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**Plenary Addresses – Environmental Health
Plenary 11 – The Future of Agriculture and the Green Environment
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When I left Adelaide, the weather forecast was for showers some time this week, and you may not believe how happy that made everyone. In South Australia (and much of Australia) we have had a drought lasting several years. As a result of the lack of rain, farmers have become ever more reliant on irrigation from rivers, in our case the River Murray, and pumped ground water. Because of the lack of rain, the rivers have much less water in them, and the more ground water we use, the higher the salinity in the topsoil. Crop production is down, and after some years of drought now stands at about 30% below the five year average; rice, meat and wheat production have fallen, and world prices have risen.

Only last week, you would have heard the Secretary-General of the United Nations say that we must double world food production by 2030 to meet the world's needs and prevent escalating food riots. Is this a result of the now well-accepted concept of climate change that has been described in the UN Intergovernmental Panel on Climate Change report which was a recent joint-winner of the 2007 Nobel Prize. Or are there other factors? If it is, then what are the principal causes, and is agriculture contributing to those causes, or can it assist us in addressing the issues.

Agriculture can:

- feed us
- clothe us
- provide energy and fuel
- have a major impact on the environment
- make the world a better place to live in

Without agriculture, we revert to being hunter-gatherers clothed in the skins of wild animals and suffering poor health. If you compare agriculture with the other industries that surround us today, you will appreciate that in the larger scheme of things, those other industries don't much matter.

So why is it that we value agriculture so little? Why do we resist many of the new ideas and technologies? Why do we allow the land, and the air and water on which it relies, to be abused and degraded?

If I go back just a few years to my own days as a student of agriculture, when the population of the world was around 3.5 billion, many of those people were hungry. Pollution and environmental damage had not been recognised, and the concept of global warming didn't even exist. Clean water, at least

where I lived, was plentiful, but arable land was in short supply, as always, because they'd stopped making it.

We all had a mission which was to feed the world, and we innocently thought that meant growing enough food for its population.

The role of economics, politics, and corruption were unknown concepts, but this would soon change. Of course, we should have understood these issues, and I certainly should have, growing up as I did in Ireland, the land of the Great Potato Famine. The potato was the staple of the local community, and its production was cruelly administered by the Government, with much of the potato harvest, along with other crops, exported for profit. By the early 1840s, food shortages were common, and when much of the crop failed, beginning in 1845, the effect on the population was enormous, with perhaps a million deaths out of a population of 8 or 9 million. Yet throughout the worst years of the famine, huge quantities of grain, meat and other foodstuffs were exported from Ireland to England throughout the period when the people of Ireland were dying of starvation, and food was shipped under guard from the most famine-stricken parts of the country. The impact of economics, politics, and corruption are not as new as we might think.

I went on to become a plant physiologist, and many of my friends became crop scientists, plant breeders, food scientists, animal scientists, and the like. Around the world, research had been focussed for some time on how to dramatically increase food production, and when the former USAID director William Gaud first used the term "Green Revolution" in 1968, he gave a name to the movement that had seen the spread of new technologies and other developments in the field of agriculture since World War II. By the late 1960s, modern, high-yielding varieties of rice and wheat had been developed and were growing in many countries. This continues and now extends to most crops, with many thousands of scientists developing new varieties which, given proper growing conditions, give stunning yields.

So agriculture did what it said it would do. It produced enough food for the world's population. Of course, people needed to be trained how to grow the food, as they required suitable soil, as well as economic and political stability. But in those parts of the world where these conditions were met, there was truly spectacular growth.

Yet as farming became more intensive, there were unexpected consequences. Fertilizers were finding their way into water ways and creating problems that only gradually became apparent. Pesticides enabled further huge increases in production, though once again there were some effects that only became apparent later, most notoriously in the case of the first of the synthetic pesticides of the modern era, DDT.

In addition, greed, stupidity, and natural disasters often meant that food was not in the right place at the right time. We still see all of these today. A willing world should be able to mitigate the impact of natural disasters such as we have recently seen in Myanmar/Burma. High quality education that crosses national boundaries has become available and is arguably the best, and perhaps the only, remedy for ignorance and downright stupidity. Unfortunately, there is no easy solution to the problems of greed and misplaced ambition, as we see, for example, in Zimbabwe at present.

So we have had a Green Revolution, but this has occurred in parallel with environmental degradation and Climate Change. People are still starving, and there are more of them, with the world population now estimated at around 6.7 billion, with estimates of a world population of nearly 9.5 billion by 2050. Many diseases have been controlled, nutrition has been improved, infant mortality has been reduced, people live longer.

In fact, people are in danger of becoming the problem, rather than providing the solution: we need another Green Revolution, though the next one will need to be more sophisticated than a push to increase crop production.

In the past, agriculture was assumed to be sustainable (assuming that means “green”, among the many understandings of that word nowadays). Now, however, we must make agriculture sustainable and it must play a role in making our entire lifestyle sustainable.

Agriculture can, and will continue to, provide:

- food
- clothing
- energy

The fourth thing agriculture does is impact on the environment. The key environmental issues facing agriculture at the present time are

- air
- water
- soil
- temperature
- biodiversity

Addressing these issues this will take place within a framework of changing consumer preferences. We see many parts of the world preferring meat to carbohydrate and as a consequence reducing total food production.

We also see a growing organic production industry, again with lower yields and higher prices. We see resistance to genetically modified foods; to foods whose production has resulted in environmental damage, such as deforestation for coffee growing; to foods where the grower has not been properly rewarded. As well as these growing consumer preferences, the normal political and economic pressures apply.

Only two weeks ago, I noted this heading in the Sydney Morning Herald: “How green was my latte? The big switch.”¹ Do you care if your coffee was produced on cleared rain forest, or if the people growing it received a fair price? Increasingly, people do care and the report was to the effect that Macdonalds in Australia will, from next year, ensure that all its coffee beans are grown in environmentally friendly conditions. The 484 Macdonalds restaurants have already begun switching to coffee brought from South American plantations with the highest environmental standards. This represents 20% by value of

¹ Sydney Morning Herald, 28 May 2008.

all the coffee sold in cafes in Australia. They will carry the green frog label of the Rainforest Alliance and will almost certainly cause other retailers to follow.

The same also applies with regard to other big ethical and social issues such as animal welfare vis-à-vis poultry products, pig farming, and so on.

Of all the ways in which agriculture impacts on and interacts with the environment, the issue of greatest concern in the global community surrounds **atmospheric temperature**, and there can be few people who have not yet heard of Global Warming.

The main driver in global warming is, of course, **carbon emissions**. We have seen carbon dioxide levels rise from around 280 parts per million at the start of the Industrial Revolution to around 390 ppm at the present, and possibly climbing to as much as 550 ppm by 2050. Agriculture contributes to this in a number of ways, mainly through the use of tractors and other machinery, and through crop burning in some countries. There is a move towards no-till and reduced tillage systems in many places as a means of carbon sequestration, but its economic benefits are yet to be fully realised, and it continues to present significant challenges in terms of soil quality.

After carbon dioxide, the next most common greenhouse gas is methane. The relative abundance of methane and its clean burning process makes it a very attractive fuel, but it is also a potent greenhouse gas, generating something like 25 times the impact on temperature of a carbon dioxide emission of the same mass.

More than half the world's emission of methane is due to human activity, and the single largest contributor is the cultivation of livestock, mainly cattle, of which there are estimated to be some 1.5 billion worldwide. Over the course of a day, the average cow will produce between 200 and 300 litres of methane – and in case you were wondering, something like 97% of it comes out the front end – they burp! This is a consequence of eating grass which, although it is a magical plant and grows almost everywhere, is not easy to digest – which may explain why so few people have tried to survive on salads made with grasses. Cows have a special stomach in which there is a bacterial population that begins the digestion process, producing methane as a result.

This might be remedied by changing the type of grass, or the type of bacteria by selecting new strains and genetically modifying them, and there are Cooperative Research Centres in Australia working at present on just this problem in an attempt to decrease methane output without having a big impact on an animal's ability to grow, while still using the feed they eat.

Biofuel. One area in which agriculture has the ability to utilise carbon dioxide to solve not only its own problems but those of the wider community, is in the area of biofuel, though it should be noted that this potential goes hand in hand with an ability to significantly reduce food production, and not just in the wealthier countries.

Put simply, plants extract carbon dioxide from the atmosphere, converting it into carbohydrates which can then be converted to fuel, usually alcohol, biodiesel or gas. Alcohol production has become all the rage, especially in the USA. A recent estimate forecasts US production of ethanol to reach 7.3 billion

gallons by the end of 2008.² This is mostly made from maize which would otherwise be food for humans or animals, or grown on land where foodstuffs would otherwise be grown. The *Energy Dependence and Security Act 2007* (US) will ramp this up to 36 billion gallons by 2022. The 2008 figure would account for 4.3 billion bushels of maize and is almost certainly a contributing factor to increasing world food prices.

And before I leave that slide, it is worth noting that Australia is coming in strongly in third place behind Brazil and the USA.

Alcohol production is, of course, nothing new. It has been happening in some countries for many years. Brazil, for example, has an ethanol fuel program stretching back 30 years, where sugar cane is grown and used as feedstock. Whether biofuel is part of the problem, or a potential solution, to our addiction to oil, is a question that is yet to be answered.

And it is worth remembering that we don't have to pay to produce crude oil – it is a legacy many millions of years in the making. We do, however, have to pay for the production of biofuel, and part of that price may be a reduction in the amount of food that is available for human consumption.

If we do move to biofuel, will it be oil-plants for biodiesel, or carbohydrate for alcohol, or perhaps neither, if we opt for natural gas. In any case, our focus should be on the use of waste or the production of biofuel on land that cannot be used for food production. Brazil can again be cited as an example, where residual cane-waste is used to generate heat and power, and is directly attributed to the very competitive price of ethanol produced in this market.

Currently, ethanol is produced from sugar, but we must remember that biofuel can, after all, theoretically be produced from any living source. Ethanol produced from useful components of non-food energy crops, especially cellulose and lignin, is showing promising signs, but is still prohibitively expensive. One option would be to use perennial, aggressive plants, though this would bring risks to biodiversity, and the threat of weed invasion. The basic message, however, must be – “Don't make biofuel *instead* of food.”

If solutions to current disincentives can be found, a multitude of possibilities would open up. Perhaps we could even convert the vast quantities of sewage flowing out of our cities into biofuel, thus solving two problems at the same time. Algal biodiesel from sewage ponds is showing encouraging results.

How much of this would be agriculture, and how much an industrial process? In the future, we may well see a blurring of the line between these activities. Already in Australia we see many farmers producing biodiesel for their own use. We will see forests of trees capable of being harvested every 2 or 3 years before regenerating. And we may well see giant grasses and reeds. Indeed, it may well be that biofuels are produced by algae growing in large plastic bags which the sun can penetrate, and while we might feel this is a process more akin to brewing, it is at the same time not far removed from hydroponic vegetable production.

² Lynn Grooms, Biofuels. Corn and Beyond, *Farm Industry News*, February 2008.

The farmer of the future will likely be farming for energy, and where the farm is not sufficiently productive to grow crops in the soil, they may be grown in an artificial environment, or else the energy may simply be collected using a solar system. If farming of the future is to feed cars as well as people, then we will need to be very clever in maintaining a balance.

Residues and contaminants. Generally these are seen to be the pesticides and herbicides used in modern agricultural production, now increasingly regarded as undesirable.

However, not all contamination can be blamed on agrochemicals, eg, how do we deal with our own rubbish? Put it in a hole in the ground? Dump it at sea? Or a more novel solution like the one used for domestic rubbish in Paris (and later, Rheims) which was to grind it up and spread it over many of the Champagne vineyards as a fertilizer. Never mind the possibility of persistent and toxic heavy metals! And when did this happen? For nearly 30 years, from 1960 to 1998!³

Now, back to pesticides. If we don't use them, production falls and the risk of food contamination rises, and most of today's agrichemicals are environmentally friendly to a greater extent than many natural productions which are sometimes touted as the solution to these issues. I, for one, would prefer not to eat crops treated with materials such as nicotine! We can continue the development of environmentally safe agrichemicals and develop the use of biocontrol systems which we already see on some farms and which can undoubtedly be extended significantly.

Let us by all means find ways of minimising chemical inputs (eg Kiwi Green, a New Zealand program of initiating environmentally-friendly projects into the community). This will not, however, be enough in the green future. The recent headline in the *Straits Times* "Not so sweet news for mango lovers" is an example of the likely impact of climate change on crops, and the doubtful measures to which desperate growers may resort. It also shows the importance of standards and a tracking system to protect consumers and ethical growers.⁴

And I haven't even talked about water and the extraordinary steps – and supporting research – we need to ensure a reliable supply and effective utilisation by people, crops and the environment, including crops that use less water, and don't mind that water is a bit salty. Or biodiversity, and the steps we will need to take to ensure the plants and animals with which we share the planet are protected for the future.

A better place. Universities and their alumni were the drivers of the so-called Green Revolution that ran through the 1940s to the 1970s, in which an international effort aimed at increasing the productivity of land by means of the introduction of science-based technology in the production of foodgrains. However, despite the fact that the Green Revolution did achieve its objective of increasing food supply in developing nations, it had massive and lasting ecological and socioeconomic implications on both the environment and society. In focussing solely on food production, scientists failed to take into account the impact of distribution and equity on food supply. It offers many lessons to modern scientists, especially the importance of adopting an integrated approach to research both now and in the future. It also demonstrates the importance of the sort of research being conducted at places like the Waite Agricultural Research Institute and the Roseworthy Campus at the University of Adelaide.

³ Andrew Jefford, *New France*, Mitchell Beazley, 2002, p.31.

⁴ See also, for example "Climate, chemicals cruel India's mango harvest", *The Australian*, 10 June 2008, p.10.

Conclusions

1. Food production will increase dramatically.
eg, cereal demand will increase 50% by 2050 / control population / value farmland.
2. Agriculture will be responsive and Climate Change will be one major driver.
eg, temperature, salinity, consumer preferences.
3. Service niche markets.
eg, organic, environmentally friendly, ethical (to growers and animals)
4. Agrochemicals will need to be proven environmentally friendly and minimised.
5. New techniques will be widely adopted.
eg, biocontrol, genetic modification, minimal energy impacts
6. Enforceable international standards of food quality.
7. International food tracking systems.
8. New “crops” – farming will feed cars, but not at the expense of food.
eg energy (biological, wind, solar), natural ecosystem management
9. Massive breeding programs and rapid adoption.
eg, water efficient, salt tolerant, temperature tolerant, pest and disease resistant, perennial wheat, rice, etc.; health supplemented, eg, iodine, fluorine, nutrients.
10. An end to distortion by subsidy.
11. Growers properly rewarded in all countries.
12. Education and research should replace emotion
the future is built on science and everyone needs to understand it.