Julian Cribb and Associates

Global Food Security: defusing the timebombs

Our Hungry Future campaign, May 21, 2013

Julian Cribb FTSE

Abstract: Feeding 10 billion people sustainably through the latter half of the 21st century presents the greatest challenge humanity – and the tropics - have ever faced. While food demand will double by 2060, critical scarcities and instabilities are emerging in almost all the key resources required to satisfy it. There is a cluster of 'ticking timebombs' with far-reaching strategic significance that challenge us to rethink food itself, how we produce it, and how to create diets and foods for the future that are safe, healthy, nutritious, use fewer resources and tread less heavily on the planet.

Slide 2: population

Since 2008 there have been three world food crises, and the UN has warned a fourth is possible this year.

Last night 216,000 more people sat down to dinner than did the day before.[i]

While birth rates are slowing, the human population continues to expand, as fewer children die and many people live longer. On present trends it will reach 10, maybe 11, billion people in the 2060s.

The population of the tropics will be 5, rising to 6 billion – double what it is today.[ii]

At the same time, the demand for protein of nations like China, India and Brazil is soaring.

Within half a century these factors will double global food demand.

Then we will require around 600 *quadrillion* calories every single day to feed everyone. And we will have to keep on producing them for over half a century, until the women of the world can bring the population down to a more sustainable figure, perhaps 4 or 5 billion.

The central issue in the human destiny in the mid-21st century will be whether or not we can achieve *and sustain* such a mighty harvest.

Slide 3: wicked problem

Some people see this as a simple problem: just repeat the technical miracles of the Green Revolution and redouble agricultural production.

However, worldwide, our food systems now face *critical* constraints.

There are timebombs ticking in each of the major resources needed to secure our food supply – in water, land, nutrients, energy, technology, skills, fish, finance and climate stability.

By timebombs I mean what scientists call tipping points, where the food system shifts from one state to another, far more perilous, often without much warning.

These have far-reaching geopolitical and geo-strategic consequences, affecting all nations and all people, particularly in the tropics.

In some situations, agriculture itself may prove unsustainable.

Food has become a *wicked* problem, requiring complex solution at the global level and by the whole human species.

Slide 4: water 1

Take water. Today the average person uses 1240 tonnes of water a year. In a lifetime each of us will use enough fresh water to float the largest aircraft carrier on Earth.

Worldwide, groundwater is presently being extracted at a rate of 4000 cubic kilometres a year – so massive is the mining of water it actually contributes 13% to sea level rise!

The most dangerous ticking time-bombs for groundwater are in northern China (which feeds 400m), the northern Indo-Gangetic region (which feeds 1.3bn) and the Midwestern United States, all of which are forecast to exhaust key resources in 15-20 years.[iii]

Important food-producing regions such as North Africa, the Middle East, sub-Saharan Africa and central Asia feeding another 360m also face critical water scarcity.

All of the world's major grain bowls have suffered major climate impacts in recent years, and governments are slowly beginning to realise grain yields are at real risk.

In the tropics the opposite problem prevails, with destructive storms and flooding increasingly imperilling food security in South and Southeast Asia, especially, but also parts of Africa, Central America and the Pacific. Major food growing regions such as the Ganges, Mekong, Irrawaddy and Nile deltas face rising sea levels and salinisation.

There have been notable declines in snowpack on high mountain ranges, and in inflows to lakes, rivers and aquifers in dry lands.[iv] Vast waterbodies like Lake Chad, which feeds 40 million, have all but vanished in the past 25 years.

Slide 5: water 2

The International Water Management Institute warns us that world food production faces critical water scarcity as early as the 2030s.[v]

This is especially the case in Asia, where seven countries are presently withdrawing water at unsustainable rates [vi], and water scarcity is emerging as a major threat to economic growth as well as geopolitical stability.

In particular, IWMI warns, tropical coasts and delta regions face dramatic food impacts from drought, flooding and sea level rise [vii] along with the displacement of 52 million people. [viii]

Slide 6: water 3

Water is one of the largest food time-bombs – and is primed to explode within 1-2 decades.

A sign of this are the rising tensions worldwide between farmers and other users, notably the gas, oil and minerals sectors[ix] who are mining groundwater that may be needed for future food and drinking uses.[x] The energy sector alone is predicted to double its demand for water by 2035. [xi]

By the 2050s the cities will be home to 7-8 billion. Their voracious demand for water will double to around 2400 cu kms a year.[xii]

To feed this demand, unless they desalinate or recycle, cities and energy corporations could steal up to half of the world's supply of farm water.

The world's irrigation farmers may thus be asked to double food production with less than half of the water they currently use to feed us all.

Slide 7: soil

Land loss and soil degradation represents a major physical threat to the human future.

It is estimated that human activity causes the loss of 75-100 billion tonnes of topsoil a year[xiii]. An FAO satellite study found we have been losing about 1 per cent of our farm land every year since 1990.[xiv]

Put bluntly, every meal you eat costs ten kilos of topsoil.

Despite appearing plentiful, soil is finite. Its formation takes thousands, even millions of years.

Soil erosion in the tropics is worst of all, especially in croplands and on hill slopes, where it can average 100 kilos of soil lost per cubic metre in a single rain event.[xv]

Authoritative commentators say that if present rates of loss continue, the world could largely exhaust its arable topsoils within 50-70 years.[xvi]

Slide 8: soil 2

At the same time we may already have passed peak farm land. FAO statistics indicate the global farmed area has contracted in 8 of the last 10 years,[xvii] possibly due to urban expansion.

The FAO's latest State of Land and Water report indicates around half the earth's land area is badly degraded or useless, while only 10 per cent is thought to be improving.[xviii]

Slide 9: soil 3

It is difficult to predict when the soils time-bomb will explode – in regions such as the Middle East and Central Asia it is close to detonation. In Asia it will become critical within two to three decades. Europe, North and South America and Russia represent reservoirs of good soil, but are losing it at unsustainable rates nevertheless.

Most places will experience the impact as a decline in crop and pasture yields, in spite of new technology. Eventually regional and then world tipping points will be reached, precipitating local food crises.

The worldwide scarcity of good farm land has fuelled a "global landgrab" by Arab, Chinese and American investors among others. According to a recent book, an area the size of Western Europe (230m ha) has been seized from poor farmers since 2001, much of it in tropical Asia.[xix]

We now need to face a second inconvenient truth – that every extra tonne of food we produce raises the risk of "progressive breakdown in productive capacity" (FAO 2012).

This carries major risks for population upheaval, mass migration and conflict and competition for dwindling resources intensifies.

Slide 10: megacities

By 2050 there will be gigantic tropical conurbations like Guangzhou-Shenzen-HongKong, which may hold as many as 120 million inhabitants.[xx] Cities like Manila and Jakarta will have populations of 40-50 million.

The world's cities will together occupy an area of soil the size of China. They will consume a third of the world's fresh water and 80 per cent of its nutrients.

Alarmingly, the modern city produces next to none of its own food.

It is fed by a river of trucks that flows every night, to restock the shops and supermarkets.

To feed a city of 20 million requires the physical delivery of more than 6000 tonnes of food every day.[xxi] To deliver Australia's food requires about 80,000 truck movements per week.

What happens if - due to an oil crisis, a war or natural disaster - that transport river fails?

The answer is supplied by Australia's Sunshine Coast: during the 2011 floods supermarkets were stripped bare in less than 48 hours.

The modern city and society cannot survive more than a day or two without oil and without food.

So each of the world's megacities represents, in its own way, a ticking time bomb – one that we will witness exploding in our lifetimes. Any megacity failure has obvious consequences for geopolitical stability and peace – and the most likely failures are in our immediate region.

Slide 11: oil

Modern agriculture and food production use about 30 per cent of the world's energy.

Each day the average consumer 'eats' 4.1 litres of diesel fuel embodied in their food. (Along with about 29 kilos of soil and 2.2 tonnes of water.)

Global peak oil was in 2006, according to the International Energy Agency [xxii] – but the peak is less important that when the scarcities and high prices begin.

Critical to this are the 61 million new cars which hit the world's roads in 2012. [xxiii]

The global vehicle fleet is currently forecast to grow from 750 million today to around 1.2 billion by the 2020s – around 6 to 7 per cent a year.

Global oil production from all sources, on the other hand, has grown by only about 0.7 per cent a year since 2000 according to the US Energy Information Administration.[xxiv]

The number of vehicles is thus growing an order of magnitude faster, increasing the probability of an oil-driven tipping point with major impact on food security, food prices, and global stability.

Slide 12: nutrients

Ours is the first generation in the whole of human history to waste a third of our food.

The picture shows what the average affluent family throws in the garbage every month.[xxv]

This is a practice which is neither moral, nor economic, nor sustainable.

Much of the world's food security now depends on a supply of cheap fertilisers. Yet phosphorus, potash and natural gas (used to make N fertilisers) are finite and will become both scarce and costly by the mid-century.[xxvi]

Phosphorus is currently expected to peak somewhere between 2035 and 2060 – but of far greater concern is that 85 per cent of the world's high-grade supply is controlled by a single country, Morocco.[xxvii] Clearly there is a risk of a major failure in the world food supply were this country to suffer internal disruption.

World supplies of potash are dominated by just two countries – Canada and Russia. Natural gas, used to make nitrogen fertilisers, is also finite and likely to peak by mid-century.

As there are no substitutes for these nutrients in agriculture, the risk of a major tipping point is at least as high, maybe higher, than of an oil shock.

When the scarcity occurs it will take the form of very steep price rises and reduced availability of fertilisers, making them unaffordable to most farmers in both the developing and developed world.

This will impact tropical food production hardest, as there are few indigenous fertiliser sources and tropical soils are heavily nutrient-depleted.

For many the idea of wars over fertiliser may seem remote – but it is no more improbable than the wars already fought over oil, diamonds, water and other key resources.

Slide 13: peak fish

By 2060 world demand for animal protein is forecast to reach 570 million tonnes.[xxviii]

That includes an extra 100 million tonnes of fish – which will not come from the oceans, because the wild catch has already peaked (in 2004) and is now in decline.[xxix]

So, another ticking time bomb is the need to produce around 5 billion tonnes of feed, to raise all these animals, poultry and fish on farms.

To do so with grain, we would need to discover three more North Americas. We would also have to factor in an increasingly erratic climate and the massive land degradation it would entail.

The short answer is that this vast amount of feed cannot come from grain production and must be found elsewhere.

Slide 14: knowledge drought

One of the reasons for the present global food crises is that governments, aid donors and scientific institutions have cut funds for agricultural and food science over several decades.

This explains, in part, why growth in crop yields is not keeping pace with growth in food demand.

The starvation of the world's food science research effort is a ticking time bomb of a different sort.

It is already exploding in slow motion, as the stagnation in crop yields testifies.

Today, the world invests about $50 billion a year in food and farming research, public and private. [xxx]

That's roughly what we were investing when there were only 3.5 billion people on Earth.

Today the world also spends $1,750 billion a year on new weapons.[xxxi]

So we spend *35 times more* on better ways to kill ourselves than we do on better ways to feed ourselves.

The time is fast coming when all nations need to see agricultural research as defence spending, in that it can prevent wars far more effectively by ensuring ample food than buy buying better weapons.

Slide 15: climate

The Holocene climate in which agriculture was born is changing – probably forever.

As both the World Bank and PriceWaterhouseCoopers have warned, 2 degrees of warming is now unavoidable and 4-5 degrees is very likely.[xxxii]

The largest droughts, floods and storms of recent years are now strongly linked by science to man-made climate change.[xxxiii]

Beyond two degrees, on an increasingly violent planet, grain production especially is at risk.[xxxiv] So 2 degrees represents a serious food time-bomb, and a global tipping point into a new, highly uncertain world food regime.

Current scientific estimates suggest that every degree of global warming costs us about 10 per cent of world food

output.[xxxv] This makes current official predictions about the size of the food target perilously unrealistic.

At two degrees, for example, India risks losing half its grain crops, leaving over 700 million facing starvation. Africa risks losing a third of its arable land, threatening another 700 million by mid-century.

While the temperature increases may be smaller in the tropics, scientific commentators consider the effects of climate change may be more severe – due to metabolic impacts on both animals and plants, as well as direct weather damage

Finally, climate is synergetic with other critical inputs to food production, and may exacerbate or precipitate tipping points in soil and water, to name but two.

Slide 16: conflicts etc

Wars are often driven by scarcities of food, land and water. The French and Russian revolutions both began with famines.

More recently Dafour, Rwanda, Eritrea, the Balkans were all destabilized, at root, by disputes over food, land and water.

In 2011, governments in Egypt and Tunisia fell following bread protests, foreshadowing a new era of regime failures.

The UK Ministry of Defence – which developed this threat map – America's CIA, the US Center for Strategic and International Studies and the Oslo Peace Research Institute

all identify food scarcity as a trigger for revolution, government collapse and wars, possibly even nuclear.

Slide 17: challenge

I have discussed the main threats in the global food security outlook.

Summed up, this is the challenge they present.

It is appears daunting.

Yet it also harbours magnificent opportunity.

This is the challenge of our Age.

Slide 18: solutions

First we most reinvent how we produce food.

We need an entirely new agriculture founded on ecosystem thinking, which produces more food while using far less soil, water, energy and other inputs and being resilient to climate shocks.

For this new agriculture to emerge before tipping points are reached requires massive new reinvestment in knowledge, both in discovery and especially, dissemination.

The global agricultural science effort must be placed on a war footing.

Food itself must change. A hot world of 10 billion people will not eat the same kinds of food as a cooler world of 2.5 billion.

The future diet will be far more diverse, interesting, tasty and healthy. It will kill fewer consumers. It will contain more vegetables as well as completely novel foods.

Driven by the intransigent economics of globalisation, a significant part of this future world diet will come, not from farms but from factories – whether we like it or not.

And cities themselves will be completely redesigned to recycle their water, their nutrients, carbon and energy back into food.[xxxvi]

Slide 19: future farm

By the latter part of the century, driven by relentless economic pressure, less than half the world's food will be grown on farms, and these will look very different.

The future farm will blend the very best ideas from modern intensive agriculture with organic methods – using systems which are evidence-based and scientifically proven. It will operate at both large and smallholder scales.

It will weave together soil biology, crop science, nutrient recycling, soil, water, energy & carbon conservation with new thinking about sustainability, on permaculture lines, and robotics. It will embody new concepts in landscape-scale management

It will adopt entirely new paradigms like solar farming with salt water in the deserts. Indeed such solar farms can help

defuse food timebombs in the Middle East, Africa, India, Central Asia and western China.

Slide 20: urban farms

To avert the risk of urban famines, we need new food industries in our great cities.

Giant vertical farms and forests are already being planned and built in farsighted cities in Sweden, the Netherlands, Italy, Canada, Singapore and the United States.[xxxvii]

They will use hydroponics, aquaponics and similar intensive approaches, as well as smallholder agriculture, to revolutionise urban food production.

They will recycle urban organic wastes back into food. They will be largely 'climate proof'.

This is a colossal opportunity for new and existing farmers and investors, large and small, in which this university can be a pioneer for the global tropics.

Slide 21: aquaculture

As ocean fish catches dwindle, aquaculture will expand *fourfold* to become the world's largest livestock sector by 2050 – in lakes, rivers, along coasts and in the ocean itself.

In Australia, aquaculture could become a $5 billion sector by 2050, exceeding all our present livestock industries combined. This is because fish turn plant matter into meat

more efficiently than do land animals. The greatest reserves of land and water to do this are in the tropics.

With the climate change hammering the world's food bowls, the necessary animal feed cannot come from grain.

So a new industry, algae farming, will emerge as world's primary source of stockfeed, especially for farmed fish, but also other livestock such as dairy cows, poultry, small livestock and insects.

Slide 22: algae farming

By mid-century algae could be the world's biggest cropping industry – growing not only food for humans and feed for livestock, but also supplying most of the world's transport fuels and plastics, along with pharmaceuticals, fine chemicals and textiles.

Current oil yields from algae are 150-450 barrels of oil per hectare, making it possible to produce all of the world's aviation fuel plus its road, rail and marine transport fuels from an area smaller than Tasmania.[xxxviii]

The prime ingredients are sunlight, water and open space. Algae can be grown in salt lakes, on coastal margins, in estuaries, tailings dams, industrial plants and in containers on and beneath the ocean. They can thrive in sea water, brackish water, saline groundwater, stormwater and waste water.

This industry has the potential to double the value of world agriculture, employing tens of millions of people in new jobs and professions.

Any country with plenty of sunlight and water can participate in green fuel production – and sustain its own food security regardless of what happens to oil.

In the case of Australia, we can potentially grow our entire quota of transport fuels from an area no larger than a single big sheep station, 600,000 hectares, generating new industries worth around $50 billion a year, creating tens of thousands of new jobs and giving us total fuel self-sufficiency.[xxxix]

This is the greatest agricultural opportunity we have ever had – as well as a major way to reduce carbon emissions. I am pleased to note that JCU is already at the research forefront in this field. This is FNQ's next big industry and will completely dwarf sugarcane, cattle or horticulture.

Slide 23: biocultures

Novel food industries will also arise from recycling organic waste into biocultures of vegetable, microbial, fungal and animal cells - turning them into healthy, novel and sustainable foods as well as animal feed.

This 'factory production' of food will arise as a result of remorseless economic pressure by globalised supermarket and food chains which are making agricultural systems

uneconomic, as well as the looming scarcity of land and water.

However it will also mitigate the risk of famine in the megacities, enabling every city to produce much of their own food needs locally and to slash its 'food miles'.

The University of Maastricht, Netherlands, has already created the world's first synthetic sausage grown from animal stem cells in vitro.[xl] This may prove a major new source of cheap meat protein for consumers by the 2020s.

Biocultures uses far less land, water, energy, time and other inputs than do farming systems. Furthermore they are climate-proof. They will naturally advantage the tropics.

Slide 24: new crops

Today, one consumer in every two dies by their own hand – the one holding the fork – as a result of a diet-related disease.

Awareness of the massive healthcare costs of our current diet by government and consumers will drive a global quest for healthy, sustainable diets. This in turn will triple world horticulture.

There are more than 25,000 edible plants, of which we currently eat only a couple of hundred. [xli]

We have not yet begun to explore Planet Earth in terms of its food and farming potential.

Our country, Australia, has 6100 edible plants the world has never tasted. (We eat only 5!)

The future world diet will be vastly more interesting, nutritious, healthy and diverse than it is at present.

We are on the brink of the next great food adventure – one that offers abundant opportunities for novel diets, jobs and industries.

Slide 25: conclusion

The challenge of meeting the world's future food need is great.

Many dangerous tipping points lie ahead, replete with risks for global stability, mass migration, regime failure and conflict.

Yet the opportunities are greater still – and means exist to mitigate the risks.

We can develop new science-based eco-farming and food production systems, and share the knowledge globally, using it as a platform for peace and prosperity.

We can create healthier and more sustainable diets.

We can design cities that do not waste, and which grow more food.

We can teach our children to respect and value food – so we can pay our farmers enough to steward the Earth that feeds us.

This is more than an inspiring challenge.

It is one on which depend the future prosperity, security, stability, peace and happiness of civilization.

Ends

Slide 26: TCF

---

[i] UN Population data
[ii] Based on Tropical Data Hub http://tropicaldatahub.org/research-in-focus/people-and-societies
[iii] Groundwater and Global Change, UNESCO 2012
[iv] Climate Science 2009–2010: Major New Discoveries. A Strong, K Levin and D Tirpak, International Resources Institute, December 2011.
[v] Out of Water, C Chartres and S Varma, FT Press 2011
[vi] Resource Efficiency: Economics and Outlook for Asia and the Pacific, UNEP 2011
[vii] Tropical Deltas and Coastal Zones, Chu T Hoanh et al (IWMI) CAB International 2010.
[viii] http://www.scidev.net/en/climate-change-and-energy/news/rising-sea-levels-threaten-islanders-with-displacement.html
[ix] Demand for Energy Tests Water Supply and Economic Stability in China and the U.S., K Schneider, Circle of Blue, June 2011
[x] http://independentsciencenews.org/health/risk-and-responsibility-farming-food-and-unconventional-gas-drilling/ also http://www.bloomberg.com/news/2012-11-12/water-scarcity-threatens-energy-plans-from-u-s-to-china.html
[xi] http://news.nationalgeographic.com/news/energy/2013/01/130130-water-demand-for-energy-to-double-by-2035/
[xii] Projection based on current urban demand of 1.4 cu kms (IWMI)
[xiii] Human Health, the Nutritional Quality of Harvested Food and Sustainable Farming Systems, JB Marler & JR Wallin, 2006, also The Global Food Crisis, B Sundquist, 2008
[xiv] Bai ZG, Dent DL, Olsson L and Schaepman ME 2008. Global assessment of land degradation and improvement 1: identification by remote sensing. Report 2008/01, FAO/ISRIC – Rome/Wageningen
[xv] Investigation of soil erosion from the bare steep slopes of the humid Philippines. A.L Presbitero et al., Earth Intteractions, 2004.
[xvi] Marler& Wallin and Sundquist B, op cit.
[xvii] Data from FAOSTAT, 2012
[xviii] FAO State of Land and Water report, Rome, Dec 2011
[xix] See Kugelman M et al. The Global Farms Race: Land Grabs, Agricultural Investment, and the Scramble for FoodSecurity, Wodrow Wilson Centre, 2012. Also Deiniger K et al., Rising Global Interest in Farmland. World Bank, 2011
[xx] http://www.guardian.co.uk/world/2010/mar/22/un-cities-mega-regions
[xxi] Urban Agriculture: a response to crisis. A Drescher. RUAF 2005.
[xxii] Birol F., International Energy Agency (IEA) in interview with ABC: http://www.abc.net.au/news/2011-04-28/age-of-cheap-fuel-is-over-iea/2695928

[xxiii] International Organisation of Motor Vehicle Manufacturers (OICA). http://oica.net/category/production-statistics/

[xxiv] USEAI 2012 http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=5&pid=53&aid=1

[xxv] Source: USDA and NY Times. For more on food waste see Gustavsson J, et al., Global Food Losses and Food Waste, FAO, Rome 2011

[xxvi] The story of phosphorus: Global food security and food for thought, D. Cordell, J Drangert, S White, Global Environmental Change, May 2009.

[xxvii] Grantham J. http://www.nature.com/news/be-persuasive-be-brave-be-arrested-if-necessary-1.11796

[xxviii] FAO High Level Export Forum, How to feed the World: Investment, Rome, October 2009. http://www.fao.org/fileadmin/templates/wsfs/docs/Issues_papers/HLEF2050_Investment.pdf

[xxix] Merino, G., et al., Can marine fisheries and aquaculture meet fish demand from a growing human population in a changing climate? Global Environ. Change (2012), doi:10.1016/j.gloenvcha.2012.03.003
Also State of the World Fisheries and Aquaculture (SOFIA) 2010 (FAO 2011).

[xxx] J. Alston, J.M.Beddow, P. Pardey, "Mendel versus Malthus: research, productivity and food prices in the long run," University of Minnesota, 2009. http://ageconsearch.umn.edu/bitstream/53400/2/SP-IP-09-01.pdf

[xxxi] Perlo-Freeman S., et al. Military Expenditure, Stockholm International Peace Research Institute (SIPRI) Yearbook, 2011

[xxxii] http://www.pwc.com/gx/en/sustainability/publications/low-carbon-economy-index/index.jhtml and http://climatechange.worldbank.org/sites/default/files/Turn_Down_the_heat_Why_a_4_degree_centrigrade_warmer_world_must_be_avoided.pdf

[xxxiii] World Bank, November 2012, op cit, p18.

[xxxiv] Climate change already hurting agriculture. S Reardon. Science, 5 May 2011

[xxxv] Warming World: impacts by degree. US National Research Council, 2011

[xxxvi] J Cribb, op cit.

[xxxvii] See for example, http://www.verticalfarm.com/

[xxxviii] http://www.oilgae.com/algae/oil/yield/yield.html also Shirvani T et al. Energy and Environmental Science 4. 10, 3773, 2011

[xxxix] Cribb JHJ, Peak oil and global food security. ACT Peak Oil Assn, ANU, Nov 27, 2012

[xl] The need for meat. Maastricht University Webmagazine, 20 June 2012

[xli] See French B, http://www.learngrow.org/about-learngrow/history-of-learngrow/