



A Nuffield Farming Scholarships Trust

Report

Award sponsored by

The late Harold Cowburn NSch

The true cost of cheap food

Robert K Craig

October 2013

NUFFIELD UK

A Nuffield (UK) Farming Scholarships Trust Report



*"Leading positive change in agriculture.
Inspiring passion and potential in people".*

Date of report : October 2013

Title	The true cost of cheap food
Scholar	Robert K Craig
Sponsor	The late Harold Cowburn NSch
Objectives of Study Tour	<ul style="list-style-type: none">• To study consumer attitudes towards sustainable food production; have we decided we want it?• How scalable are truly sustainable food systems?• What are the main constraints and how are we dealing with them?• Is business as usual an option?
Countries Visited	<ul style="list-style-type: none">• China, New Zealand, India, Chile, Peru, Brazil, US - California
Findings	<ul style="list-style-type: none">• Major change is almost upon us and it will be driven by a combination of economics and consumer desire• Competition for available water is strong and water usage for food production is in critically short supply• The impact of climate change is real• We've failed to take account of the true cost of food production in both the price and value of food• Business as usual isn't an option

Contents

1. Introduction	1
2. Background	2
3. My Study	4
4. China	6
4a. China's Agriculture	6
4b. Model Farm Project	6
4c. Key benefits of the CSA approach.	7
4d. Beijing to Shanghai.....	7
4e. FHC China	8
4f. Water management in China	8
4g. China conclusions.....	9
5. New Zealand.....	10
5a. Fonterra.....	10
5b. Water management in NZ.....	11
5c. Taupo Beef: Mike and Sharon Barton	12
5d. N Cap and its implications.....	12
5e. New Zealand Conclusions	14
6. India.....	15
6a. The changing face of agriculture in India	17
6b. India Conclusions	18
7. Chile	19
7a. The agricultural industry in Chile	19
7b. Chilterra (southern Chile).....	19
7c. Staff management at Chilterra	20
7d. Growth of Chilterra	20
7e. Northern Chilean dairying.....	21
7f. Ministry of Agriculture in Chile: INIA, Chile's National Institute of Agricultural Research.....	22
7g. Water management	22
7h. Chile Conclusions	23

8. Peru	24
8a. Peruvian Dairying	24
8b. Water management	25
8c. Peru Conclusions	26
9. Brazil	27
9a. Dairying near Rio	27
9b. Brazil Conclusions	28
10. California	29
10a. Dairy overview	29
10b. Full Belly Farm CSA (Community Supported Agriculture)	30
10c. Straus Family Dairy	32
10d. California water management	33
10e. Center for the Urban Education about Sustainable Agriculture (CUESA)	34
10f. California Conclusions	35
11. Discussion	36
12. Conclusions	38
13. Recommendations	39
14. After Nuffield	40
15. Executive Summary	41
16. After-word	42

DISCLAIMER

The views expressed in this report are entirely my own and do not represent the views of the Nuffield Farming Scholarship Trust or any of the people who have assisted me in my study.

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Our good friends and fellow farmers in St Lucia, Stephen and Joyce Best, have a saying:

Behind every successful man is an exhausted woman!

Even with the enormous advantage that modern communications bring, as a Nuffield Farming Scholar you are hugely dependent on others for direction, contacts and guidance while planning and travelling. I'm enormously grateful to the **Nuffield Farming Scholarship Trust** for the opportunity to do my Nuffield Scholarship and also to my generous sponsor, the late **Harold Cowburn NSch**, whose untimely death prevented our meeting.

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1. Introduction

Married to Jackie and with four growing children between 9 and 14 years there's rarely a dull moment in the Craig household. I'm the third generation of Craigs to farm Cairnhead in North Cumbria. The first was my grandfather who relocated lock, stock and barrel on a specially chartered train from Sussex to Cumbria in the late 1940s.

Leaving school at the tender age of 16 and attending Newton Rigg Agricultural College for several years, I joined the family partnership and I've been farming full time for the past 27 years and have honestly loved every minute. I lead today a life I once wouldn't have believed was possible.

I'm currently a partner in two separate dairy farming businesses that jointly milk 900 cows and employ 9 members of staff. The situation I find myself in 2013 is so completely different from the life I had earlier in my career.

Well before leaving school at 16 I don't recall ever *not* wanting to be a farmer. I must have been the most stereotypical farmer's son of my generation, outdoors on the farm at every available opportunity, soaking up the wonders of fresh air and livestock.

Ending my formal education in 1986 at a time when very many of my peers were staying on and continuing their full time education, there was a high expectation that I would slot straight into life on the then small family dairy farm and, being a naive 16 year old, I don't recall putting up much of a fight. But, in hindsight I don't regret any of the decisions I made.

This early experience of very hard work, coupled with a degree of freedom and high expectation, did undoubtedly shape the person I've become. Determined to succeed and improve my prospects in life I developed a strong passion for farming and I'm immensely proud of my achievement of the past almost three decades. Although in the early years I was determined life would get easier and more rewarding, I didn't set out to become a relatively large dairy farmer. My current position came about through a combination of constant learning, life planning and understanding what I really wanted from life; but most importantly the realisation that securing true wealth is about being able to choose how you spend your most valuable resource: time.





2. Background

Since the publication in 2011 of the Foresight Report **-The Future of Food and Farming: challenges and choices for global sustainability** - lots has been written about how much more food from less resource we must produce in the future until global population peaks and plateaus somewhere between 9 and 10 billion in 40 years' time. The goal of sustainable intensification in agriculture wouldn't seem to have yet produced anywhere near the advancement needed to keep up with the extra demand from both the economic and population growth that sees the equivalent of an extra UK to feed every 12 months.

From the outset it's been my intention to travel far and wide during my study to get a global perspective of the food production systems and explore the core food values that less developed countries have, compared to our own. As you will read in this report, some of my conclusions have been very much as expected and others have shocked and amazed me.

The one overriding positive message I've picked up time and time again is that farmers, wherever you are in the world, are overwhelmingly passionate about their occupation and the environment in which they live and work. They are generally highly principled people, who are massively undervalued by modern society although I think this is rapidly changing.

In 2010, around 12 months into my two year period as NFU county chairman for Cumbria, I

received an email. This email was inviting me to join a steering group that was meeting to arrange a conference to examine the merits of trying to establish a "Local and Fair" brand for local farm produce, roughly along the lines of Fairtrade, where the consumer was guaranteed that the cost of production was covered in the purchase price of the product. Intrigued, I went along and I suppose you could say that, from the outset, I got it, in that I understood what all the other people were

saying - or at least one in particular, the group leader and local Fairtrade campaigner Joe Human.

I believe the opportunity arises only a few times in life to

meet and get to know truly inspirational people. Joe is one such person. I'm grateful beyond belief that our paths crossed back in 2010 and we became really very good friends from the very first meeting.



St. Lucia: with Moses, a banana farmer

In organising the Fair and Local conference we decided we would attempt to get a farmer



who produced a Fairtrade product to come to the UK and address the conference - alongside a British farmer - to generate discussion about the challenges and similarities each had to endure to get food to the market place and secure a fair and sustainable price. I was that chosen British farmer and was lucky enough to visit St Lucia and Dominica in the Windward Islands to spend time studying Fairtrade banana production and the Fairtrade system. It was during this study that I decided I would apply for a Nuffield Farming Scholarship and the direction this would take.



Coffee beans in St. Lucia

Representing fellow farmers as an office holder for the NFU it's reasonably easy to get drawn into what can be the negative element of farming politics. It's easy to start believing very little is ever going well in agriculture and that it can be a relentless and continual progression from crisis to crisis. Staying above that negativity was quite a challenge at times

while serving as county chairman, so the trip to St Lucia not only helped me realise how fortunate we are with our supported agriculture but also how much farmers can achieve if they choose to work with one another; not only to sell a product but to market the story behind the product as well. In pure economic terms Fairtrade shouldn't really work. It's consumers who decide to make it work. It's a decision made by a consumer to effectively subsidise the activities of a farmer/producer who otherwise wouldn't be economically sustained.

Our British consumers have never been more detached from the source of their food than they are now. As our food has become cheaper we've seen consumer values shift massively. During my study I wanted to see if the change in value we've experienced in the West is happening in other parts of the world. One of the consequences of having vast quantities of cheap food is food waste, which has accelerated beyond belief until today unbelievable quantities of perfectly good food are being dumped into UK landfill.

Currently we waste in the region of 7 million tonnes of food. Yet, some consumers do value food and are consciously willing to pay more for food, happy to pay extra for food with a story attached, be that a story of environmental benefit, social or economic benefit, or simply the food being in season. Is this the template of the future food system?



3. My Study

To satisfy growing global demand agriculture needs to deliver more food. From my travel and study I wanted to uncover the answers to a series of questions relating to the structure of food production:

- Is it possible from the world's resources to produce sufficient food to feed a further two billion people?
- What are the main constraints to producing more food and how do we overcome them?
- How much of our current food production system is already sustainable? Are truly sustainable farming practices scalable?

To explore both the production systems and the consumer values of rapidly developing countries I visited China, India and South America. In order to learn how sustainable food production already is I chose to visit two countries that are each very dependent on, and very efficient at, producing food from the land: California and New Zealand.

China: November 2012

I visited China to learn not only how they intend to overcome the challenges of feeding 1.3 billion people, but also to see first hand if the growing affluence among China's population would change how the Chinese people value their food as they fast track towards a western lifestyle. Around 60% of the 1.3 billion current population lives in rural areas although this is changing fast as the lure of a better life in the city draws them in.

New Zealand: November/Dec 2012

New Zealand's economy is hugely reliant on food exports. Surely they must be taking

sustainability seriously? Setting the global standard for pastoral farming, New Zealand has been future-proofing for years, but how are they going to cope with supplying the rapidly emerging markets of Asia?

India: December 2012

India is closely behind China in term of economic growth and also has a rapidly expanding population of over 1.2 billion people. The majority of India's population is still closely linked to the land. With the green revolution now running out of steam the country is going through an industrial revolution with increasing urbanisation as people migrate to the large cities to find employment. As one of world's largest exporters of rice, crop irrigation is vital in India. With exploding urban sprawl, how will urbanisation verse food production evolve in a country where even the monsoons fail to deliver adequate rainfall to meet their growing needs?

South America: February 2013

Chile and Peru are known for their food and wine exports. They would provide a glimpse of another two countries undergoing rapid change and strong economic growth. Exporting product both to North America and Europe, Chile has a growing market supplying the northern hemisphere's out of season demand for fruit and vegetables, the production of much of which is totally dependent on irrigation. How secure are the water resources and what impact is climate change having already? Peru is even drier than Chile and also heavily dependent on irrigation, exporting mainly asparagus and artichokes out of season to the more affluent



demanding palates in the Northern hemisphere.

Brazil. Very well known for its diverse agricultural economy, Brazil is almost self-sufficient in food and is a big player in the world food market. Farming and food production employ almost 25% of the working population and contribute up to one third of all Brazil's export trade. The majority of Brazil enjoys high rainfall with the exception of the north east of the country. One of the world's largest protein producers, it exports vast quantities of beef and chicken along with soybeans and coffee. The expansion of agriculture in Brazil has come at a cost to the environment. Vast areas of the country that were once tropical rainforests have been cleared and are now either grazed with beef cattle or produce soybeans for either export or animal feed. With a seemingly endless supply of water the benefits of scale and strong world demand for its products, few could argue Brazil needs to change very much. But how does Brazil consider the future sustainability of its agricultural industry and can we be assured that the products being

exported are produced to the standard we expect?

USA, September 2013

California: the Golden State, the bread basket of America - however you see it, California produces a huge amount of food. It is the most densely populated state in the US with half the population of the UK residing in it I wanted to learn how food production on an industrial scale connects with modern consumers. How does the average American value the food they eat? The home of the drive-through, with more fast food outlets than anywhere else on the planet, how aware is the US of the need to reduce food waste and conserve the precious resource base we all depend on? It's often pointed out we would need around four planets to sustain us if we all consumed resource at the rate the North Americans do, so is anything being done to constrain this? Heavily reliant on water for irrigation, how will climate change affect the way in which Californian food is produced in the future?

I discovered reasonably early in my Nuffield study that there's very definitely more bad news than good regarding sustainable food production. It's obvious that we're heading towards some massive challenges as the global food system breaks down:

Challenges that will have to be overcome during our lifetime.

Challenges that will need to see almost seismic changes in consumer attitudes towards food, resource management and energy use.

I hope the messages within this report help to clarify to consumers, food industry leaders and policy makers alike that the current direction is *no* direction.

"Be the change you want to see" (Ghandi)



4. China

I'm not sure what I was expecting China would be like, but in any case it was different, unbelievably different, from any place I've been to before. Flying into Beijing and emerging from the underground near the city centre I felt very foreign. In most places I've been it's possible to work out what the street signs might be saying. A Nuffield Farming Scholarship is supposed to be challenging so, with no indication of even the direction I was walking in, finding my reservation at the River View hotel was going to be challenging.

Once in China one thing that's apparent almost immediately is the obvious variation in wealth. The roads are packed with new big, black, German cars, while people on the other end of the economic scale gather up plastic bottles and other bits of rubbish from the streets and load it up onto dilapidated wheel barrows or into giant plastic bags. Almost 20 million people now live in the metropolitan area of Beijing, twice the number of 20 years ago, and a staggering 70 million live within a 60km drive of the centre. China is building continuously, 24/7. Everywhere you look there's construction taking place; little wonder they consistently use annually half the world's cement powder and steel.

4a. China's Agriculture

Although China has the third largest land area in the world, 70% of its land is un-farmable, mountainous or at high altitude and infertile. Of the 30% that remains, urbanisation has been taking approximately 300,000 hectares every year for 30 years. China now not only finds itself with 20% of the global population

to feed but has less than 10% of the world's productive land on which to do so, as it's rapidly being covered with asphalt or concrete. Close to 40% of the farmed land in China, amounting to around 550,000 hectare, is irrigated. That's grown from 300,000 hectares only two decades ago. As one of the world's largest manufacturers of chemical fertiliser, China is also one of the biggest consumers, and currently uses annually around 45 million tonnes of it. This is almost one third of the total supply of global soil inorganic nutrients, and twice the amount China used 50 years ago.

Everywhere you
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construction taking
place

While in Beijing I was very fortunate to be helped and guided by Ashleigh Bright and Ron Lane who each work for FAI (Food Animal Initiative) which specialises in sustainability programmes for agricul-

ture. FAI has been involved in running a program called the Model Farm Project for WSPA (World Society for Protection of Animals) on various sites one of which is on the outskirts of Beijing. Ashleigh and Ron's familiarity with China was greatly appreciated and they were an enormous help.

4b. Model Farm Project

The farm we visited (The Green Cow Organic Farm) was 20km out of Beijing and, at 6Ha, was larger than the average for China. The project was exploring the merits of CSA (Community Supported Agriculture) where a group of individuals would pledge their support to a farm and pay for their produce in advance. The CSA principles are to develop highly sustainable agriculture that's both antibiotic and pesticide free, and where



nutrients are continually recycled back into the farm. While more commonly vegetables and fruits were produced on CSA farms, this farm also had livestock and, as well as directly supplying consumers, it supplied a local restaurant belonging to the farm owner's wife. The farm carried 8 cows, 17 pigs, 16 geese and 200 chickens. All the nutrients from the livestock manure were used to grow other crops and although it was early winter several of the farm's poly tunnels were full of mainly-salad crops ready for consumption. The farm welcomed visits from schools and community groups throughout the year and had built classrooms and a large café and kitchen so the farm visitors could be catered for. The entire waste generated from the visitors was composted and recycled back into the farm, with the liquid being used to irrigate while also providing nutrients.



Community Supported Agriculture - China



Model Farm project for WSPA and CSA

4c. Key benefits of the CSA approach.

- **Economic.** Customers prepaid for their produce enabling a guaranteed market which in turn helped finance the farm.
- **Environmental.** Organic and biodynamic agriculture with reduced carbon dioxide emissions due to little transportation of product.
- **High Animal welfare.** CSA strongly promotes healthy animals, in a natural environment, outdoors with space to adopt natural behaviour.
- **Provenance and quality.** Local, fresh and trusted high quality.
- **Strong consumer-producer links.** CSA members can visit and get involved in the farm, and are also encouraged to share recipes through a farm newsletter.
- **Flexible.** CSA schemes are tailor-made to meet the needs of both the farmers and the local consumers.

4d. Beijing to Shanghai

The fastest way to get from Beijing in the north to Shanghai in the south is by high-speed bullet train. At times travelling at over 300km/hour the 850km from Beijing to Shanghai was covered in exactly 4 hours and 48 minutes. Travelling hour after hour, we passed cotton and wheat fields occasionally populated by clusters of people picking the cotton by hand. Being so densely populated China has an enviable abundance of cheap labour and currently employs around 300 people per 100 hectares of land. Compare this to only 2 people working 100 hectares in the US and it's easy to see there's very few tractors and machines. In fact very little mechanisation was visible at all from the train. The scale of China's investment in its infrastructure is breath taking and takes some believing. Vast eight-lane highways track



across the landscape, often without any vehicles on them, as huge new cities appear on the horizon, all built in readiness for a future that, if forecasts are correct, will see a further 250 million Chinese moving from the rural to the urban areas to populate the newly built facilities. Once China's modernisation plan is complete around 900 million Chinese will be living in megacities; that's over 70% of the country's population.

4e. FHC China

I spent two days at "FHC China", the largest consumer and hospitality food trade show in Asia, where over 70 countries from around the world exhibit mainly branded food products. More than 30,000 food buyers visited the trade show in three days. First Milk (of whom we at home are milk supplying members), the largest farmer-owned dairy company in the UK, was exhibiting for the first time at the FHC in 2012. A constant stream of potential First Milk customers visited the stand discussing the availability of supply arrangements and package sizes to suit the Chinese market. Confidence in food safety is paramount in China. Following the controversial melamine contamination of milk in 2008, consumers have little trust in dairy products produced in China and are far happier to spend more money buying a dairy brand from overseas. Consequently there's growing demand for dairy imports, the most lucrative being milk powder for babies and young children, but as people become more wealthy and increasingly have access to domestic refrigeration, diets are changing

towards the type of dairy that we commonly consume such as spreads, yoghurts and hard cheese. The demand we experienced at the FHC for our First Milk cheeses including own Lake District Cheese brand was staggering and proves the Chinese consumers aren't just looking for low value commodity type dairy products, but that there is also a growing demand for branded, high margin dairy products.

4f. Water management in China

Put simply China is running out of water. If its current increase in usage is maintained, by 2030 it will be using 25% more than now and will have a serious supply/demand problem.

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running out of water.

But it's not only the supply of water that's the issue in China: it's also the *quality* of the water. The huge increase in industrial usage has seen a massive increase in the chemical pollution of both surface and ground water. Underground aquifers have been over-pumped to the extent that in over 50 cities subsidence has occurred as the ground compensates. A major project is now underway constructing an aqueduct that will see as much as 45 billion cubic metres of water moved via canals from the south of the country to the north. The whole project is expected to take 50 years to complete and although currently the south has more water available than the north, in 2012 the south experienced their worst drought for 50 years and, if this was to become a trend, the feasibility of the whole project could be challenged.



The effects of climate change are also likely to have implications for water availability in China. With only 7% of the world's fresh water reserves China is already struggling to find solutions to the growing problem it faces, balancing the domestic needs of a growing population with those of irrigated food production. If predictions are correct and the estimated rise in population and urbanisation takes place, domestic water consumption will massively increase as 60% of the expected extra 1.6 billion dwellings will be urban, as China gradually moves from a

supply economy towards a consumer economy more similar to that of our own.

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Gauging the implications for food production that mass urbanisation, climate change and pollution will have is very difficult.

China will become more dependent on the rest of the world for its food nutrition, resources and energy, and as its GDP increases towards the levels we enjoy in Western Europe and the US, it's likely we'll see unprecedented demand and volatility in global food trade.

4g. China conclusions

- Mass urbanisation leading to strong competition for land
- Little or no more available water to increase food production
- Rapidly changing diets consuming greater volumes of dairy and meat protein
- Strong economic growth securing land and resource globally
- Serious water quality and availability problems



Walking the Great Wall of China – all part of the Nuffield experience

The true cost of cheap food by Robert Craig

A Nuffield Farming Scholarships report generously sponsored by the late Harold Cowburn NSch



5. New Zealand

Having travelled to NZ almost 10 years ago I had a fair idea of the approach the Kiwis have taken towards business growth and, in particular, grassland management. Deliberately staying away from technical grassland management was going to be a challenge for me during this visit as it's been both my day job and my passion for the past 15 years.

For a country so reliant on agricultural sustainability it was interesting to see how the dairy farmers, researchers and the dairy companies were planning to deal with the challenges they confronted and that were now the undeniable priority. There are 6.4 million dairy cattle (4.2 m. cows) in NZ at the moment and the dairy industry continues to grow at close to 5% per year. Since my last visit in 2003 the average herd size has grown from 285 cows to close to 400 in 2012. Of these dairy farms, 75% are located in the North Island where the majority, 65%, are still owner-operated while 35% are on a share milking agreement or equity partnership. One major difference from the industry of the early 2000s is the level of producer debt, driven by strong dairy payouts. Many dairy farming businesses have grown aggressively during the past decade and now find themselves in a situation where their cost of funds (interest) can amount to 6-8% in an industry where an owner occupier might only be achieving 4% ROC. The consequence of this is there's very little margin for error and businesses will find it very difficult to further

invest to comply with additional environmental legislation that could be just around the corner. New Zealand, with a relatively small population of around 4.5 million, consumes very little of their dairy production, meaning that dairy exports have become an important and essential part of the whole country's economy. It's crucial for

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the whole NZ economy that they are not only developing the correct products for their new markets, but also delivering the high level of trust, sustainability and transparency the growing markets in Asia demand.

5a. Fonterra

One of the largest dairy cooperatives in the world, Fonterra is owned and controlled by 10,500 New Zealand dairy farmers and is processing 17 billion litres of milk from NZ with a further 4 billion sourced from Australia and Latin America. Fonterra is clearly targeting future growth in the emerging markets of China and India where it's being predicted we'll see demand for dairy outstrip domestic supply potential by two to one in the next decade. Fonterra has already made significant progress into the Chinese market where sales account for almost 10% of its overall business, and now has a clear strategy to concentrate more on their growth in branded products, where Fonterra already sees one third of their revenues coming from.



Fonterra:

- collects and processes 89% of NZ milk
- has 17,300 staff globally
- processes 22 billion litres globally
- spends NZ\$100 million/per/year on R & D, brand and product development innovation
- constitutes 26% of NZ exports

Before launching its new approach to sustainability in early 2013 Fonterra worked hard gauging the opinions of its customers, NGOs, government and environmentalists in order to build a broad sustainability programme that aims to be world class. They're working hard to build trust and integrity into their dairy business, driven by the demands of society and the need to link in with their main customers' needs. A new approach has been launched taking full control of the supply chain from "Grass to Glass". Producers are encouraged to comply with the "Supply Fonterra Programme" which is the industry standard. The new sustainability programme will be built into the agreement and advice offered on a one-to one-basis to get all farmers to conform to the same level. Sustainability is an essential part of everything that Fonterra is planning for the future. They are already the number one milk processor in the world and unlikely to stop growing any time soon.

the main issue with water in NZ is fresh water quality and pollution from the main agribusiness, dairy farming

almost 70 years and everybody who could was pumping water out of the ground, it's amazing so little ground water is used for irrigation.

Although there are major concerns in some areas about the amount of ground water reserves, the main issue with water in NZ is fresh water quality and pollution from the main agribusiness, dairy farming. The dairy industry is trying to shake off the image of "Dirty Dairy " that it's been labelled with in

recent years, where the media have highlighted concerns about the level of nitrates that have been leaching into the ground water, plus

surface water pollution from livestock most frequently accruing during the heavy rains of the winter. Already farmers are being required to fence off waterways to prevent livestock from drinking or accessing streams and rivers. But the main problem is the amount of ammonia rich run-off and the



Centre pivot irrigation

5b. Water management in NZ

Of the 500,000 million cubic metres of water that NZ receives each year through rainfall and snow around 5% - or 25,000 million cubic metres - is extracted and used for industry. Staggeringly only three quarters of this abstracted water is used for crop irrigation. Considering that during my visit in December 2012 NZ was going into its worst drought for

nitrate leaching from out-wintering dairy cows and young stock on highly stocked areas of forage crops. Very few large dairy farms are able to house cows during the winter period and therefore have little or no ability to collect or store the effluent until spring or



summer when the nutrients could be used more effectively during the growing season.

5c. Taupo Beef: Mike and Sharon Barton

Taupo Beef was launched in 2005 with the primary aim of marketing a premium beef from the Lake Taupo catchments area where animals have been reared on a system of pasture based agriculture that leaches less than 20kg/N/Ha. In order to achieve an adequate economic return the beef is being niche-marketed into high class restaurants in and around the Lake Taupo area, with a pre-condition that it's the most expensive item on the menu.



Taupo Beef

Taupo beef is now being supplied to a number of high class restaurants from three different farms but, most importantly, the price is set to maintain a level of profitability ensuring long term sustainability for the farms. I found this a fascinating example of how understanding the issues and developing the correct solutions have enabled businesses to remain profitable and progressive. The true cost to the environment is not internalised into the cost of mainstream food production. Taupo beef is proving that it can be and consumers will and are making the conscious

decision to make it viable. Could this be a model for the New Zealand dairy industry?

5d. N Cap and its implications

Farming is responsible for 93% of the manageable nitrogen that leaches into Lake Taupo. The immediate area around Lake Taupo has been placed in an "N Cap" for the next 1,000 years. "N Cap" means an area that has an annual nitrate leaching limit placed on it. The aim is to reduce the amount of nitrogen leaching from the catchments area into the lake. Most of the nitrogen that's leached from livestock is from urine and during the winter, so the nitrogen cap effectively places a stocking rate limit on the land. This therefore limits any response farmers have to offset future production cost increases by intensification or stocking rate increase.



Lake Taupo

Almost 30% of the farmed land in the lake's catchments area will need to be taken out of agricultural use in order to achieve a 20% reduction of the nitrate reaching the lake. A nitrogen management plan for each farm is constructed which is audited annually. This is required so each farmer can apply for a 25 year consent to farm. Consent is given for a nitrogen discharge allowance that's based on



the farm's historic production between 2001 and 2005.



Cows at grass in New Zealand

The economic implication of these restrictions is significant as, during the past six years, on-farm production costs of beef have risen by 38% and only the constant rise in stocking rates has enabled farmers to remain profitable and stay in business. The future prosperity of farms now depends on their receiving a premium price for their product, whether it's livestock or dairy. There's no other way. If no premium is available or obtained, within only 5 or 6 years most farms would become uneconomic due to the constant erosion of margins.

If nitrogen caps were placed on the entire country it would place significant pressure on profitability. Both dairy and beef production in NZ has followed the science-based research in recent years - trading principles for economics - and in doing so has failed to fully understand the concerns of consumers. There's a real fear that changes will be imposed on the industry and very little time will be available to respond with well researched alternative systems. Stocking rates across NZ are at an unsustainable level but

forced rapid change will be hugely damaging to the livestock industry on which the economy of the country depends. Once leading the world in grassland research and utilisation, New Zealand now needs to channel more resource into finding solutions to the implications of ignoring the environmental cost of food production.

It's clear there's some very good work underway in New Zealand and much of this is being driven by public demand. It's important that the work continues and the true cost to the environment is embedded into the cost of food.

NZ is keen to point out their standards are world class in the world they have to compete

More research into even greater production from even greater inputs is so out of date and, as all the big gains have all but gone, there is little point chasing small gains that do little or nothing for the future of sustainable

in. This could be a significant disadvantage when others are less environmentally aware, and in the market with less attributed sustainability cost. More research into even greater production from even greater inputs is so out of

date and, as all the big gains have all but gone, there is little point chasing small gains that do little or nothing for the future of sustainable production. Learning institutions and colleges that were once at the forefront of pastoral system development in the 1960/70s are now behind the trend and will need to catch up very fast. But they will be very important to the development of systems of sustainable production for the future and could once again become as important as they were in the past for a world striving for solution.

Mike Barton: ***"Forget feeding China: we need to pander to the pampered palate"***



5e. New Zealand Conclusions

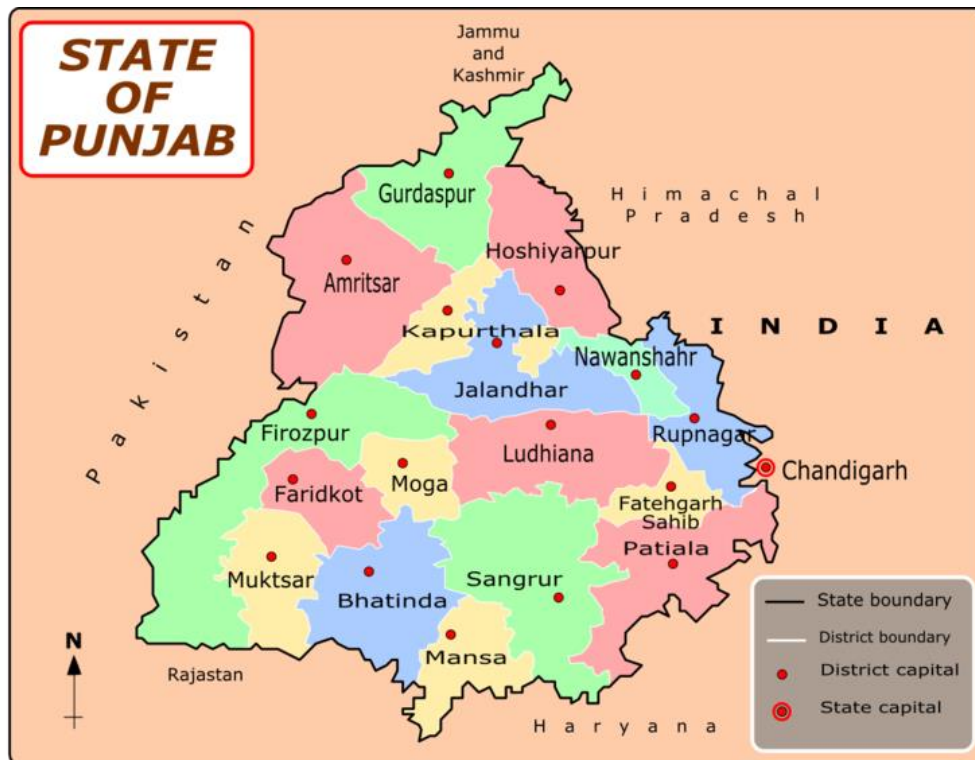
- Largely ignored environmental impact of the growing agricultural economy
- Serious water quality problems
- Adequate water availability although vulnerable to a changing climate
- Shallow volcanic soils hugely dependent on irrigation with low cost energy
- Risks becoming uncompetitive complying with environmental legislation
- Clear global perspective
- Well placed to supply growing Asian market



Auckland from the Sky Tower



6. India



Flying straight into Delhi from New Zealand was to be by far the biggest culture shock of my entire Nuffield experience. The entire population of NZ represents around three weeks of current global population growth - most of which, it seemed, was taking place in India! The stark difference in population density is difficult to appreciate until it's experienced.

With a population of 1.23 billion India is only just behind China and is predicted to peak at just over 1.7 billion in around 40 years. With almost 25% of the global population India is attempting to feed its people off just 7% of the world's productive land and will require at least 23% more agricultural production to remain food-secure as population peaks. Plagued with a long history of famine India

has been self-sufficient in its own food since the green revolution propelled its agricultural prosperity in the 1960s.

Since then agriculture in the Punjab has been noted for being some of the most progressive and productive in India and in 1962 Ludhiana became home to the Punjab Agricultural University, the largest

such facility in India. With a central campus of 1,500 acres along with a further 4,600 acres of regional research facility it was clear to see India has been seriously investing in the future of food production in the past, although funding now is more difficult. Reasonable wheat yields of 6.5 tonnes per hectare and 10 tonnes of rice have been recorded with the average being closer to 5 tonnes and 4.5 respectively.



India is still largely exposed to crop failure as some 60% of Indian agriculture remains rain-reliant with the remainder being irrigated. Of the irrigated land the most concentrated area is in the Punjab state where 97% of the farmable land now relies on either ground or surface water irrigation to sustain its productivity.

I travelled north from Delhi to Ludhiana in the Indian Punjab and to a city with a population of around 1.6 million. Ludhiana is centrally placed in the Punjab which currently grows around 42% of India's rice and 55% of its wheat. Considering it represents only 2.6% of India's productive land, it just goes to prove how fertile the area is and how well it's currently being farmed. Commonly the land is double or even triple cropped each year. This has enabled the Punjab to become massively productive due not least to the vast number of tube wells drilled in recent years to supply water for irrigation.

A growing problem emerging across India is the rapidly falling water table. The Punjab is not immune to the problem and is becoming increasingly affected. It's estimated that India could have as many as 21 million tube wells, 1.2 million of which are in the Punjab. Water pumping depths are seeing an annual fall of almost one meter in the Punjab, forcing those who can afford to, to drill deeper wells to reach sufficient supplies. Towards the southwest an area more reliant on canal irrigation water is becoming increasingly saline as the natural flow of ground water is being disturbed, allowing sea water intrusion.

In response to the water problem there's been a switch in government policy to try to reduce agriculture's dependency on water. Now farmers are being advised away from

rice and wheat production towards more vegetable production with also calls for more maize, soya and cotton to be grown. 25% of the electricity used in the Punjab is used to pump irrigation water and is heavily subsidised. As the water table falls, the power consumption to bring the water to the surface increases dramatically.

25% of the electricity used in the Punjab is needed to pump irrigation water and is heavily subsidised

Power is now being limited during the traditional rice planting season, aimed at both reducing the area planted and at delaying the planting date until later

in the summer where less water evaporation occurs.

The Government's aim is to reduce the irrigated area from 2.8 million hectare to 1.6 million hectare in an attempt to allow the aquifers to recharge back to a level where current usage can be sustained. One of the main problems in achieving this aim is the government's guaranteed price for both rice and wheat, meaning that many farmers see growing alternative crops as high risk.



PDFA: Progressive Dairy Farmers Association

At the University in Ludhiana the PDFA has 6,000 milk producing members and its role is to help dairy farmers on a variety of levels, both technical and industry facing. Members are invited to attend meetings at the



university, where they can learn about new research and technologies that are taking place, and are also encouraged meet regularly on farm to discuss industry and technical farm issues. Typically a PDFA member would have 60-70 milking cows with individual members' herds ranging between 30-400 cows. All would be operating a housed TMR type system of milk production with modern Holstein cows. Most would be triple cropping their land and balancing their home grown forage with cotton seed, soya, mustard seed and groundnut cake. Production costs have steadily risen from historically 12-18p/litre 5-6 years ago towards 20-24p which is only just below the current milk price. India's very poor cold-supply chain infrastructure means very little of their own dairy production is processed into higher value products for local consumption. Local district milk value can be 3-5 times less than that of the achievable market value. PDFA would ideally like to invest in their own processing facility which would enable producers to achieve better returns.

With little help on offer from the government, there was strong optimism for the future following a recent meeting with Fonterra NZ. Securing money has become very expensive for farmers recently. Typical historic interest rates would have been 4-6%, whereas now money is costing farmers 11-14%. The PDFA can help farmers borrow money at reduced rates from banks although, to do so, farmers must have already have had some basic training in the dairy industry.

6a. The changing face of agriculture in India

The dairy industry is undergoing continual restructuring in India. The constant challenge of increasing costs with producers having little or no ability to improve returns from the market, along with many beginning to run

short of irrigation water and increased debt, has led to an increase in the suicide rate across the Punjab. Over 7,000 suicides have been recorded in the past decade, a number which is twice the national suicide rate.



Small scale dairy in India

It's estimated that 3.5% of India's available productive land is being lost each year to urban sprawl as the country's industrial revolution dictates the economic direction.

The lack of effective structure within the food industry is limiting India's ability to progress more quickly towards a situation where the growing production of dairy can be processed into product. Currently only 2% of milk is processed into added value products. Poor cool and cold chain storage limits progress in all fresh foods including fruit and vegetables.

Part of the answer the food industry needs may come from investment from multinational food companies although, since independence from the United Kingdom in 1947, endemic corruption throughout India has restricted investment as many find India a difficult place to do business. Moving government subsidies away from input to output will encourage farmers to diversify away from the staples of rice and wheat - which are heavy water consumers - towards less water-dependent vegetable crops and flowers. This change, whilst also using water more efficiently, would also provide Indians



with much needed variety in their diet. High debt, reducing water availability, plus the inability to gain scale due to very small land holdings are all barriers to the successful restructuring of agriculture in India.

The continual lack of long term stable government policy is also restricting agricultural progress and, as with much of the rest of the world, fewer young people now see agriculture as a progressive career. Although hunger and malnutrition are very visually apparent in India, there's often between 2-3 years' worth of grain in stock in the form of wheat and rice. These stocks are periodically released onto the world market when prices are high but as

High debt, reducing water availability plus the inability to gain scale due to very small land holdings are all barriers to the successful restructuring of agriculture in India.

much as 40% of these stocks can be wasted due to poor storage facilities, the poor transport links and failing to prevent monsoon rain damage. Crops grown from unsustainable

irrigation, and water pumped with heavily subsidised and predominantly coal produced electricity, which are then never consumed, makes little sense in a country where almost a quarter of the population is effectively starving. The prospect of India producing more

food in the future to cope with an increased population looks very slim indeed. If climate change and water depletion are taken into account, India will become increasingly dependent on food from outside its own borders.

6b. India Conclusions

- Little ability to grow more food due to lack of available land
- Disorganised food systems and poor cold storage
- Endemic corruption
- Seriously depleted water reserves
- Highly fertile soils
- Heavily dependent on irrigation
- Exceptionally productive with triple cropping



7. Chile

7a. The agricultural industry in Chile

Inflation at 3-4% and typical bank interest rates of 3-4% makes Chile an attractive place to currently be in business. Although seen by many as risky and with a developing economy, Chile ranks highly in the Human Development Index (HDI), a comparative measurement of productivity, education and life expectancy. The cost of living is relatively low and under control, enabling Chilean businesses to grow with confidence. Sound economic principles seem to be working in Chile, leading to a continual fall in unemployment to its lowest point for 18 years at 5.7%.

However, although the rest of the country is faring well, farming is failing to appeal to the young people of Chile. This is partly a consequence of the current unattractiveness of the industry but also due to other more appealing opportunities elsewhere. Mining is able to pay more than agriculture and the constant drain of people towards other occupations has increased the average farmer's age to 55 years. Along with labour, mining is also taking valuable water away from agriculture and food production. Accounting for 75% of Chile's exports, copper is seen as far more important than food exports, leading to many farmers selling their water directly to the mining companies. Many farmers have to pump water from depths twice as deep as they once could, a direct result of over pumping by the mining industry.

The natural topography of Chile means the agriculture is very diverse. The extreme south is mainly concerned with sheep production whereas, slightly further north, dairy cows are

more suitable. Cropping and vineyards replace cows in the midlands while the northernmost areas are either desert or irrigated vineyards with only a small amount of confinement dairy farming

7b. Chilterra (southern Chile)

I would say if I was looking for the highlight of my Nuffield experience it would have to be the two days that I spent with Ricardo Rios in the south of Chile near Valdivia. With practically no background in dairy farming Ricardo is building one of the most impressive and long term sustainable dairy farming businesses I've had the good fortune to encounter. Travelling to New Zealand in the mid 1990s to study dairy farming, Ricardo quickly realised the similarities of each country in their ability to grow inexpensive, high quality pasture.

After moving his family from the southern city of Valdivia in 1991, Ricardo was successfully pursuing a career in IT in the country's capital Santiago. But buying 200 hectares of land close to his original home, Santa Laura, in 1992 was to be the beginning of a dairy venture that's now become Chilterra. Working closely with dairy consultants and partners Paul Corkhill, Gary Stockes and Mike McBeath - all from New Zealand - Ricardo has quickly established a large milk producing business. In 2006 the opportunity arose to purchase a further 3,200 hectares of land and so Chilterra, an equity partnership involving more partners from New Zealand, was formed.

In 2010 the first dairy on the new block of land was operational. The aim of the current

Many farmers have to pump water from depths twice as deep as they once could



project is to establish 9 dairy units on the new land each milking 800 cows. 150 km of internal roads and cow track have been installed on the 3,200ha block of land. Along with the new dairy units and situated in the centre of the 3,200 hectare block, is the main fabrication and design unit that is manufacturing the dairy buildings and all the required stall work, gates, fixtures and fittings that are needed in a modern dairy unit. With little or no support industry in Chile for pasture dairy farming, Chilterra has chosen to build everything themselves, become their own support structure, and therefore have little or no reliance on any other business for success. Perfecting the design of both the dairy building and the actual milking parlour, Chilterra already has several different versions currently working. Once all the units are complete the intention is to design and manufacture milking parlours, dairy buildings and equipment for sale to others, potentially all over the world.

It was fascinating to see such a huge project in several stages of development at Chilterra. Some of the land has been drained, reseeded and is in full milk production, while other areas of this massive 3,200 ha block are still to be broken up, drained and fenced. We (at this point I was in the company of two fellow Nuffield Farming Scholars) witnessed every stage of development in-between.



Chilterra parlour (1)

7c. Staff management at Chilterra

Very keen to avoid a structure of hierarchy in Chilterra, Ricardo strongly believes in everyone being responsible for themselves. The aim is to employ only resilient people who have already looked to achieve and improve in their lives. Ricardo finds such people are easy to train and more likely to deliver to expectation. Find people who have strived to better themselves in life was Ricardo's advice. With incorrect management most employees become dependent on instruction from their superiors and dependent on their salary. This will eventually control how they work. They become risk averse and as a result don't challenge themselves and don't think intuitively. Chilterra has developed "Dual Learning", an initiative in which they work closely with a local secondary school and a farm collage to offer the practical training for young students. Students' time is alternated between the classroom and the farm where young people interested in dairy farming can get hands-on experience working with stock and machinery.

7d. Growth of Chilterra

With a background in electronics Ricardo was monitoring everything connected with his business and one of his many strengths was his clear understanding and control of the business. 90% of dairy production in Chile is from the American TMR system. Almost



Chilterra parlour (2)



uniquely understanding the long term constraints of this high cost and energy-intensive system has allowed Ricardo and Chilterra to grow almost effortlessly and, it seems, without competition. Although there's been strong capital growth in the last 10-15 years from when land was very cheap, land is still relatively inexpensive in southern Chile when compared to New Zealand, but with comparable production potential. Most of the land Ricardo and Chilterra has invested in has needed simple drainage which, once completed, has enhanced both productivity and capital value, allowing further leveraging to grow the scale of the business again.

Growing at an annual rate of 23% Chilterra is going to be a very large dairy business very soon. All Chilterra's milk is currently being sold to Soprole, originally a Chilean coop that the New Zealand Dairy Board acquired a part share of in 1986, and now almost totally owned by Fonterra. Surprisingly Ricardo has little interest in his milk once it leaves the farm. This could well change as the scale of his operation increases. Ricardo commented he expects dairy farming in Chile will evolve into just a few hands over the next 20 years. As with all other industries, only a handful of businesses will dominate milk production, and his aim is to be one of them.



TMR dairy near Santiago

7e. Northern Chilean dairying

Visiting dairy farms in the north of the country was an altogether different experience to that of the south. Almost identical to the dairies I visited in California, confinement dairy units with large numbers of cows were almost totally housed on maize-based diets, plus bought in truck loads of soya from neighbouring Argentina. The northern part of Chile has very low rainfall and is virtually



TMR dairy in northern Chile

desert needing constant water for irrigation. The availability of water for irrigation is crucial to the ability of the farms to grow anything. Although largely due to its proximity to the capital Santiago, land in the north is still worth 3-5 times that in the south, provided it has a good water supply. As the capital Santiago grows from its current 6 million inhabitants more land is being taken for the city, enhancing agricultural land value in the area.

The profitability of these higher cost units in the north was becoming very marginal or non-existent. Every dairy we visited said they needed more money for their milk to cover the high and rising costs of feed, labour and energy. There was growing concern that the local creamery would become unsustainable. Running at 50% capacity and having to bring in seasonal milk from further south was preventing them paying any more for their more local milk. Dairy consumption is rising steadily in Chile with a 15% growth recorded



in the past 3 years; a market that as yet Chile's dairy farms have been unable to keep up with.

7f. Ministry of Agriculture in Chile: INIA, Chile's National Institute of Agricultural Research

INIA is involved in agricultural research and extension in Chile. As part of the Ministry of Agriculture and also its primary source of funding, INIA works alongside private companies carrying out agricultural research and delivering an extension service to the farming industry. Working mainly with the livestock sector INIA offers laboratory services ranging from analysing soils to greenhouse gas emissions, and is currently involved in projects developing grass based systems for cattle plus greenhouse gas and carbon evaluation, whilst also heavily involved in potato breeding. Raising funds is a continual challenge and while the government funds 40% of INIA's \$55 million budget this represents only 3% of the Ministry's total spend.

There are around 280,000 small farmers in Chile. The government is targeting 16,000 medium sized farms for additional help with the aim of seeing these businesses become more productive and efficient. The growing cost of living relative to neighbouring countries is making Chilean agriculture less competitive and, faced with the prospect of many more people leaving agriculture, the government through INIA is attempting to improve the situation. Currently there's little use of information technology or KPIs (key performance indicators) so farmers are being encouraged to come together and share information via discussion groups to improve their technical knowledge and business development skills. Dairy groups are working most effectively

where, similar to our own discussion groups, farmers would meet in groups of no more than 10 to share knowledge in an un-intimidating and friendly environment. These meetings usually finished with a meal or BBQ on the host farm and seem to be very popular. The target is to get 5,000 of the 16,000 targeted involved in technology transfer in some way.

"Everyone loves farmers in Chile, but no one wants to be one"

This was said while we attended a meeting in the Ministry of Agriculture in Chile.

7g. Water management

Water management is a growing concern in Chile. When meeting the people involved in extension services it was obvious they were frustrated about the apparent lack of attention being given to the problem. An increasing number of areas in the north are beginning to struggle to remain productive because of reduced water availability, while other areas still have plenty. If you're lucky

Water management is a growing concern in Chile.

enough to be downstream of Santiago there's an excess of dirty water coming from the city. The dirty water (treated sewage) is channelled straight into land irrigation ditches where its nutrients are used to grow the next crop, which is usually maize. It would seem there's little hydrological work is being done to examine the problem and, with irrigation vital in some areas of the country, more needs to be done. Dairy farming in particular is being encouraged to improve its pollution record so, rather than being allowed to discharge dirty water into the irrigation stream in the winter - which will finally find its way to the rivers and sea - dirty water separation lagoons now have to be built to store effluent so it can be used to both nourish and irrigate crops during the summer.



7h. Chile Conclusions

- Strong work ethic and productivity
- Growing and controlled economy with low inflation and interest rates
- Competition for land and water in the north
- Great opportunity for sustained growth of pasture systems
- Strong research and extension service
- Marginal TMR systems in the North



Errazuriz Estate vineyard, Northern Chile



8. Peru

Lima, the capital of Peru, with a population of approaching 9 million, is the largest desert city in the world and its sprawling development now covers a huge area of almost 1,000 sq km. One of the fastest growing economies in South America, Peru is heavily involved in the export of aluminium, copper and gold. The Lima area receives just 10mm of rain annually so it's obvious this area of Peru is going to be heavily reliant on irrigation for anything to grow. The past 20 years has seen strong growth in Peruvian agriculture since the restructuring of land ownership and today Peru has become a major exporter of fruit and vegetables, most especially artichokes, asparagus, grapes and avocados, to the North American and European markets.

8a. Peruvian Dairying

We spent several days looking at the dairy industry in Peru, and its processing and production methods. In many ways the dairy industry in Peru is very similar to that in the north of Chile. Dairy farming in Peru is totally TMR confinement type with American Holstein cows housed in a combination of free stall and dry corrals.

Gloria, a privately owned dairy company, receives almost two thirds of the milk currently produced in Peru. We visited one of Gloria's processing sites where almost 900,000 litres of milk is delivered each day. Employing three shifts of 500 people, this facility was manufacturing condensed milk and yoghurt for both domestic and export consumption.

We visited two dairy farms on the outskirts of Lima, each supplying Gloria. Although one was three times the size of the other (200 and 600 cows respectively) they were operating very

similar systems and each was unprofitable with the current milk price. Feeding a mixture of predominantly fresh maize, soya and fish meal, both farms looked labour intensive employing around 10 people per 100 cows. The weekly collection of dried cow manure by hand seemed a very laborious job. Loaded into plastic sacks and then loaded on trucks,



TMR dairy near Lima

the manure was sold to small vegetable growers and seemed an important part of the economics of milking cows. The milk price was between 50-55 cent per litre and both farms insisted they needed a price closer to 80 cents if reasonable profits were to be achieved.



Dry dung collection

There was concern that Gloria was abusing their local dominance and only paying a price they could get away with. Gloria was looking



after the smaller farmers but not the large. One particular farm was having to buy in additional maize silage and was trucking it 700km to feed his cows at huge cost while also having to truck in water for his stock to drink due to his own supply becoming saline. He didn't expect to be farming much longer as the city of Lima was gradually surrounding him and the value of his land for development was increasing.

8b. Water management

We managed to arrange a meeting with the Ministry of Agriculture department in charge of water in Lima. They explained how every new water extraction project planned in Peru that requires ground water must first be both profitable and sustainable before they will give it their approval. Each proposal must demonstrate it's carried out the required hydrological assessment work to prove its water sustainability. Other than this sporadic up-to-date-data it seemed somewhat frustrating that little other hydrological data was available and, as the last national hydrological study is now 20 years out of date, difficult to understand how decisions were being made. We were assured Peru has sufficient water reserves to carry out its current agricultural activities and also has the potential to develop a further 600,000 hectares of coastal desert if required. Several times we were told that "if river water reaches the sea it's seen as a missed opportunity in Peru".

There was little apparent enforcement of the current regulation regarding water usage in the country. While the department

acknowledged recent issues with some of the large asparagus growers they were dismissive of this and pointed to poor management of water rather than an overall shortage. The issue of climate change affecting future water availability didn't seem to be of major concern. They considered that as long as there was water reaching the sea at some point during the year there was a surplus. Mining activities, again similar to Chile, were now requiring a greater flow of water, while agriculture used 75% of all water consumption.

As Lima continues to grow, irrigation and food production is bound to lose an increasing amount of its current supply to urbanisation. Research suggests that climate change is

If river water reaches the sea it's seen as a missed opportunity in Peru.

already having an effect on weather patterns in the area; flooding is more common and rain rather than snow now falls in the Los Angeles Mountains (Andes). Heavy

rainfall is more likely to run off the mountains carrying with it many thousands of tonnes of soil which is lost, settling out to sea. The only reason many of the rivers in Peru and northern Chile have water at all is the supply of melt water coming from the tropical glaciers in the Andes. Many of these glaciers have shrunk by between 30-50% since the 1970s and it's likely will be completely depleted in 10-15 years - meaning the rivers will only flow during the winter when it rains. If the region reacts by pumping more ground water to supply the growing needs of urbanisation plus current farming and mining activities, this will only hasten the demise of its alternative source of water, leading to even more rapid aquifer depletion.



8c. Peru Conclusions

- Serious water availability problems
- Growing urbanised population's demand on available water
- Vulnerable to even slight changes in climate and extreme weather
- Food production less important than mining
- Lack of up to date hydrological data
- High cost dairy production unsustainable



TMR dairy farming near Lima, Peru



9. Brazil

Very well known for its highly productive and diversified agriculture, Brazil leads the world in many agricultural commodities. Its production of sugar cane has more than doubled since 1990, driven largely by ethanol production, while in the same period soybean production has also doubled to supply strong export demand. Largely self-sufficient in food, Brazil exports large amounts of coffee, cocoa as well as many soft fruits and fruit juices all over the world.

Based in Rio de Janeiro for a few days we visited dairy farms in the area and the Agricultural University located just south of the city of Rio. Covering 5000 hectares, the beautifully designed campus is the largest university in South America with 10,000 students enrolled, 25% of which are on agriculture related studies. Agriculture is the second largest employer in Brazil and plays a hugely important part in the economy of the country.

9a. Dairying near Rio

Nestle and Fonterra have joined in a venture called Dairy Partners of America (DPA). DPA is working with producers to improve the milk quality in the area and, along with help in the form of a tax break from the government, also seeks to increase production. Since the local coop went into receivership and stopped processing, many dairy farmers in the area have given up milk production altogether. The investment in a new processing facility - 140km south of Rio - by the joint venture is hoping to increase both returns to the farmers and attract more production.

To get an idea of the challenges farmers face producing milk in the area, we visited a grass based farm supplying the new creamery. This farm was trialling cows that were a new breed

consisting of 75% Holstein genetics and 25% Gir of Indian origin. The intention is to breed a cow that can cope with the extreme heat of Brazil and also produce an economic quantity of milk. Paddock grazing was being practised. Although the grass quality appeared poor it was all that could be grown due to the semi tropical climate. The prolonged heat of the summer when temperatures can reach 45 centigrade made it very difficult to grow more productive ryegrass that we would commonly grow in the UK. A common problem in this



Pasture farm

area is that farmers would typically only milk their cows once a day, choosing to suckle with calves for the second milking. Being already small in scale with only 20-30 cows in their herds, losing half the milk to calves only compounds the problems of the dairy companies in regard to efficient milk collection. Somatic cell counts are another issue with the average being well over the new limit of 600. Ideally the new factory wants a milk supply with a cell count of below 400 but, to date, are struggling to achieve this on all but a few farms.

Many dairy farmers are only part time and rely on another source of income. As the dairies start to penalise producers for poor hygiene and quality many will be forced to



quit the industry, while it's hoped those remaining, with slightly larger herds and full time farmers, will expand to produce more. Brazil once had a staggering 900,000 dairy farms producing 12 billion litres of milk. The



Cross bred cows

number is now around half that: 450,000 producing close to 32 billion litres, or around 70,000 litres each.

We don't tend to think of drought when we think of Brazil but in 2012 four states in the north east of the country suffered the worst drought for 50 years when the rains failed for over 18 months. Farming communities lost half their grazing animals and milk production more than halved in the area.

In its single biggest infrastructure spend the Brazilian government is 8 years into building two controversial canals that will bring water from the Sao Francisco River to the affected area, supplying much needed water to agriculture and cities. Unfortunately it's as yet incomplete and won't help the farmers escape from the current drought. Opponents are concerned the river is already over-used, and that the diversion to the north east is unsustainable, and threatens the hydro-electric plant further downstream.

9b. Brazil Conclusions

- Strong diverse agricultural economy supplying global markets
- Dairy systems lacking in economies of scale
- Large number of very small or part time farmers
- Strong growing economy
- Agriculture important for economy and employment



Agricultural College, Brazil



10. California

Often called the Golden State, California is a leading producer of dairy and livestock and, from over 80,000 farms, produces almost half of the United States's fruit, vegetables and nuts. California has over 25 million acres of farmable land, 9 million acres of which are routinely irrigated, predominantly in the Sacramento and Joaquin Valleys. The state enjoys a moderate Mediterranean climate that sees almost the entire rainfall in the winter months between October and March.

Already the most highly populated state with almost 34 million residents, the recent growth in urbanisation of towards an extra 600,000 every year is becoming a cause of major concern in controlling California's main resource, water. Climate change is already starting to affect weather patterns in California resulting in smaller annual rainfall and a reduced snow-pack (40% of normal in 2012) in the Sierra Nevada Mountains from where the majority of California's irrigation and domestic water is derived. 14 million acre-feet (1 ac-ft = 1,233,000 litres) of fresh water is collected from snow melt and run-off in the mountains. This water is stored in reservoirs and delivered to the cities and farmland through an intricate network of pipes and tunnels much of which was constructed almost 50 years ago for a state with half the current population. Sea levels in the San Francisco bay area have risen by 15cm in the last 20 years and are predicted to continue to rise as climate change increases global warming. It's possible the western coastal areas of the US will see an increase in average temperature of over 2°C by the end of the 21st century; this would potentially reduce the amount of snow melt and run-off by as much as 50% in future, massively reducing the availability of water for both

urban consumption and crop production. A combination of more water storage and more efficient usage of water is essential if the economy of California is to be protected. Considerable investment will need to take place - and very soon - if major water shortfalls are to be avoided.



San Luis Reservoir 17% full



Water Canal

The San Luis Reservoir the largest off-stream reservoir in the world capable of holding 2 million acre-feet of water when pumped full, enough for approximately 10 million people. It was 17% full in September 2013.

10a. Dairy overview

Although still the leading food commodity producing sector in the state, dairy farming is undergoing considerable and painful restructuring. Many dairy farmers have left the industry in recent years as the profitability has leached out of milk production. With an



average herd size of just over 1,000 cows there aren't many small dairies left in the state although it's clear to see that formerly there were a lot. The remains of old redundant dairy sheds are apparent almost everywhere. Moving from a simple, pasture based system in the 1970s towards milk production centred around growing corn (forage maize) and cereals through double cropping has massively increased the productivity of the land. Pushing up stocking rates and intensification has led to a conventional system of milk production that now sees many farmers reliant on buying in 50% of the total dry matter requirement for their herds.



Bio gas production

The global push towards bio fuels has seen huge growth in the percentage of the maize harvest being processed into ethanol and, although maize production has increased, ethanol production is now taking close to 40% of the total maize supply. As a consequence dairy farmers have seen purchased feed prices double or, in some cases, even triple in the past 6-8 years.

Water for irrigation use is critically important to California's dairy farmers. Most of the land is flood irrigated from river water, although it's common for farms to also have their own well from which they could pump unrestricted volumes, although at greater expense. Regarded as the most regulated dairy industry in the world by the farmers, air quality and ground water is routinely monitored for

pollution of nitrates. Growing public concern about the levels of water and air pollution has prompted dairy farmers to become part of the California Dairy Quality Assurance (CDQAP) Program where they can become a voluntary certified producer. Nutrient use plans must be written and monitored to obtain and maintain a production licence.

Most of the dairy farms I visited were using free stalls (cubicles) to accommodate the cows. Flush wash systems were commonly used to clean the concrete and then the solids are generally separated from the dirty water and are either sold off the farm, incorporated during cultivation or, in many cases, were being dried and used as cubicle bedding. Water is either sprayed or misted onto the cows during periods of extreme heat during the summer.

High health costs and low fertility - with high replacement rates approaching 40% - have convinced many dairy farmers to cross breed their cows. Using Norwegian Red, Jersey and Holstein genetics in a three way cross gives the ability to lock in the heterocyst effect while also improving the milk solids percentage and hence the milk price.



TMR dairy, California

10b. Full Belly Farm CSA (Community Supported Agriculture)

North West of Sacramento in the Capay valley, Full Belly Farm is a great example of



CSA farming. It now has 1,200 members who can forward-buy from either four, twelve weeks or up to 12 months up-front for a weekly vegetable and fruit box that's delivered to a central point close to their locality ready for collection. Full Belly was originally set up in 1985 as a fully organic farm by four partners, with the intention of "Fostering sustainability on all levels" At the time little organic food production was evident and there was limited local market demand.



12' corn, Central Valley, California

The range of different crops growing on the farm is vast - over 100 different types of fruit and vegetables - ensuring a constant supply and choice of high quality products throughout the year. As well as the membership vegetable box scheme the farm also sells produce wholesale, through local stores and farmers' markets within 100 miles of the farm. To market all the farm's produce

through the membership scheme they would need easily ten times the current membership, so having several other routes to market enables greater variety to be offered to the members and also ensures adequate supply, even during the winter when the summer fruits aren't available. Although members don't get involved in the day to day farm work the farm does invite members to visit several times during the year where they're also able to camp on the farm and see first hand where their food is grown. Currently the farm is employing between 60 and 100 local staff involved with planning and harvesting.

The timing of my visit coincided with one of the busiest seasons at Full Belly, harvesting, clearing and replanting winter crops. Being totally organic nothing was wasted on the farm; a small herd of cows was used to eat the crop residue and sheep were also grazing on another part of the farm. Any un-saleable fruit and vegetables were composted and returned to the land in the form of fertiliser.

With so many different types and varieties of produce growing on the farm, organising the harvesting and distribution looked like a nightmare. Every day harvesting had to be meticulously planned so the daily orders and veg boxes for the following day were filled.

I found a fantastic atmosphere on the farm; everyone seemed very happy and content working very hard providing high quality, highly sustainable food. It was very similar in many ways to the CSA farm I visited in China and again I wonder how scalable this concept is. CSA doesn't mean food has to be more expensive although it does mean fruit and vegetables are only available seasonally which many consumers don't really understand. Interestingly I wanted to know if there was such a thing as a typical CSA member. Apparently there's both young and old and



very often young families are keen to be involved as members; but the one commonality was the members were all well educated to the nutritional value and safe production of their food.



Full Belly tomatoes



Full Belly Farm

10c. Straus Family Dairy

In the beautiful rolling hills north of San Francisco bay is Marin County. Enjoying almost twice the rainfall of more eastern parts of California this area is predominantly and traditionally a pasture dairy farming area with

small amounts of corn (forage maize) and some cereals grown to feed during the summer dry period. My visit in August 2013 was towards the end of a very dry and hot summer following a winter where California had received around 40% less rain than normally expected. Other than irrigated areas there was very little greenery, with the majority of the hill areas covered completely with dead grass and vegetation.

Strauss Family Dairy was originally started by the current president Albert Strauss's grand parents, Bill and Ellen Straus, but it was Albert who converted to organic in 1994 and began processing and selling the farm's milk into product. Although today relatively small in the context of dairy processors, Strauss has been very successfully growing its market for high quality organic and GMO-free dairy products. Producing yoghurts, ice cream, cream and butter as well as bottling milk for both retail and wholesale, Strauss is enjoying being at the forefront of the strong organic food growth in the US. The current pace of growth is such that the original creamery is running out of capacity and Strauss will have to invest in more processing, a new site for which is being sought.



Marin county north of San Francisco

As both the first organic dairy farm in the area and the first 100% certified organic creamery in the US, Albert isn't surprised that almost three quarters of all dairy farms in the Marin and Sonoma counties are now either fully organic or in conversion. The premium that



Strauss family dairy

organic milk production attracts is literally a lifeline to many struggling dairy farmers in this part of the US.

Typically US dairy farms would expect to be buying in 50% of total dry matter requirements to feed their cows. A combination of several factors, not least the relatively recent huge growth in ethanol production, has almost tripled the cost of many of these purchased supplements, forcing many dairy businesses to quit the industry or to diversify into other crops. Many have diversified into growing almonds on part of their land, to gain a share of the booming export demand from Asia. Other farmers who can, have opted to convert to organic farming. One of the main limiting factors for many dairy farmers that prevents them from converting to organic is the vast reduction in stocking rate as many farmers have insufficient land area to carry a

sustainable number of stock. As 30% of the dry matter intake has to come in the form of grass, many highly stocked conventional dairy farms just simply cannot achieve this.

The strong values of organic production, GM-free and environmental stewardship that have driven the development of the Strauss Family business since its inception in 1994 now places this model of dairy farming as both profitable and highly sustainable in an area of the US where dairy businesses have typically intensified production systems but have found sustained profitability challenging in recent years. With milk that is produced locally, processed locally and consumed locally, Strauss are also employing people who live locally and as such are contributing to the social and economic prosperity of the local community.

10d. California water management

It seemed clear to me the water system is already in crisis in California. Although the north of the state has water in abundance its commitment to providing the southern parts of the state with some of its needs is placing huge pressure on this finite resource. As the population in California grows and urbanisation draws ever more water away from agriculture, considerable investment is going to be required in the near future to provide additional storage of melt water and seasonal rains.

Californian agriculture contributes \$37.5 billion to the US economy from its largely family farms. Finding a balance that meets everyone's needs in the future is going to be very difficult. It could be that the current reduction in rain and snowfall is just a short

It seemed clear to me
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term cycle. If, however, it's the beginning of a long term weather trend and is indeed a result of climate change, the long term impact on ground water levels is going to be very damaging for the state.

In an interesting and novel approach conservation groups are already working on projects that are attempting to recharge the ground water levels. Sustainable Conservation, a charity funded organisation, has partnered up with the industry to help farmers develop new technologies that will enable them to make better use of water and their nutrient resources. Collecting data from farms and measuring the crop reaction following the application of fertiliser or dirty water, the aim is for farmers to be more accurate in the timing of their nutrient application without restricting crop yield potential. Their philosophy that good environmental practice can be good for business has been embraced by many farmers who are keen to be part of the development of a sustainable future. Working with farmers to reduce the emission of greenhouse gasses and nitrate into the ground water has been central to their work so far.



Dirty water flood irrigation

10e. Center for the Urban Education about Sustainable Agriculture (CUESA)

In California I visited the Ferry Building, housing the Farmers' Market on the harbour

front in San Francisco. Attracting between 25,000 and 30,000 visitors a week it's one of the busiest farmers' markets in the world. Since it opened in 1993 the market's gone from strength to strength and is now a vital link between the local farmers and their consumer public. Seldom have I seen such a



Ferry Plaza Farmers Market

vibrant display of produce as I witnessed on the day I visited. Fruits, vegetables, dairy products, meat and honey - to mention a few - and all produced from the local area; more a celebration of food than a market. There's no doubt that the sustainable food movement's alive and well in San Francisco with many people consciously choosing to buy local sustainable food that's not travelled halfway around the world.

While operating a very successful farmers' market, CUESA also provide an educational service for schools, offering farm tours, cooking demonstrations and information relating to sustainable food production. They've a fantastic commitment to the community, helping to incubate new small food businesses by supporting entrepreneurs to get a foothold in the market place, promoting high quality, healthy food that's available locally.



Ferry Plaza Farmers' Market

10f. California Conclusions

- Almost totally dependent on irrigation
- Vulnerable to climate change
- Urbanisation requiring a greater share of the available water
- Growing consumer awareness of food system and sustainability
- Highly dependent on immigrant labour
- Adaptable to change
- Marginal profitability of dairy, leading to lack of investment
- The opportunity and threats of growing crops for fuel



The sign says it all, really!



11. Discussion

Being exposed to a snapshot of global agriculture during my travels in the past year, it's become apparent to me that major and unavoidable change of the global food system is imminent. The variability of the changing climate and the unpredictability of weather pattern will, I believe, be the most challenging aspect of farming and food production in the future. The demands of an anticipated extra 2 or even 2.5 billion extra consumers will draw heavily on the earth's resource, meaning the available productive land and water decreases.

Are we concentrating too much effort towards extra production rather than controlling consumption? Most developed western countries have seen populations rise and peak and, as fertility rates reduce, populations are stabilising at their current levels. Rather than accepting continued population growth to a peak of between 9 and 10 billion, could we through the provision of education and improving the availability of effective family planning in developing countries attempt to reduce the peak?

A modern western society that accepts massive food and resource waste will need to become more aware of its responsibility to successive generations. Discarding food that been grown with an unsustainable water source and has then been transported halfway round the world, is simply irresponsible. Not only are we burying the

food waste but we also bury the valuable resource with it. We need to establish a network of local food production and delivery systems, reducing where possible the energy consumed hauling food around the globe and helping to reconnect consumers with local and seasonal food production.

The speed of the transition the developing economies of Asia are making towards lifestyles based on consumerism will leverage unprecedented pressure on the world's current ability to deliver. While the discovery of new energy in the form of shale gas makes it difficult to predict the timing of fossil fuel depletion, the urgency that we greatly extend our use of renewable energy will increase as we see the consequences that increasing

levels of CO₂ in the upper atmosphere bring to food production and the rise in adverse and unpredictable weather.

Farming systems that are reliant on the input of nutrients, energy and water heavily dependent on inexpensive hydro-

carbons will need to examine alternative methods as the demand, availability and the cost of energy increases. The efficient use of nutrients on farm will become increasingly important, with all farmers needing to be aware of the need to balance their own nutrient flow. With the increase in global urbanisation comes competition for water currently used in agriculture. Improving water

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use efficiency is crucial for all end users if we are to balance the need of everyone.

The future food systems we develop will be determined by how effectively we can implement change and how quickly we can develop and integrate new technologies. Industry leaders need to fully understand the future challenges and be able to effectively communicate the correct messages to our politicians and policy makers. The short term

thinking of the past, when we could rely on ever increasing crop yield and cheap energy, is out of date. There's greater consumer awareness of the harm industrial farming is doing to the world ecology so it's more essential than ever we have clear discussion of the issues and clear development of future policy where farming systems that promote sustainability and protect biodiversity are encouraged and rewarded.



12. Conclusions

1. **Major change is unavoidable as 2.5 billion Asian consumers fast track towards a western lifestyle.**

The extra demand on global resource is huge as we try to provide for a combination of growing affluence and growing population. We have only one planet; change for us all is inevitable.

2. **At the current rate of abstraction I believe the world is rapidly approaching a potential water crisis.**

Over half of the world population now lives in countries where water tables are continually dropping over large areas. Many countries have already depleted their aquifers well beyond their recharge rate and have been forced to reduce their irrigated area and food producing capacity.

3. **The competition for water between growing urbanisation and growing crops will only intensify.**

Massive growth in urbanisation and its subsequent water use is already reducing the availability of water for agriculture all round the world. It's unlikely this will improve until the perceived value of food changes.

4. **Producing fuel from irrigated crops is a short term fix for a long term problem.**

As the available water is found deeper underground it becomes increasingly uneconomic to abstract for crop irrigation and food production. Most of the easy oil has already been used so it's highly likely that oil will only ever now increase in price. Food economics are going to be increasingly determined by oil economics in the future.

5. **Climate change is already having a major impact on food production.**

Irregular weather patterns, excessive heat, cold and rain are impacting on agriculture and water availability. Crop failures will become more common in the future. The unpredictability and severity is more challenging to agriculture than the gradual rise in global temperatures.

6. **The food industry has largely failed to incorporate the true cost of food production into the value of the product.**

Cheap and abundant food production has led to consumers being misled as to the real value of food. The long term environmental cost of industrialised farming has been largely ignored, but will still need to be funded.

7. **The gradual stripping of value from food during the past four decades has led to huge amount of perfectly edible food being wasted.**

Between 30-50% of all food grown is never consumed. Perceived by the majority of consumers as cheap and plentiful, food is massively undervalued.



13. Recommendations

1. **Managing population growth could be more achievable than attempting to feed 9.5 bn people.**

Stabilising population growth needs to become an international priority. Investing in improved access to family planning and education in the developing world would pay dividends.

2. **We need to improve how we educate the consumers of today and tomorrow.**

Today educated consumers already eat healthier diets and buy more sustainable foods. Education in food and nutrition needs to start very early and continue throughout every child's education.

3. **Innovation could provide the answers or at least some of them.**

It's more essential than ever that we continue to expand the amount of research and scientific work developing new technologies for agriculture.

4. **We need to cultivate the middle ground.**

The future success of agriculture depends on a combination of past, present and future. An open-minded, flexible approach will enable solutions to be developed. We cannot allow ourselves to become polarised in our opinions, GMO v non GMO, organic v conventional.

5. **Clear signals from governments are essential.**

Governments have a crucial role to facilitate the change in consumers' eating and buying habits. Tax incentives and adapting EU support payment terms could be used to move agriculture to a more sustainable footing. Internationally government can influence change on a much larger scale.

6. **Consumers need to be informed in order to make informed choices.**

It's very difficult to gauge from current food labels or packages how sustainable a food or a food product is. Clear labelling, detailing the virtual water use and carbon footprint, would help consumers make decisions.

7. **We need to establish an effective network of local food production and delivery systems.**

Reduce where possible the energy consumed and help to reconnect consumers with local and seasonal food production. The high financial and environmental cost of transporting food around the world to satisfy consumer choice will become unacceptable.

8. **The UK is very well placed to produce high quality, highly sustainable food in the future - if we're asked to and if we choose to.**

Few places could compete with the climatic advantages we have in the UK for growing sustainable food. The luxury of the cheap, out of season alternative to local food won't last for ever. But there's little time for complacency.



14. After Nuffield

Realising that my dairy farming businesses have managed without me has been truly liberating and I see my Nuffield Farming travels as the beginning of a new chapter of my life.

Similarly to many other Nuffield Farming Scholars before me, I now feel the need to inform and educate all around me with the messages of my study. Reviewing the many pages of notes taken while travelling and researching has proved once again how few people are aware of the limitations of the world's current food system. Using the unique perspective my Nuffield Farming Scholarship has given me, I intend to focus some of my time post-Nuffield to help promote sustainable farming, while also influencing industry leaders and politicians. Already I've been requested to speak at various events during the next few months about my Nuffield study, and will also

continue to welcome visitors to our farms from groups and individuals seeking to learn.

Business as usual is no longer an option and it's essential more people recognise this and the sooner the better. I believe it's important all Nuffield Farming Scholars continue to transfer the messages we've had the privilege to acquire and encourage fellow farmers to apply to become the Scholars of the future.

Spending considerable time involved in industry politics with the NFU gave me a taste for further political involvement, so in early 2013 I became chairman of Penrith and the Borders Conservative Association, a maximum three year term which, to date, I find both challenging and enjoyable. I now need to establish the most effective route available for me to convey the messages from my study to those who can drive and engage in change.

The relentless pursuit of endless economic growth based on finite global resources is surely flawed. We need to develop a new model for future prosperity that is aware of its own limitations.



15. Executive Summary

To satisfy growing global demand agriculture needs to deliver more food. From my travel and study I wanted to uncover the answers to a series of questions relating to the structure of food production. Is it possible from the world's resources to produce sufficient food to feed a further two billion people? What are the main constraints to producing more food, and how do we overcome them? How much of our current food production system is already sustainable? Are truly sustainable farming practices scalable?

To explore both the production systems and the consumer values of rapidly developing countries I visited China, India and South America. In order to learn how sustainable food production already is I chose to visit two countries that are each very dependent on, and very efficient at, producing food from the land: California and New Zealand.

As a result of my findings I've decided to concentrate the bulk of my report on the most important constraint that I believe will have the largest impact on whether the world can sustain or increase food production; and that's the availability of water for irrigation.

I've become increasingly concerned by the lack of awareness to what I see as a potential global water catastrophe. As the global population and the demand for food has increased, vast areas of the world are now routinely irrigated to meet that growing

demand. Water is now being used faster than nature can replace it, aquifers are being depleted, rivers dammed and diverted. Areas dependent on glacial melt water are experiencing reduced flows and once-dependable weather patterns are now increasingly difficult to predict.

Once a climate change sceptic, I now realise how serious unpredictable and changing weather patterns are for many areas of the world. Excessive heat, reduced rainfall, or even just rain instead of snow, are having an increasingly dramatic effect on food productivity around the world. Cheap oil has enabled mass transportation of commodities and food products around the globe, facilitating vast consumer choice of foods with little regard for value or seasonality. This growing choice and abundance has delivered a modern consumer who has little regard for the resource that's been delivered during their food production.

This, I feel, we must change. Sustainable food production is now widely available and I believe we will see more consumers making a conscious choice to use it in the future. In helping make that change I feel it's vitally important we improve the food education of our children to enable the consumers of tomorrow to make value driven choices which will drive the marketing and production changes the world needs to see.



16. After-word

You could be forgiven for thinking that I've overlooked a whole range of contributing factors that will add to the challenge of feeding our crowded planet. Soil erosion is a very real and constant threat to how much productive land is available to grow food. Some would argue a combination of desertification and flooding is having the greatest impact of all, relocating thousands of tonnes of valuable fertile soil every year. Others would point to the plateauing of grain yields reaching the so called glass ceiling where future increases in productivity will be only fractional when compared to the past.

Another commonality in virtually every country I visited was the lack of young, well educated, enthusiastic farmers to deliver the industry to the future. It still amazes me that an industry which is so important to us all is so apparently disrespected by so many. Farming can still be seen as uninspiring and manual, a bottom-ladder occupation which is only an option for the less academic students.

Managing the expectation that several decades of cheap, valueless food has instilled in consumers could be the biggest challenge of all. Changing the eating and buying habits of several billion of the world's population isn't going to happen overnight.

I certainly didn't set out to study the consequences of the world running sort of fresh water. During my report I've referred to Virtual water several times. Virtual water is a means of quantifying how much fresh water resource has been used up in the growing of and/or the production of a commodity i.e. food. Very soon after I started researching and travelling it became apparent to me that water was by far the most critical element of our global food chain.

On the next page I've included two diagrams that I believe visually explain the current movement and consumption of water in our global food system.

As more of the world's population look to consume animal rather than vegetable protein, virtual water consumption will increase massively which in turn will lead to increasingly volatility in commodity trade and food insecurity for many of the world's poorest. As we are now seeing in an increasing number of failing North African countries, it's highly likely there will be more conflict, the catalyst of which is inadequate food and water as a growing number of countries find themselves unable to provide for their people

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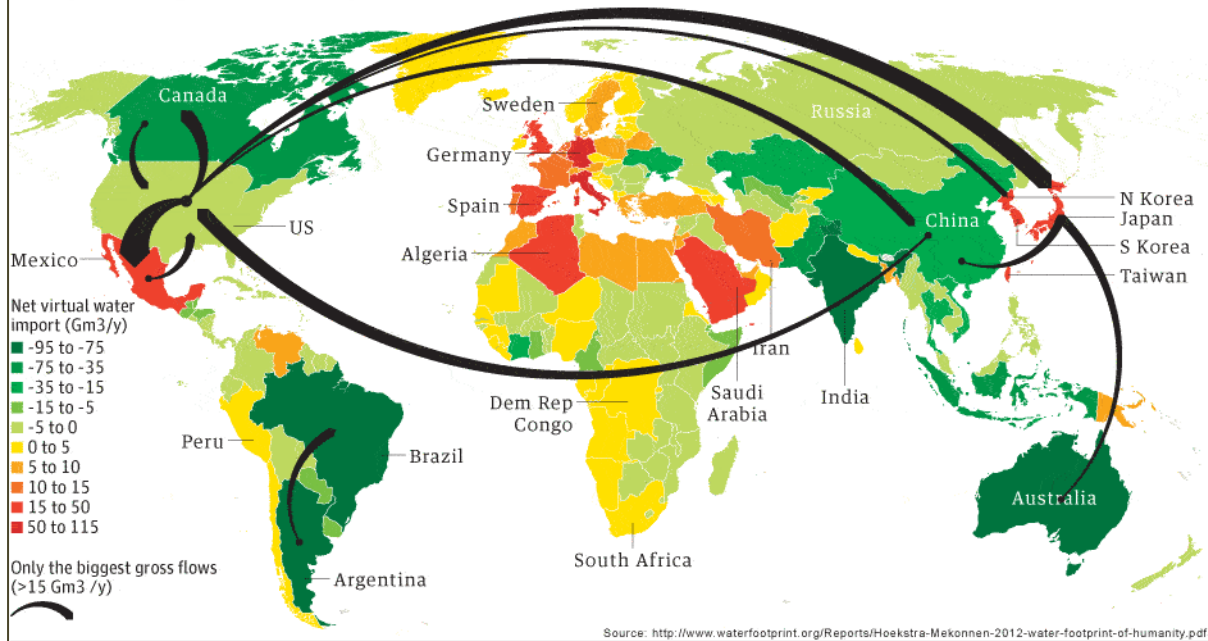
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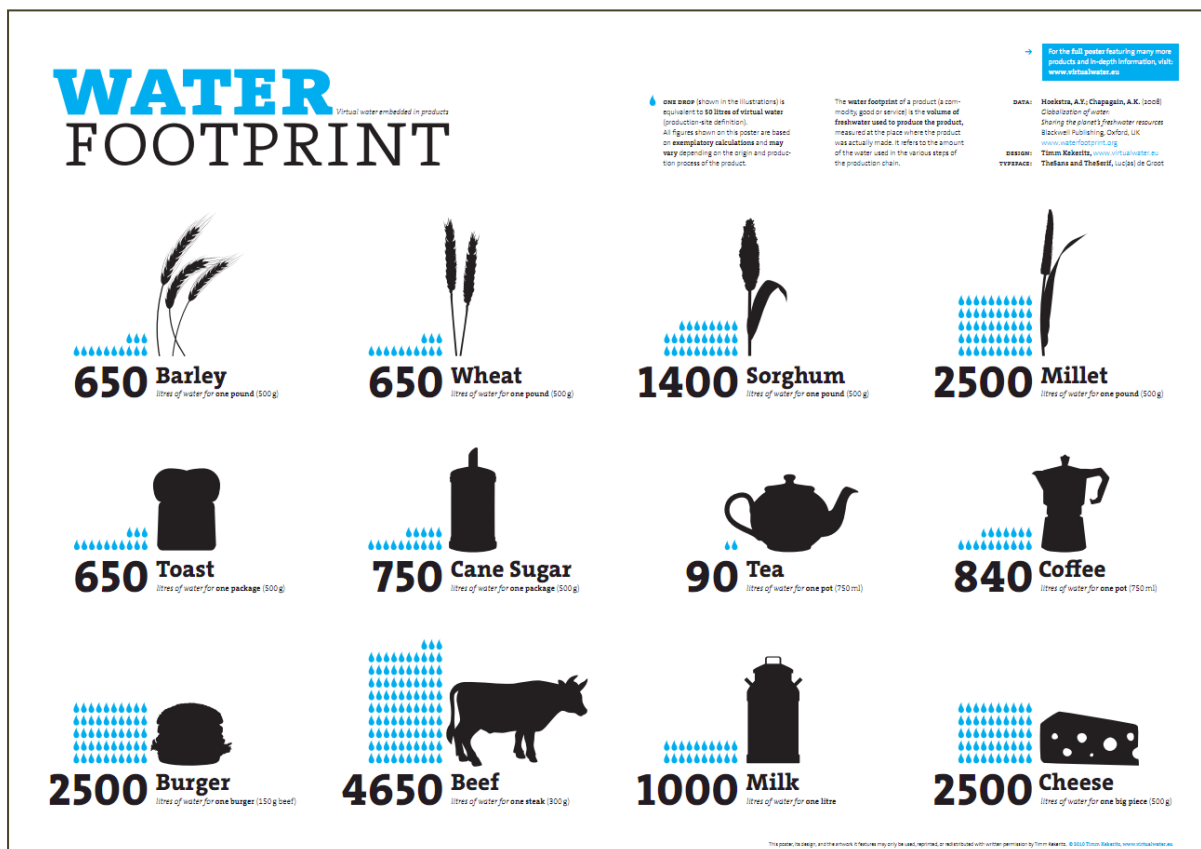


Virtual water balance

The exports and imports of water through food and commodities, 1996-2005



Virtual water movement



Water footprint

The true cost of cheap food by Robert Craig

A Nuffield Farming Scholarships report generously sponsored by the late Harold Cowburn NSch