CHECK AGAINST DELIVERY

Frank Parkinson Lecture

CLIMATE CHANGE: CHALLENGE OR OPPORTUNITY?

It's a very great honour to be invited to deliver the Frank Parkinson Lecture, following in the footsteps of such distinguished predecessors.

Having heard Stuart Agnew say that climate change isn't happening I wondered if I should ditch this lecture

But I am not. Because he's wrong.

But his comments and those of the other politicians this morning make an interesting listen for me as a scientist. They say that they want more science and evidence, but what they really mean is that they want more science that supports their policies, whether its on climate change as in Stuart's case or badgers and TB.

They are happy to cherry pick.

Not like you who depend on science

How confident can we be that the climate is already changing, will change more in the future, and that human activity is the main cause?

The Intergovernmental Panel on Climate Change's latest report, reflecting the views of thousands of scientific experts from around the world, concludes that it is *"extremely likely (defined as more than 95% certain) that human influence is the main cause of climate change".* The IPCC's confidence in this conclusion has increased since its previous report.

While this is not the time and place to go into the details of the evidence for climate change, it is perhaps worth reminding ourselves of three incontrovertible facts

First, the world is warming: the global average temperature has increased by about 0.8 degrees Celcius since 1900, and the US National Climate Data Centre reports that up to 2013, nine of the ten warmest years in the 134 year record have been in the 21st century. 2014 will probably turn out to have been the warmest year yet on record, making the score 10 out of 11 since 2000.

Here in the UK 2014 was our hottest year since records began, so that 8 out of the top 10 warmest years have been since 2002.

Second, the concentration of carbon dioxide in the atmosphere has increased rapidly in the past 150 years, as a result of humans burning coal, gas and oil, carbon stores that have been secure underground for up to three hundred million years.

Third, carbon dioxide, along with other gases released into the air by us, acts as a blanket to keep the sun's heat close to the earth's surface: the greenhouse effect. The greenhouse effect was first shown in experiments by John Tyndall in the 19th century.

There is, however, uncertainty about the magnitude and speed of climate change.

Scientists cannot predict the precise path of global warming, but we can be very confident that there will be change, so we need to build resilience for a range of possible futures.

And we mustn't forget that climate change is not just about warming.

In this country some of the most severe impacts might well be through sea level rise and consequent flooding of coastal areas, and extreme weather events such as those that caused the winter floods at this time last year, as well as summer heat waves. Once in a 100 year floods today may well be once in 10-20 years by the 2080s and heat waves such as the 2003 summer may be the norm by 2050.

To quote the Vice-President of the NFU, Guy Smith: *"The IPCC's review of the latest evidence points to the range of possible challenges ahead. The impacts on agriculture of the extreme events this decade alone mean that we can't keep on gambling on our ability to produce food in the UK whatever the weather".*

There are still some people who, in the face of overwhelming evidence and analysis, think that climate change is either not happening, is not caused by humans, or is nothing to worry about, or some combination of all three.

Perhaps they get confused between year to year variation in weather and long term effects of climate change.

The former Secretary of State for the Environment, Owen Paterson, is one of these climate deniers. They are not sceptics: that is what scientists are.

I am a statutory advisor to Defra on adaptation to climate change, and the guidance I was given was not to mention the words climate change to him when offering advice!

Today I want to share with you my thoughts about how the fruits of science could help British Agriculture to thrive in a future climate that is likely to be very different from anything we have seen in the past.

And the impacts of climate change have to be seen in a broader context of growing world population, developing countries shifting from a plant based to a meat-based diet, increasing global demand for energy, and shortage of freshwater in many parts of the world, which in combination could threaten our food security in the decades ahead.

The United Nations estimates that the world will need to produce 50% more food by 2030, a mere 15 years away, and at least 80% more by 2050. This is a real opportunity for UK agriculture.

We currently produce 60% of our own food, down from 70% a few decades ago, and we should aim to reverse this downward trend both to increase our own food security and to take advantage of new markets overseas.

At the start I want to distinguish between two implications of climate change for UK agriculture.

On the one hand the UK, along with other countries, must reduce its greenhouse gas emissions in order to prevent catastrophic changes to the earth's climate. This is referred to as **mitigation**. As I will explain, agriculture has its part to play in meeting this challenge.

On the other hand farming will have to respond to the inevitable changes that are already happening to our climate now and will continue for many decades ahead. This is the challenge of **adaptation** to climate change.

The 5th Assessment Report of the Intergovernmental Panel on Climate change, published last year, makes it clear that **both** mitigation and adaptation to climate change are needed.

Even if global efforts to reduce greenhouse gas emissions succeed, we will need to adapt. The climate is already changing and will continue to change in the future, because of the greenhouse gases we have pumped into the atmosphere over the past 150 years.

But there is a limit to what can be achieved by adaptation, so it is also essential to slow down and halt future climate change by reducing greenhouse gas emissions. The longer we delay mitigation, the more costly the consequences will be and the more likely it is that adaptation will become impossible.

And we must not forget that in the 10,000 years since the dawn of agriculture, the global climate has been extraordinarily stable.

There is simply no precedent in human history for farming in a rapidly changing climate: we are in uncharted territory and we will need all the technology and ingenuity that we can garner.

Let me now turn from generalities to specifics.

First **mitigation.**

What does UK agriculture need to do in helping the UK to meet its target of reducing greenhouse gas emissions to at least 80% below 1990 levels by 2050?

This target is legally binding, as a result of the 2008 Climate Change Act.

The Climate Change Act also created the Climate Change Committee, of which I am a member, and its Adaptation Sub Committee, which I chair.

The Committee is both advisor and watchdog: it advises Government on the most cost-effective and technically feasible pathway to 2050 as well as on the risks from climate change, and reports to Parliament on the Government's progress in both mitigation and adaptation.

At the moment, agriculture produces about 10% of the UK's greenhouse gases. But as other parts of the economy such as power generation, transport, industry and homes, reduce their emissions, agriculture would contribute nearly 30% by 2050 if nothing were done to reduce its footprint.

The two main greenhouse gases produced by agriculture are nitrous oxide (54%), largely from heavily fertilised soils, and methane (39%) from ruminants, or waste and manure management.

What kind of progress are we making in agriculture up to now? The Climate Change Committee's 2014 progress report painted a mixed picture.

The good news is that greenhouse gas emissions from farming appear to have declined by 20% since 1990, although there is a great deal of uncertainty about this number because the data simply aren't good enough.

The bad news is that it appears that little of this decline is related to active measures aimed at reducing greenhouse gas emissions.

Instead, the biggest single contributor to the decline is the fact that the number of livestock farmed in this country has declined, more as a result of changes in CAP policy than as a measure to reduce greenhouse gas emissions.

If you look at the emissions intensity, that is to say the greenhouse gas emissions per tonne of production, there has been only a very small reduction.

In view of this, the Committee suggests that the Government's current, voluntary, industry-led Greenhouse Gas Action Plan may not be up to the job.

The Climate Change Committee's advice is that emissions from agriculture will have to fall by nearly a quarter in the next 15 years, as part of the overall UK plan.

This will involve smarter use of fertilisers through precision agriculture, and changing the diets of sheep and cattle, along with genetic improvements, in order to reduce their methane emissions.

The Climate Change Committee also concludes that the necessary changes to agriculture will not be costly to farmers.

In fact three quarters of the recommended changes would bring immediate net savings.

There is also an argument that we should all eat less red meat.

The carbon footprint of beef and lamb is roughly more than five times greater than chicken, three times bigger than pork, more than 30 times that of bread wheat and over 50 times bigger than potatoes.

Even if you allow for the different nutritional value of these foods, it is clear that the kinds of food we eat and grow in this country could have a large impact on our greenhouse gas inventory.

You might, of course, argue that if we in this country reduced our production of beef and lamb without reducing our consumption, we would simply export the greenhouse gas emissions to other countries. And it is true that the Climate Change Act does not account for consumption, only for production.

Before I leave the topic of mitigation, I want to touch briefly on organic farming.

Those who espouse organic farming usually say that it is good for the environment. The European Commission's strapline is *'good for nature, good for you'.*

Setting aside the question of whether or not organic farming has overall environmental benefits, the fact that it is generally less productive per hectare means that more land has to be used to produce a certain amount of food.

Converting land to agriculture, especially arable farming, results in the release of large amounts of carbon, so from the point of view of reducing greenhouse gases, organic farming might actually be a worse option than conventional farming.

Let me now turn to the challenges and opportunities from **adaptation** to climate change.

As I said a few minutes ago, scientists are not yet able to predict the exact pace and magnitude of future global climate change.

However there is widespread agreement that limiting global warming to about 2^{O} C above pre-industrial levels should be the target, because beyond this there may be potentially very large, dangerous and irreversible consequences, for instance dramatic sea level rise, loss of arctic sea ice, and serious damage to marine biodiversity.

However, with the current global plans for cutting greenhouse gas emissions, our grandchildren may well face temperature rises of 3^{O}C or more by the end of the century.

And this would mean a greater likelihood of the other climate impacts that I talked about a few minutes ago, such as extreme rainfall, heat waves, drought and sea level rise.

Global changes will have indirect impacts on us, for example through the supply chain for commodities, but what about the direct impacts on the UK?

The Met Office has made projections for the UK's climate up to the late 21st century, and these in turn have been used to generate a national climate change risk assessment. The first risk assessment was published just two years ago, and the Adaptation Sub Committee is currently working on an update, to be published in 2016.

Although we can't be 100% certain, the experts predict that the biggest risks from climate change for the UK will be to do with water. Too much and too little: too much as a result of extreme rainfall such as we had at this time last year, and too little as a result of long periods of drought and hotter summers.

Other risks relevant to agriculture include the possible spread of new plant and animal diseases, and the loss of soils as a result of extreme rainfall and threats to animal and crops through extreme heat waves.

Although these and other risks mean that agriculture will need to adapt, the overall impact of climate change in the UK may be relatively benign compared to some other parts of the world, such as the Mediterranean

basin, and therefore there may be opportunities for UK farmers to produce more relative to others.

It seems to me to be likely that some kinds of adaptation will happen more or less automatically, as farmers adopt new crops or new varieties that are suited to changes in the climate. These kinds of decisions may even be taken on relatively short timescales.

Defra's Farm Business Survey, suggests that 64% of farmers are acting to adapt to climate change (although as this is based on self reporting it may not be an accurate figure) and that about 1 in 6 farmers get advice from Defra's Farming Advisory Service.

But other aspects of adaptation will require long term planning, to avoid locking us into the wrong path and to enable us to invest in the right infrastructure for the future.

Last spring I was in South Australia, learning how Treasury Wine Estates, one of the worlds leading wine producers with sales of over 30 million cases annually, including well-known brands such as Penfolds, Lindemanns and Wolf Blass, is preparing for the effects climate change.

One of their strategies is buy land in Tasmania, which will, in the future, be more suitable than their present vineyards for certain grapes.

Another is to invest in new fermentation facilities.

Today, grapes ripen about two weeks earlier than they did 20 years ago.

Furthermore, Chardonnay and Cabernet Sauvignon have converged in their ripening times, from 20 days apart to 11 days. This means that fermentation vats cannot be used for the two grape varieties in succession, so Treasury Wine has made the strategic decision to invest in new infrastructure to adapt to the changing climate.

Treasury Wines is also reducing its carbon footprint by investing in more energy efficient equipment, and now markets its first 'zero carbon wine' – a brand called Squealing Pig from Marlborough, New Zealand, showing that there are market opportunities in responding to climate change.

Obviously the circumstances for UK agriculture are very different from those in Australia, but here I am making the general point that we need to think long term and anticipate change, rather than waiting for it to creep up and catch us out.

We need to think **now** how we will use water wisely, maintain soil fertility and control new pests and diseases as our climate changes. We must also manage conflicting demands on land, living as we do in a very densely populated island.

Availability of freshwater will be a, perhaps **the**, key limiting factor for food production in the future. Longer growing seasons and more carbon dioxide in the atmosphere could mean that we can in theory grow more, but only if we have enough water.

People often forget how much water is embedded in our food: an apple contains 70 litres of embedded water (the water need to produce it) and a kilo of steak contains 15000 litres.

UK Agriculture uses water from the public water supply and abstracted water from rivers and aquifers. In the South East both are already under pressure.

There is a lot of uncertainty about future rainfall, but as a result of climate change, summer rainfall in the south and east is likely to decrease. As a result, by the 2050s East Anglia, the Thames Valley, the South East and Humberside are likely to be very water stressed.

Just to give you an idea of the scale, the Adaptation Sub Committee estimates that within the next 10 to 20 years the gap between supply and demand for crop production could be between 45 and 115 billion litres per year, against a current total water use by farmers of about 120 billion litres per year.

What should farmers, and the Government, be doing to build resilience against this looming problem of water scarcity? If we do nothing, the future of food production in the UK could be at serious risk.

The Adaptation Sub Committee recommends that a little under half the projected deficit could be filled by increasing supply and half by reducing demand.

Supply could be increased by on-farm reservoir storage. I know from visiting farms in Lincolnshire owned by my Oxford College that some farmers are already investing in reservoirs, and the ASC calculates that doubling the amount of storage could reduce the supply-demand gap by 45 billion litres.

On farm storage costs: typically between £50,000 and £400,000, and in order to incentivise more storage, the Government needs to ensure that the price of water, including abstracted water, to farmers reflects its scarcity (this is not true at the moment) as well as providing assistance with up front costs.

Demand could be reduced by smarter irrigation. A few months ago I was in Israel, where I learned that irrigation efficiency is 90%, whereas in this country up to half the water used in irrigation simply goes up into the air rather than into the crops. The reason is that most Israeli farmers use drip irrigation rather than spray. I have also seen how salad growers in East Anglia use smart irrigation to deliver just the right amount of water at the right timeto optimise crop growth.

New crop varieties, perhaps produced by genetic modification, that are more tolerant of drought or require less water, could also reduce demand.

Between them these two measures to reduce demand could save perhaps another 45 billion litres.

This still leaves a gap of about 25 billion litres in the worst case, but at least our resilience would be much higher than if we do nothing.

Let me now turn briefly to another essential ingredient for food production: soil.

Climate change, combined with unsustainable management of soils, may also reduce soil quality and quantity. We are already losing 2 million tonnes of soil a year through erosion and in future, extreme rainfall could increase the rate of loss.

At the same time, a combination of climate change and intensive management is reducing the carbon content of soils, and the ASC's analysis suggests that intensively farmed peaty soils in East Anglia could lose all their topsoil in the next few decades. Cf Liz Truss.

According to official figures, more than 70% of top grade agricultural soil is managed by conventional ploughing. In order to prevent potentially catastrophic soil loss, there needs to be much more uptake of minimum tillage.

Some evidence suggests that genetically modified, herbicide tolerant crops, facilitate minimum tillage agriculture, a further reason for encouraging their acceptance by the food industry.

I don't have time to say a great deal about flooding and agriculture. We can be reasonably confident that flooding will become more of a problem for the UK in the decades ahead, with extreme events such as last winter's floods becoming more frequent. And past records indicate that flooding and waterlogging reduce productivity. The NFU estimated that winter wheat production in 2013 could have been reduced by up to a third because of wet conditions in 2012.

Deciding what to do to reduce flooding of agricultural land is likely to involve a trade off between benefits to farmers and benefits to householders and businesses, since spending has to be prioritised and flood water has to go somewhere.

We do know, however, that better land management can help. Upland peat can act as a sponge to absorb excessive rainfall, but only if it is in good condition. Unfortunately 96% of upland peat is not in good condition: it has been overgrazed, drained burned or polluted. This is contributing to increased flooding in valleys.

It is also thought that flooding in the Somerset levels has been exacerbated by soil compaction associated with growing maize, so that surface water runs rapidly into streams and ditches rather than being held back in the soil. It is estimated that in an average rainstorm. Every 10 hectares of compacted soil under maize sheds over a million litres of silt-laden water, which clogs up rivers downstream.

In closing let me come back to the starting point: Frank Parkinson's desire to see research applied for the benefit of farming.

In the UK publicly funded agricultural R and D has declined by about 20% in the past 25 years. There has been a modest increase in private sector R and D, but not enough to offset the decline in public investment.

So overall we are investing less than we used to.

We heard earlier today that analyses suggest that this is part of the explanation of why the UK has lagged behind other countries in increasing its agricultural efficiency in the past 40 years. We are bottom of the league table among eleven European countries and the USA. Our growth in efficiency, for instance is only just over half that of Denmark, 40% that of the USA and well below France, Germany, Italy and Greece.

In 2013, the Government launched its new £160 million agri-tech strategy. (By the way Liz Truss was not correct to say that Research Council budgets have increased in the present Government. They have had flat cash, which is a real terms reduction over the past 5 years.

It's too early to say how effective this will be in helping our farmers to respond to the challenges and opportunities of climate change.

But if we look at the big picture, there's no doubt that we are going to need all the appliance of science that we can muster, if agriculture is to rise to the challenge of feeding the world in a changing climate with

diminishing resources.

In short we are going to have to produce more with less.

The second half of the last century was a remarkable success story for global food production. The world's population doubled but 25% more food per person was produced by the end of the 20th century when compared with 1960.

This was the green revolution. Agriculture rose to the challenge by harnessing the power of new genetic varieties, irrigation, mechanization, and use of agrochemicals.

But we now know that this revolution came with an environmental price tag. It depleted natural resources such as water and soil, it used large amounts of energy, it polluted the environment and it caused loss of biodiversity.

That is why the next revolution in agriculture will have to be even more remarkable.

It will have to use every technology to hand, including genetic modification (and here I agree with Owen Paterson – we need to move on from the irrational protest days to accepting that GM could bring real benefits), precision agriculture, big data, and ecological knowledge to ensure that there is enough food to go round without destroying the planet.

Agriculture needs to be ambitious and not complacent. I am sure that that Frank Parkinson would have applauded this call for ambition.

Thank you for listening.