques but also a whole mindset. Others, such as the major international development NGOs (spanning both the mainstream and the more radical, such as Via Campesina) argue the need for equitable access to the means of production and consumption, and for empowering poor and marginalised communities.

In this narrative the underdog is inherently more likely to farm and consume within environmental limits than powerful corporations. Environmental sustainability is predicated on justice and equity; it is less a goal and more an outcome of structural change in relations among people, groups, institutions and countries and between us and the natural world. There is less specificity when it comes to the numbers, such as actually quantifying what level of GHG mitigation can be achieved. This is partly because the idea of pressing reduction targets on poor country citizens is seen as unfair and partly because numbers per se are 'reductionist' – they cannot capture the multifunctional nature of food provisioning systems, or the importance of less tangible 'goods' such as local identity, culture and empowerment. Sustainability is analogue, not digital. It is not to be bar-coded.

The problem with livestock here is not so much that we rear animals but rather the shift towards industrialised systems of production. These damage poor people's livelihoods and health, cause animal suffering, and destroy the environment. By contrast, in the right systems and at the right scale, farm animals are integral to environmental sustainability and human wellbeing by recycling nutrients, utilising marginal land and turning these inedibles into good, nutritious food for humans while also contributing more broadly to livelihoods, culture and identities. Under these circumstances, animal farming is seen as a *natural* activity, embedded in an agrarian ideal in which humans exist harmoniously in the natural world.[17] This 'land sharing' holism stands in direct opposition to the first and second narratives, wherein nature must be 'spared' from damaging human encroachment and where the 'inefficiency' of livestock is to be addressed either through technological improvements or by eliminating them from our diets.

17 Fraser D., Chapter 12: Animal Welfare and the Intensification of Animal Production, in Thompson, P.I.B. (Ed.). (2008). *The Ethics of Intensification: Agricultural Development and Cultural Change*. Dordrecht: Springer.

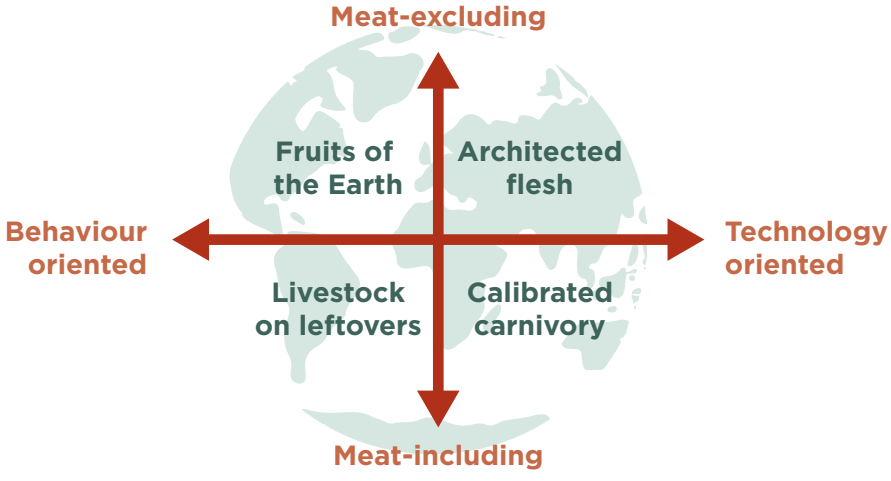
2. Year 2035. Gut feelings: four livestock futures

Not enough food; two much greed; lack of balance – different problems suggest the need for different solutions. So what are these solutions: what does success – a sustainable food system – look like and what part, if any, do livestock play in it?

Visions of the solution may not often be very explicitly articulated, but they are there if one reads between the lines. They are implicit in the assumptions interest groups make ('trends show that consumption is set to rise by x'), in the what-ifs they advocate ('if high income countries reduced their meat consumption by y'), in the moral tugs of war that words such as sustainable intensification and agro-ecology provoke and even in the way that sober, complex and ostensibly neutral academic modelling exercises are designed.

These hints and implications provide the first pen marks, or starting points for a series of scenarios (Figure 1) that are sketched out in the paragraphs below. Arguably, these sketches are somewhat parochial, coloured by analysis of the discourse that takes place in developed countries and in international policy and advocacy circles, and among the more obvious stakeholders identified above. Other scenarios might also be envisaged if one were to imagine massive and disruptive changes in the global political economy or the physical environment – the introduction of a global Caliphate perhaps, or a globally prevalent, uncontrolled and incurable disease outbreak, or the proverbial asteroid hitting the earth. And they are not formal scenarios constructed via the formal workshop exercises of oil executives or policy planners, and intended to help people anticipate and prepare for the future. The purpose rather, is to use the future to look at today – to explore people's present hopes, desires, fears, warnings and anticipations – and, by thinking about where they might lead, ask: do people really want what they think they want?

Figure 1: Four scenarios



Scenario 1: Calibrated carnivory

People continue to eat more and more meat. A combination of industry lobbying, limited investment in social sciences and the dominance of research showing the importance of genetics in determining human behaviour, bolsters policy makers' conviction that consumption patterns cannot and should not be moderated.

Thus a vigorous 'green growth' agenda is being pursued, underpinned by substantial public and private sector investment in a very wide range of technologies, and with the food industry taking a strong lead. Major efforts have been made to increase the efficiency of production, defined as the delivery of as much fish, meat, eggs and dairy output as possible for a given unit of GHGs emitted and land utilised. There have been successes in breeding livestock to be more productive, in improving feed formulations to maximise nutrient use efficiency, and in designing highly intensive housing systems that optimise conditions for growth, productivity and thus feed conversion efficiency. There have been advances in producing nutritional supplements, including antibiotics, that inhibit methane production in the guts of ruminant and in growth-promoting hormones that build upon earlier types such as BsT. Efforts to genetically modify the rumens of sheep and cattle to inhibit methane are showing results. Other research approaches treat enteric methane as a positive resource – a substitute for natural gas – and some labs have been successful in capturing this at scale. The technology is now feasible, if expensive, but prices will likely fall in coming years. Since animals are intensively reared in confined systems, animal manures are routinely collected and inputted into anaerobic digestors. In the pig and poultry sector there are now working demonstration examples of closed loop vertical pig and chicken towers;[18] located at an optimal distance between feed inputs and consumer markets. Housed animals are fed on grains and livestock at the bottom of the tower. Their manure is then anaerobically digested, the resulting methane used to heat greenhouses located on the roof, and the digestate used as a nutrient rich growing medium for vegetables and mushrooms. The Chinese government has invested heavily in the technology and will be rolling it out to cities and megacities across the country. Within the aquaculture sector a combination of highly calibrated feeds, closed recirculating and highly sophisticated integrated multi trophic systems are massively improving feed conversion efficiency.

As for feedstuffs, there is ongoing, priority-funded research into developing high yielding strains of soy and other protein rich feed alternatives. The need for such research is very evident as, despite ongoing geoengineering efforts, climate change is hitting yields and making forecasting more unpredictable. Agriculturally-induced deforestation, which still happens despite policy and business rhetoric around land sparing, only makes matters worse. Notwithstanding technological advances, climate change is reducing productivity and pushing up the costs of food production.

Insect production is emerging as an increasingly important feed input for the pork, poultry and aquaculture sectors. While insects in principle transform food and agricultural wastes into high quality protein, their use is constrained since some people are allergic to meat from animals reared on them.[19] Worryingly, some who

18 Driessen C. and Korthals M. (2012). Pig towers and in vitro meat: Disclosing moral worlds by design, *Social Studies of Science*, 42(6) pp. 797–820.

19 Verbeke, W., Spranghers, T., De Clercq, P., De Smet, S., Sas, B., Eeckhout, M., (2015). Insects in animal feed: acceptance and its determinants among farmers, agriculture sector stakeholders and citizens. *Animal Feed Science and Technology*, DOI: 10.1016/j.anifeedsci.2015.04.001.

have had allergic reactions after eating insects subsequently become sensitised after skin contact with insects in the environment. A thriving industry in providing certified meat from insect-free feed sources has sprung up, catering to those who can afford it. This niche but serious problem simply underlines the need for viable plant based feed sources. Proponents of algae continue to proclaim its wonders, with the proverbial breakthrough always just another ten years away.

Food prices have risen, but retailers are fearful of raising them too much lest they lose business to their cannier competitors. There is thus a 'value for money' arms race as retailers fall over themselves to provide the least expensive food offer, which they do by squeezing their suppliers. Since all the retailers are now doing this – and since the retail sector is now more concentrated than ever – suppliers are unable to take their goods elsewhere. So they look to cut corners – and one way they do this is by finding ways around existing land use and forest protection legislation.

Consumers, for their part, look to spend as little on food as possible. This is essential if they are able to continue spending on the other aspects of life – technology, holidays, clothing, cosmetics, housing – now inherent in any definition of an acceptable lifestyle, and all of which are also experiencing climate-induced price rises. This financial pressure has led to a dent in sales of certified high welfare animal products. While people may not like the idea of intensive animal production, most are not willing to pay more for food produced in conditions where they are reared in a more 'natural' environment or allowed more space. What is more, the food industry has been extremely successful in challenging these 'romanticised' notions of welfare. Through 'customer engagement' activities, it shows how intensive systems optimise animal health and highlights the lower mortality rates of animals reared in intensive systems, compared with their free-range counterparts. The livestock genomics sector has managed to breed docile animals who display less stress in these confined conditions – some breeds even shun open spaces and natural light. Animal products from these systems are now starting to carry 'high welfare' labels, with the blessing of some welfare NGOs. Since most people now live in cities and are digitally connected to a near infinite range of virtual experiences, few but a handful of fringe greenie dissenters and artists value the idea of 'freedom to roam'. As the food industry points out in its touching and just-the-right-side-of-sentimental advertising campaigns: what would your kid prefer? Kicking around in a damp park, or staying home to enjoy an almost infinite range of entertainment on line? Why should animals be different?

Policy makers and livestock watchers note with approval that global demand has largely moved away from meat of ruminant origin and converged upon poultry and aquatic products that lend themselves well to intensive and feed efficient production – although in the case of aquatic products, more resource intensive carnivorous species such as prawns, shrimp and salmon are preferred over mussels and carp. But demand for one ruminant product, milk, continues to rise, prompted by heavy industry marketing that emphasises the role of protein in weight management and of calcium in combatting the bone-related diseases of ageing. Osteoporosis is now a major and expensive concern given the changing age structure of the global population and most people's sedentary and indoor lifestyles.

Zoonotic disease risks are clearly *the* major concern for industry. All foods are fully traceable and information instantly available to consumers via smartphone and other technologies. But outbreaks do occur, prompting outrage and calls for different

production and consumption practices – both for a shift to vegetarianism and for investment in developing artificial meat. In the absence of political, commercial and public will however, and following assurances of ever more stringent traceability and containment policies, things die down again.

The industry has now become very effective at utilising all parts of the animal carcass. Historically, this was achieved through global trade – for example chicken feet were sent from Europe to China – but since about the mid-2020s, tastes almost universally converged upon western dietary patterns, and so this route offers less potential. Instead industry is extracting value in other ways. Less appealing parts continue to be turned into foods such as nuggets and crab sticks. A limited amount is recycled back into animal feed ingredients – but there are tight regulations given the potential for major food safety outbreaks. A more recent development has been the rapid and highly profitable growth of the neutra-pharma-cosmeceuticals industry, which has been boosted vastly by an ageing population still desperate to hang on to its looks and do battle with the diseases of ageing. The food industry makes much of these successes in closing nutrient and resource loops; but NGOs argue that for the most part these new applications do not substitute for existing materials but rather feed new industries that create new demand. To which, of course, industry responds that they are catering to latent demand that would otherwise have to be met in more resource intensive ways.

Most people have now adopted eating patterns high in animal products, sugars and fat, generally in the form of processed foods. About half of the world's population is now overweight or obese. There are fierce debates in the media as to what a 'normal' size actually is, now that most people have a high body mass index (BMI). Fashion models representing mid-range clothing are generally a size 14 although in the haute couture sector they remain thinner than ever. The food industry has now positioned itself as a champion of feminism through its funding of 'fat acceptance' and 'big is beautiful campaigns' aimed at girls who are seen as 'vulnerable' to developing eating disorders.

At the same time, keen to demonstrate commitment to global health, the food industry has made considerable attempts to reformulate foods to lower fat, sugar and energy contents. Poultry meat, low fat dairy foods and aquaculture products are promoted as low calorie proteins, useful in offering satiety and as an aid to weight-loss. Thanks to crop breeding innovations, plant based animal feeds such as oilseed rape and soy now provide long chain fatty acids. Aquatic and terrestrial animal products fed on them are now a source of these nutrients, so easing pressure on global fish stocks. Food carbon footprint labelling is now universal. Using loyalty card data, the industry is 'working with' consumers in helping them adopt healthier, more sustainable lifestyles by suggesting unobtrusive healthier and lower carbon substitutions for the regular foods they buy. Many now offer weekly calorie controlled meal plans, delivering meals to home or workplace and a few are looking at carbon controlled meals too. Free gym membership is also available to customers who subscribe to these schemes or who spend above a certain amount on home deliveries.

The process of urbanisation continues: food production is generally highly concentrated and vertically integrated. Few people now work in farming, except in Sub Saharan Africa; on the other hand the food processing, retailing and catering sectors employ vast numbers of people. There are also graduate and post graduate

opportunities in the precision-oriented agricultural and food innovation sectors. The lucrative and increasingly mainstream market in food-porn is also a significant employer – combining cookery programme with pornography, this form of entertainment is popular with the many people now suffering from various forms of obesity-related sexual dysfunction but who nevertheless maintain a keen theoretical interest in both pursuits.[20]

Not everyone likes this new future. Some NGOs and academics continue to argue for dietary change or for more transformational approaches but they rely for support upon individual philanthropists and charities and reach only a minority of more educated and affluent individuals. On the whole, people are fat, fed and fatalistic. This is just the way things are.

Scenario 2: Architected flesh

Artificial meat has gone mainstream. On offer are not just the burgers and chicken-style nuggets developed in the early years but also products that mimic quality carcass meat, dairy products and fish. Compared with their naturally produced counterparts the manufacture of these products requires less energy, less land and less water and emits fewer GHG emissions. Insect farming has also taken off and insect-derived foods are now available in multiple forms – as components of ready-to-go stir-fry mixes, ground up and used to boost the protein content of energy bars, in the form of burgers and patties, or presented in novel and unexpected ways in high end restaurants. However problems of allergenicity mean that there are limits to sectoral growth. For those vegans and vegetarians uncomfortable with the idea of eating flesh, even where there is no connection with living beings, other forms of novel protein derived from plants and algae are available.

This food revolution has been led by the food industry and, at least initially, *despite* the policy community. In the 2020s, climatic and environmental change were disrupting the food industry supply chains, and a series of major zoonotic outbreaks caused not just widespread fatalities, but more worryingly, a haemorrhaging of public trust, leading to severe profit losses. People began to seek out alternative and more local food manufacturers and retailers, trusting these shorter supply chains to provide 'authenticity.' The situation was compounded by NGO campaigning on the links between animal production and climate change and growing animal welfare concerns among increasingly educated consumers. This combination of threats risked sinking the food industry. They began seriously to rethink their reliance on intensive animal systems.

Naturally, one option they considered was a mass marketing effort to encourage widespread shifts to vegetarianism, 'less and better' meat consumption, flexitarianism and other variants. But despite NGO activity, the efforts of celebrity converts and periodic flurries of media hype, demand for meat remained high. The alternative food movement fared no better – the initial panic over, people's interest in 'alternative' food waned because of high costs and the monotonous lack of variety.

The question that then presented itself was this: how could the major companies reorient their supply chains to be resilient to environmental, food safety and other

20 The variant for the vegan LGBT community is *QUORN*

shocks – while still keeping their customers? Since, without policy backing, mass vegetarianism was out of the equation, the only alternative was to give people the foods they seemed to want, in ways less dependent on the vagaries of climate and the shrinking natural resource base. Technology had to deliver the free lunch. They started looking around.

At around this time, a number of wealthy and highly influential philanthropists entered the food scene. Some started to fund pro-vegan campaigns; others, sceptical about the prospects of a widespread conversion to plant-based eating, turned their attention elsewhere. Having read about early experiments in artificial meat, they made major endowments to the one or two research labs that were already working on this technology. Soon, the labs started to deliver – first passable hamburgers and sausages, and then, more ambitiously, quality meat cuts, such as steaks and filets.

The food industry, particularly the big commodity grain producers and traders, took note. They too began to invest, first cautiously and then quite substantially, in this promising emerging market.

This all helped, but the really critical breakthrough for the in-vitro sector came when the Chinese government entered the arena. After watching cautiously from the sidelines it finally decided that in-vitro technology offered the potential to address food safety, food security, self-sufficiency and environmental problems simultaneously and in an integrated way – while also positioning China as a major global supplier not just of in-vitro meat but also of the underpinning scientific and technical knowledge. In 2022 the Chinese government published a dedicated Five Year Plan for the in-vitro sector and allocated massive funds to technological development and associated training.

Given China's historically disastrous food safety record there was strong scepticism – indeed alarm – within and outside China**.** NGOs issued dire warnings of antibiotic dependence, adulteration and other unknown and as yet unknowable harms to health and the environment. Right at the outset, however, the Chinese government made it clear that it would prioritise R&D on technologies that did not depend on antibiotics. Ahead of European research labs, they successfully developed an algae-derived nutrient base for cell culture development, which, by ensuring a totally vegetarian product, opened up the technology not just to vegetarian but also to Islamic, Hindu, and Jewish markets. In an unprecedented move, China convened a High Level Panel of international, and internationally respected food safety experts to monitor and verify the safety of the entire process and its output. These moves were instrumental in building consumer trust within China and internationally.

These developments were watched closely by the other BRIC economies. Brazil was naturally hostile, at least at first, given the threat to their livestock sector, and it launched a massive and subtly racist campaign to promote 'real' beef. However, more far sighted Brazilian policy makers, looking elsewhere, realised money could be made and jobs created from the rising demand for nature tourism; the more people urbanised and the more dissociated they were from the natural environment, the more they valued nature as a leisure outlet. Brazil's rainforests and cerrados offered massive opportunities for tourism, and a burgeoning private market in ecosystem payment services, which also brought in revenue. This combination of niche high value beef production and both mainstream and high-end nature tourism started to compensate for losses in livestock revenue.

India's response was even more mixed. Rising Hindu nationalism in the 2020s had prompted a strong shift away from the 'non-Hindu' or lower caste practice of meat eating. This was a disaster for India's enormous beef export sector – byproducts of the dairy industry – who now faced huge revenue losses and the task of dealing with millions of underfed, commercially useless male cattle.

But then a group of scientists from the Indian Institute of Technology discovered a method of producing artificial milk. India's thirsty masses could be satisfied with this new product, while a token amount of 'real' dairy production could continue for symbolic and religious reasons. Elite cows would be reared to the highest welfare standard as befitted their sacred status and their milk (much more expensive than the artificial variant) would be reserved for religious occasions. Brahmins could oversee and approve the production of both artificial and ceremonial real milk, guaranteeing the purity of both.

This technological breakthrough led to vigorous disputes among Hindu fundamentalists, NGOs and intellectuals – and to considerable beef industry opposition. Unlikely convergences of interest arose. For some devotees, artificial milk was inherently impure; but others felt that a centralised artificial milk system with oversight by Brahmins would be the optimal way of ensuring its ritual purity.

The NGO community too was split. Environmental campaigners, recognising the high environmental costs of animal production and the need to reduce GHGs, and mindful of animal welfare concerns, were supportive. But the poverty and food justice movement were emphatically not; for them in-vitro meat production was yet another incarnation – as with GM crops – of big business's attempt to meddle with nature and destroy peasant livelihoods.

Interestingly, the hostile beef sector found unexpected support not just from the food justice NGOs but from prominent left wing intellectuals who condemned vegetarianism as symbolic of the intolerant casteist religiosity now rife in India. Meat eating for these dissenters stood for tolerance, modernity and intellectual freedom. The outcome of this factionism – in combination with persistent corruption – was, and continues to be, chaos. Indian in-vitro meat labs took their technology to China, who embraced them with open arms.

Concerns about naturalness were not confined to India. Indeed the issue split the environmental and animal welfare/rights movement, consequently undermining their influence. Today, opponents continue to advocate a return to more 'integrated' agrarian solutions based on mixed-crop livestock rearing and a greater emphasis on plant based eating. Single issue organisations however – particularly vegan and nature protection groups – are more enthusiastic.

The industry was of course acutely aware of the 'naturalness' issue and, anxious to avoid a GM-style PR disaster, it developed a careful and segmented approach. In Western countries, it decided to go for a gastronomic trickle-down approach, by concentrating initially on influencing the 'top' end of the market. In vitro manufacturers, manufacturers, retailers and the catering sector worked collaboratively to woo celebrity chefs, trend setters and social innovators; they presented in vitro meat

(and insects) as experimental, post-post futurist[21] and cutting edge – the next frontier in molecular gastronomy. Via carefully orchestrated viral marketing campaigns, the industry also positioned the shift to artificial meat as edgy and hip – part of a progressive movement experimenting seriously with transhumanism and the use of digital technologies to extend and enhance human experience. This approach worked – both with the young but also with an ageing population desperate to maintain its self-image of cultural and social credibility.

Artificial meat was also marketed at a more collective level as the new egalitarianism – access by all to the fruits of prosperity and scientific endeavour. Artificial meat made the best cheap and affordable for all. By implication, concerns about unnaturalness were elitist and anti-poor.

Today, in 2035, artificial meat is now indistinguishable from the real thing. What is more, it enjoys a far more favourable nutritional profile – health, environment and affordability combined, in convenient nuggets, burgers or choice cuts of prime muscle. That said, since demand for processed carbohydrates continues to rise, and physical activity levels to fall, the obesity problem remains a persistent problem.

The market for 'staple' artificial meat is now booming both in the developed west and across the world. Artificial milk has been a noted success in Asia since it is suitable for the lactose intolerant. Recently it has even been possible to produce artificial infant milk formula. Although uptake was initially poor (the middle class fixation with 'natural foods' for their babies took a while to fade), it was soon realised that the nutritional profile of 'baby-boffin' milk was vastly preferable to traditional cow-based baby milk. Encouraging early-stage lab trials suggest that more recent formulations even have the edge over breast milk too, by helping boost cognitive development.

While most artificial and novel proteins are manufactured by large and often multinational companies (many of them originating in China), now that the initial technology has been copied and developed, smaller scale 'artisanal' micro-production is also booming. These supply niche products to consumers, mirroring the dynamics of the micro-brewing renaissance of the early 21st century. While many of these micro-companies have been bought by the bigger players, they are careful to maintain their craft image and continue to appeal to a more fashionable, affluent customer base.

Livestock farmers and rural NGOs have been the most vociferous opponents of artificial meat. But the new jobs created in bioenergy production and in land-based geoengineering projects, nature conservation and in rural tourism, have taken the wind out of their sails. There is also a niche but profitable pedigree livestock sector marketing high value meat to affluent consumers who persist in their prejudice against artificial meat.

As the technology develops it has inevitably started to raise new ethical and regulatory headaches. There are well founded rumours that in less regulated parts of the world, labs are now producing meat that resembles flesh from endangered species and even human flesh. There are murmurings of in-vitro cannibalism, of emerging witchcraft rituals involving in-vitro child flesh and even the development of in vitro meat capable, in some sense, of feeling pain – catering to those with sadist propensities. In-vitro human organs grown for use in surgery and medical applications go missing.

21 Marinetti, F.T. (1989) *The Futurist Cookbook*, San Francisco.

Scenario 3: Livestock on leftovers

This is an agrarian world born of fears and ideals.

Food production and distribution has shifted towards smaller scale, local systems of production. The focus is on agroecological thinking and on chemical-free growing practices that deliver multiple outputs from a given area of land. A sizeable minority of people are exiting the cities and returning to farming and small-scale food provisioning.

In this new agrarian renaissance, farm animals play a central role. Livestock are reared on 'ecological leftovers'[22] – they are recyclers of resources, providers of soil fertility, managers of landscapes, and seen as crucial in helping store carbon in soils. Farmed animals are the literal embodiment of our connection with the planet that sustains us, and venerated as such. In this world, to eat meat is to witness an act of sacred transubstantiation, the turning of nothing into something. Livestock and crop production have been reintegrated, reversing the early twenty-first century trend towards specialisation. In the case of aquatic systems, fish farms are sited on degraded lands and in brackish waters where other forms of agricultural production would not be viable and there has been a revival of polycultural practices, such as integrated duck-fish-rice fishing in South East Asia.

"Efficiency" is a dirty word, connoting reductionist scientific thinking. The emphasis instead is on optimising resource *effectiveness* and cyclicality – closing nutrient cycles, turning waste into inputs, and avoiding use of prime arable land.

What happened? The early decades of the twenty first century witnessed a series of major and very damaging breaches of food safety in the intensive livestock sector, causing major fatalities, economic losses and a total breakdown of public trust. Of equal significance, dwindling and erratic yields, water shortages and transport meltdowns caused by increasingly erratic weather led to yo-yoing food prices and fears of mass hunger. The public started to panic. And to riot.

Action was clearly required. But it soon became obvious that the food industry was unable or unwilling to rise to the challenge. And, overwhelmed by the structural nature of the problem, many mainstream political parties froze in the headlights. In this interim situation of chaos a number of things happened, sometimes all at once, sometimes in varying combinations cross the world.

In some countries NGOs shot rapidly to prominence; their Cassandric predictions now vindicated, they were finally being taken seriously. Prominent environmental activists were rush-elected into Parliament and emergency legislation enacted. The use of arable grains in animal feed was banned since it snatched food from the mouths of poor people. Irrigation water use was confined to food crops. Stringent limits were place on the use of synthetic fertilisers and pesticides. Land devoted to biofuel production was reappropriated for food growing. Stringent laws were brought in to halt deforestation. Achieving self-sufficiency became a policy priority and many countries banned their grain exports.

22 Garnett T. (2009). Livestock-related greenhouse gas emissions: impacts and options for policy makers *Environmental Science & Policy*, Volume 12, Issue 4, pp. 491–503.

Elsewhere, particularly in Eastern Europe and the Balkan regions, public panic and chaos provided fruitful opportunities for the far right whose influence swelled on a populist agenda of anti- immigration and closed-border localism. Reminding their voter base of the prescience of fascist *Blut und Boden* philosophies, they roused people with their romantic visions of back-to-the-land living. 'Indigenous' foods good – 'exotic,' foreign imports bad.

Elsewhere, communitarian, libertarian and last-days apocalyptic thinking abounded; homesteading-and-hunting communities proliferated not just in the US but in other land-abundant parts of the world, from Scotland to the Australian outback. There was a rise too in wilderness vigilantism, with particular clashes between groups set up to 'protect' the wilds from human intrusion and those who saw hunting as a mystical act of union with nature, and an assertion of their human rights.

The situation today is thus one of political fragmentation very loosely united by certain common ideologies. Agronomic research continues, but most of it focuses on learning from the wisdom of 'indigenous' and 'peasant' knowledge. Most countries have banned biotechnological research and funding for basic and blue skies research is in free-fall. Indeed science and technology are increasingly viewed with suspicion. People reject its 'reductionism' and instead embrace holism, authentic religious experience, from Eastern mysticism to Christian fundamentalism – and alternative medicine. There has been a worrying re-emergence of illnesses once thought to be nailed, such as measles and TB, but many explain this as an essential part of transitional 'detox' process and the natural order of things, a way of controlling the human population.

Most large, national and transnational food enterprises have either collapsed, although the more quick witted have deliberately fragmented, evolving into confederations of smaller scale, semi autonomous and more localised enterprises serving local communities.

As for food, the paleo-diet is in. Grassfed beef meat is the giver of protein, good fats and essential micronutrients. Unrefined carbohydrates, by contrast, are Satan Insucrinate.

The problem is that levels of meat output are not enough to keep pace with the ongoing growth in demand for animal products, particularly now that birth rates have started to rise again, a consequence of women – or men on their behalf – eschewing the contraceptive pill, with its 'harmful' hormones. Ecological leftovers and grasslands alone cannot sustain rising demand for meat – particularly grassfed beef and lamb. Food prices start to rise further. Even in rich countries animal products start to become unaffordable for low income consumers. Injunctions to eat 'less and better' meat and animal products fall on deaf ears. Meat is good: people may want 'better'- but they also want 'more.'

The ever increasing price of meat, milk and food in general creates major problems. Livestock farmers start to overstock to increase output but this leads to land degradation, sick animals and reduced productivity. High food prices trigger illegal deforestation to create land for livestock production, or for forms of silvo-pasture that undermine rather than support biological diversity. Agricultural emissions, mostly from livestock continue to rise. Disease outbreaks become more frequent as people cut corners, although given the localised nature of production, the effects tend to be

geographically contained. Marine fish stocks are depleted. Such is the demand for meat from those who can afford to pay, that arable land is being converted to pasture.

Poor people go hungry.

There is a backlash. Led by the food justice movement and the intellectual left, people start to march against the 'small is beautiful' ideology. They demand the revival of large scale, collectivised, highly intensive confined feeding operations, producing 'meat for the people.' Environmentalism becomes a class issue – green activists are dubbed fascist elitists who put nature over people. In an attempt to address these growing signs of unrest, those governments who are still coherent enough to do so, build large intensive farms providing affordable and sometimes subsidised meat. Once again, arable grains start to be fed to livestock. The food industry senses an opportunity and starts to vertically integrate, investing once again in large scale intensive livestock production. Meat consumption continues to rise. GHG emissions continue to grow.

Scenario 4: Fruits of the earth

Governments have finally realised that that environmental sustainability matters. Following the signing of a landmark and far-reaching intergovernmental environmental agreement, committing all nations to robust action on climate change, to halting deforestation and to protecting the oceans, stringent GHG mitigation and other targets have been implemented, based on the principles of contraction and convergence. It is now understood that all socio-economic activities, including those that are food related, need to contribute. National consumption-based emission accounts are now published alongside traditional production emission inventories, and there are ongoing debates about how responsibility for embedded emissions in traded products should be assigned.

This overarching climate and environment framework has finally prompted serious thinking at national and transnational levels about how best to align economic growth and environmental sustainability. Countries have adopted different approaches, based on their levels of development and their specific ideologies.

The implications for the food and agriculture sectors have been profound. Most governments have now drawn up comprehensive agri-food plans or visions. These, intended to coordinate activity across government departments and provide a steer to industry, are underpinned by policy measures that differ from country to country. Mindful of the need to continue supporting the farming sector, governments, sometimes working with private corporations, have inevitably invested in production-side solutions, drawing upon organic agriculture and biotechnology alike. However they realise that technological solutions will not save the day and that consumption patterns also need to shift if the food system is to reduce its environmental impacts and adapt to climate change.

Many governments have started to experiment with schemes such as payments for ecosystem services, and have put in place measures targeted at livestock, ranging from livestock taxes, to incentives for farmers to shift from animal rearing into other farming or non-farming activities. There has been major investment in fruit, vegetable, grain and legume production. Early experiments with hydroponics, vertical farms

and other space saving approaches have now literally started to bear fruit and now operate at multiple scales. Foods are grown locally or traded internationally based on detailed modelling of what is optimal; these models draw upon concepts such as 'ecologies of scale' 'ecological comparative advantage' and 'Biophysically Optimal Levels of Locality Avoiding Leakage And Rebounds (BOLLALAR). Beyond the farm stage, there have been huge investments in energy efficiency, renewable technologies, and in novel storage preservation techniques. There has also been strategic support for the development of complex modelling programmes that optimise between different priorities: for example that figure out the best balance, for manufacturers between accepting variability of supply so as to reduce waste versus the need for some product consistency and for providing consumers with accurate nutritional and environmental information.

Policy approaches targeted directly at the consumer have been similarly diverse. At first, many governments were wary of intervening directly in people's diets and thought they could rely on public information campaigns and labelling alone. But they soon recognised these had little effect and that more robust measures were desperately needed, particularly since obesity and related diseases were now placing massive strains on health services, just as they were also having to deal with expensive age-related diseases such as dementia and osteoporosis. The oft repeated NGO mantra – there are nutrition-environment win-wins to be had – began to make sense.

Governments started to look at how to promote eating patterns that were both healthy and sustainable. Some, strongly influenced by forceful NGO campaigns, went for simple or single issue approaches such as taxes and subsidies. These often had unhelpful consequences – taxes on carbon alone simply increased demand, among the rich and educated, for lower carbon but more water-hungry foods while the poor bought more carbon-efficient, sugary foods. One or two governments chose to target just meat and fish without considering food patterns as a whole. The effects backfired – poor people shifted towards cheap, often less healthy cuts of meat or cut back on other foods to ring-fence their meat consumption, while the rich filled their shopping trolleys with high impact hothoused salads and airfreighted berries. A few governments imposed measures both at the production and the consumption stages, so doubly penalising livestock farmers -prompting outrage and the need for embarrassing policy retractions. Others still introduced contradictory measures that simply cancelled one another out. These early failures caused *Daily Mail* style outrage and nearly derailed the whole process. But not quite.

One or two forward thinking governments recognised straight away the need to invest properly in social science research, so they could better understand what combination of policies could most effectively shift eating practices, while also ensuring coherence between production and consumption policies. Other governments started to follow suit. In low and middle income countries, the notion of environmental 'leapfrogging' – the possibility that developing countries might be able to skip some of the polluting and energy intensive stages of development – was extended to include ideas about social and health 'leapfrogging ' – jumping over Western style patterns and alighting instead upon a more sustainable pathway.

Industry, fearing catastrophic profit losses, was initially hostile. But once the signals from government became clearer and more consistent – and recognising that policies had now levelled the proverbial playing field – they responded with innovations

ranging from product reformulations to repricing strategies and subtle choice editing strategies. They also worked closely with food developers, restaurateurs, and celebrity chefs to create and promote healthier, lighter food, inspired by diverse global cuisines.

Today in 2035, big retailers are competing with one another to provide 'omnivalue' to their customers – baskets of goods that deliver the best nutrition for the lowest environmental cost. Restaurants now offer various forms of nutritionally and environmentally based 'prix fixe' menus. Public catering specifications reflect the latest understanding on what constitutes 'healthy and sustainable eating patterns;' uptake of school dinners is now almost universal and there has also been a massive expansion of public sector canteen provision. An interesting development in the handful of countries where citizens are subjected to personal carbon rationing has been the growth in public-private financed restaurants that are open for breakfast, lunch and dinner. Mass catering makes possible 'ecologies of scale' and people realise that they can enjoy a better meal for their carbon buck in these restaurants than they can at home.

The countryside looks very different now. Very little land is now used for animal rearing. There is, however, much debate about the 'optimum' level of animal production and different countries have adopted different strategies based on their geographies, climates, cultures and the nutritional needs of their populations. But disputes about the future of land use continue to abound. It is now received wisdom that landscapes should deliver on multiple objectives, including the provision of nutritious food, textiles, bioenergy, carbon sequestration and biodiversity protection – but arguments about the spatial resolution at which this should be achieved, and the role of large versus small-scale production remain unresolved.

Some very limited livestock farming continues. In some countries allowable livestock production is set at the level required to produce sufficient manure to condition soils and contribute usefully to soil fertilisation. Countries with relatively more abundant land have focused heavily on legumes, crop rotations and silvo-pasture; those with more limited resources make greater use of synthetic fertilisers, nitrogen fixing GM crops and composts and digestates from anaerobic digestors. With manure surpluses are no longer a problem and fears of deficits, there are ongoing discussions about how best to address nutrient deficiencies in some soils.

For countries with extensive rough pastures, limited livestock grazing continues, but many argue that this land would be better used for other purposes, including rewilding. Good quality pasture land is now often used for bioenergy. Some object, arguing that a better use would be for livestock rearing, particularly since bioenergy yields are low. Others maintain that extensive bioenergy production contributes to a multifunctional landscape and can provide important wildlife habitats.

Most controversial still is the now very significant use of good quality arable land for bioenergy production. This has followed intensive and successful lobbying by energy companies, which has started to fund the vegan movement, sensing important economic advantages if land previously used to produce animal feed could be converted to bioenergy production. The bioenergy issue periodically causes outrage and exacerbates schisms within the environmental community.

In coastal and water-abundant regions, a small aquaculture industry produces, low-input shellfish and, more significantly, seaweeds and algae both for direct

consumption, and as protein and nutrient-rich bulking agents ingredients in processed foods and meat-substitutes.

The upshot of all this is that early twenty first century eating trends have stabilised and are going into reverse. People in rich countries have drastically cut back on animal foods and their diets now largely consist of legumes, meat analogue products, fruits and vegetables. The policy-enshrined principle of contraction and convergence has enabled poor people in developing countries to increase their meat and dairy intakes to now lower rich-country levels.

In some regions and for people this shift has been achieved through a total dietary reinvention towards a new 'modern' lighter way of eating; others have gone back to their traditional more plant based food cultures. In some countries and contexts, diets still look 'meaty' but are based on plant-derived meat analogues. More people define themselves as vegans and vegetarians than ever before, but they remain a minority since most people still eat animal products about once a week.

The health consequences have been profound. The prevalence of overweight, obesity and associated chronic diseases has levelled off and is in decline. Acute problems of hunger have also been substantially reduced. But micronutrient deficiencies persist. Some of the simpler problems have been addressed through Government investment in crop biofortification, despite vigorous opposition. For example genetically modified rapeseed and other vegetable oils now provide long chain omega 3 fatty acids. Vitamin A deficiencies have also been successfully tackled. Many governments distribute free vitamin supplements or offer slow-release vitamin vaccinations.

Despite these successes, nutrient deficiencies remain and have worsened in some areas. Single-nutrient fortification approaches do provide some of the less understood trace nutrients, while not everyone eats a wide enough range of foods to compensate for low meat and dairy intakes, notwithstanding Government's efforts to promote 'diverse' diets, 'rainbow eating' and so forth. The livestock industry points out that allowing some increase would address a great many nutritional problems in a holistic and integrative way, and urge for the relaxation of 'biased' anti livestock policies. But the environmental costs are deemed prohibitive and, besides, anti-meat thinking in now a dominant cultural meme.

While there are nutritional problems, in aggregate population health is improving since people are now both nutritionally and environmentally literate. Nutritional and environmental education is now a core element in the school curriculum, starting in the first year of schooling. University courses also include compulsory modules on various aspects of health and sustainability. Food from all outlets – whether a supermarket or a takeaway stall – are now fully labelled with appropriate information, and there are innumerable apps enabling people to optimise their nutritional intakes per unit of environmental impact, and vice versa. Cookery shows are as popular as ever but their focus now is on health and sustainability.

More recently, the environmental and nutritional spotlight has started to embrace not just meat but confectionary and beverages too – tea, coffee, chocolate, alcohol. Environment and health activists point out that these are unnecessary foods. They are not only nutritionally valueless and in some cases harmful to health, but occupy large land areas – land that could be used for rewilding, flood protection or other purposes.

In any case, coffee and cocoa yields have been badly hit by climate change. The livestock tries to capitalise on this growing rhetoric, pointing out that animal rearing offers a better nutritional bang for environmental buck than booze, caffeine and sweets – to which NGOs respond that it is not a case of 'either or' but 'both and.' We cannot, they assert, afford either meat or unnecessary indulgences. Dietary guidelines once again start to be reassessed. There is a proliferation of 'planet before parties' campaigning.

Unnecessary and energy using forms of food preparation such as toast-making now start to be challenged. Life cycle assessment specialists now weigh up the energy saving benefits of eating food raw against the nutritional costs of lower digestibility in order to seek out the consumption optimum. The oven has become the new outdoor patio heater.

The policy focus on food, health and sustainability is of course just part of a larger set of government actions to address climate change. Few people own cars; the bicycle dominates urban transport. Home energy use has fallen sharply, thanks to substantial investment in renewables and energy efficiency. Policy action has gone hand in hand with a very fundamental shift in public attitudes favouring public goods and collective responsibilities. In this, the new frugalist era, displays of wealth, excess and consumption are frowned upon. People buy less and make and mend more. Voluntary simplicity is now, some commentators suggest, a competitive sport, with celebrities vying for top position. Websites offering tips for slimming and eco-slimming are multitudinous, and the gaming industry has also cashed in on the trend, providing a range of educational and 'serious games' to incentivise change. Local *Consumers Anonymous* groups have been formed to support those who struggle to curb their wasteful habits.

One side effect, unforeseen by public health and environmental campaigners has been a very substantial rise in eating disorders, including anorexia and bulimia nervosa but also new manifestations of righteousness or guilt-driven dietary obsessions variously termed orthorexia,[23] ecorexia, and planet purging. Food, for many men as well as women, is now an overwhelming obsession. Even very young children now worry about being fat or eco-guzzlers. Despite the official public stand that fatness is just a medical condition, in the public mind fat people are morally irresponsible, placing a strain on public health services and eating more than their fair share of planetary space. The growth in eating disorders is starting to place a strong strain on health services. Psychologists warn of the creativity losses likely to result from this obsession with food, and the attendant economic costs.

Moreover, with health and sustainability of paramount public importance, government funds have inevitably had to be diverted from other areas. All science now has to meet strong 'impact' criteria, with priority given to health and sustainability oriented research; theoretical science and studies such as literature, drama and archaeology, that offer no immediately obvious practical benefit receive much less attention and support. Students who want to study arts subjects at university are strongly discouraged and in any cases university arts departments are closing down through lack of funding. Public arts funding has severely suffered too, partly because of there is only so much money to go round and partly because the embedded emissions

23 https://www.nationaleatingdisorders.org/orthorexia-nervosa

associated with theatrical, music and dance performances are fairly substantial; their purpose, in a carbon constrained world, is open to question. That said, budget is still available for creative projects which promote sustainability messages or that help foster public understanding. The school curriculum has yet again had an overhaul, to prioritise subjects that promote 'the public good.'

On the whole, people go to bed early.

There are the beginnings of a counter current. An eclectic group of 'cultural activists' starts to form, encompassing artists, musicians, writers, the odd celebrity and intellectuals on both the far right and far left. This loose collective defines itself in opposition to what it sees as the politically correct, joyless and individuality-repressing mainstream. Influential metropolitan centres – London, Beijing, Mumbai – experience a rise in 'backlash dining' – a coming together of the beautiful and the damned in semi-underground locations to gorge themselves on black-market meat and processed foods, to smoke, drink and light fires. Variously self-defining as the New Hedonists, the Glory Bingers, or more simply still, the Burners, they see themselves as children of the early civil rights and cultural revolutionary movements of the 1960s, as Blakean visionaries and Nietzschian loners crying out in a wilderness of rectitudinous sheep. They embrace not just meat but also fatness, speed, and the extravagant, deliberately reckless squandering of fossil fuels (*"The road of excess leads to the palace of wisdom")*[24] as a political act – an attempt to disrupt the passive and 'emasculating' status quo. Their message is of liberation.

Their influence grows.

24 Blake W, *The Marriage of Heaven and Hell.*

3. So what?

As the science fiction writer William Gibson once (apparently) remarked, 'the future is already with us – it's just unevenly distributed.'

The visions sketched out above are just that. All are improbable in their singleness – reality is never just one thing – and of course the future is only predictable in its unpredictability. That said, these scenarios do have something true to say about *contemporary* society; they delineate the generally implicit, unstated value clashes that riddle debates about food today.

These clashes are less about the numbers and facts and much more about our gut feelings: feelings about our place in the world; about the potential and limitations of technological innovation on the one hand; the mutability or otherwise of human desires on the other; and the extent to which we can or should shape the environment to suit our requirements or adapt society to fit within the limits that nature affords us.

These scenarios are mirrors; they magnify and make manifest the fears, hopes, beliefs and ideologies that underpin discussions today and whose unstated nature leads to misunderstanding and hostility. Of course they are also caricatures of particular ideologies. Most people are more nuanced in their opinions, and rarely slot neatly into one camp or another. Interest groups may well straddle different visions; equally opposing groups may end up advocating the same vision for different reasons. For example, proponents of an intensive and efficient livestock future may see artificial meat as a logical consequence of this vision, and thus complementary. Others, equally forceful in their promotion of intensive production view artificial meat as a threat and prefer to 'supplement' intensive farming with a limited level of niche, high-profit margin grassfed production, along the lines of the ecological leftovers approach.

Environmentalists who advocate a 'fruits of the earth' vision may also accept a role for livestock reared on the principle of 'ecological leftovers;' this is in keeping with an aesthetic that places strong value on us 'connecting' to the natural world. On the other hand, others in the same plant based camp may hold quite opposing views. For vegan groups, eating animals is damaging to the planet and bad for our health – but much more importantly, it is wrong. And so rearing animals on ecological leftovers still crosses that moral boundary. In contrast with their environmental bedfellows for whom artificial meat is another manifestation of us 'meddling with nature,' for many vegans artificial meat offers a legitimate and bloodless way of satisfying our desires.

People may also endorse scenarios with varying levels of conviction. For example, advocates of ''calibrated carnivory' may genuinely believe that this offers benefits

for growth, sustainability and hunger reduction. Other advocates may be more ambivalent, theoretically preferring an alternative scenario but not optimistic about the prospects for global vegetarianism. An intensive chicken future is the pragmatic 'least bad' option – preferable to, say, a world of unbridled, forest-clearing cattle expansion. These reluctant proponents may have more in common with advocates of plant based eating than might appear – their differences are more of disposition than ideology.

Of course, the obvious question to ask is 'so what?'

At one obvious practical level, there may be merit in quantifying these scenarios.[25] It would be helpful to know how much meat one might be able to obtain if livestock were confined to "ecological leftovers" or how much land one could theoretically save given a breakthrough in in-vitro meat technology, or how land might best be used if one wished to obtain a sufficiently diverse range of nutrients under a plants-only scenario. Having undertaken this kind of analysis one would at least arrive at a theoretical understanding of how much, and what kind of land would be used, what landscapes might look like, what resources used, what volume of GHGs emitted and how much and what kind of food could be produced.

However while modelling exercises are helpful, it is equally important to look more closely at the often implicit assumptions that drive these scenarios. Each one is predicated on a host of assumptions, about, for example, the likely pace of technological innovation, the capacity of policy makers to act, or the malleability of human preferences and behaviours. These in turn are founded upon assumptions about how the world works, what is inevitable, what can be changed, what should be changed, what is ethically non-negotiable and what at heart, 'good' really looks like.

This is what is missing from the current debate about food in general, and livestock in particular. And this is why nothing is done. We have a cacophony of visions today, driving different kinds of advocacy, using different numbers, selected on the basis of different underpinning and unarticulated values. The consequences are miscommunication and inaction. Rather than fixating on the 'facts' there is a need to understand the emotional and ideological context within which the facts are understood. We need to explore and take seriously the principles and beliefs that underpin people's vision of the future, for many reasons.

First if we know where we and other people are coming from, ideologically speaking, we can gain more complete understanding of the basis upon which we and our 'opponents' select, choose or reject evidence. This helps us clarify whether we disagree about the research itself, or the boundaries or the limitations of the research, or the importance of the research finding relative to other insights or issues. In other words, we will know if we disagree about whether the fact in question is the truth, or the extent to which it is whole truth, and nothing but the truth – or how important that particular truth is relevant to all the other truths out there.

25 Röös E., Bajželj B., Patel M., Little D. and Garnett T. (submitted). Protein futures beyond sustainable intensification: potential land use and climate impacts of different consumption scenarios in Western Europe, *Regional Environmental Change*.

Second, people are complicated, inconsistent and contradictory. Different people may advocate the same thing on the basis of different values, or different things on the basis of similar values, or advocate one approach on Tuesdays in a certain context and a different one on Wednesdays in another. These inconsistencies are chinks in the rigid walls of ideology-driven discourse and potentially provide a way for us to see through to other people's perspective.

And finally, closer exploration of our gut feelings through the medium of storytelling – which is all that scenarios are – might reveal some unwanted surprises. Do we really want what we think we want? As they say, careful what you wish for.

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