#179: Reaping what we sow: Agriculture's role in climate change

VOICEOVER

Welcome to Up Close, the research talk show from the University of Melbourne, Australia.

DYANI LEWIS

I’m Dyani Lewis, thanks for joining us. Over the last 150 years, human activity has caused ongoing changes to the earth’s climate. Now in an effort to stem the flow of carbon dioxide into our fragile atmosphere many of us are finding ways to live greener and lessen our environmental footprint. Walking where we used to drive and wearing more layers instead of turning up the heating. But where does food sit in all of this? Climate change is raising serious concerns about our future food security, yet fingers are being firmly pointed at the agriculture sector and in particular livestock production as major contributors to greenhouse gas emissions. To tell us more about agriculture’s role in and response to a changing climate, we are joined on Up Close by agricultural scientist Rich Eckard. Rich is Associate Professor and Reader at the Melbourne School of Land and Environment here at the University of Melbourne and he’s also Director of the Primary Industries Climate Challenges Centre. Welcome to Up Close, Rich.

RICH ECKARD

Thanks for that, Dyani.

DYANI LEWIS

Now, Rich, the way in which we use land has changed immensely over recent centuries. Could you start by painting for us a picture of how landscapes have been changed to accommodate agriculture?
Obviously, with agriculture there's been extensive land clearing. There's been cultivation of soils for planting crops. In the case of livestock industries, where there was range land those range lands have changed over time since livestock production came into them. But also there was forest before and that forest has been cleared, all that carbon has left the landscape and it has been replaced by agricultural production. All of that has been essential for food production for a growing population so we have to actually do that. But it has meant a change to the landscape a change to the carbon stored in that landscape and a new source of emissions.

If we set aside land clearing for a moment, what are the main other ways in which agriculture contributes to global warming?

The introduction of livestock for example the ruminant side of livestock like cattle and sheep, they've got four stomachs when we've only got one. And the first stomach is a very large sack the rumen that mainly relies on microbes to break down high fibre diets that they eat. That generates enteric methane. So enteric means coming from the rumen and that methane is a greenhouse gas global warming potential of 25 times that of CO2. The other greenhouse gas from agriculture production would be nitrous oxide and that's produced in soils wherever nitrogen fertiliser or nitrogen from legumes or nitrogen from animal waste has been put into the soils. And in those soils the nitrogen can de-nitrify into a gas called nitrous oxide. That's a powerful greenhouse gas around 300 times the global warming potential of carbon dioxide.

Rich, how do these agricultural emissions compare with emissions from other industries?

Well obviously the coal-fired or fossil fuel powered energy sector is the highest source of emissions anywhere in the world. In most countries, that is the largest emission source. And that's just from the burning of either coal or oil or gas for energy production. Transport emissions, the burning of diesels and fossil fuels in cars is about the second largest emissions' sector. In some countries agriculture is about the same size as transport being around 20 per cent of emissions. In Australia even though we have extensive agriculture, agricultural emissions are around 15 per
cent of the emissions. But you go to countries like New Zealand or Brazil, you’ll find agriculture is 50 per cent or more of their total emissions just because of the structure of the country. In most industrialised countries agricultural emissions are less than 10 per cent.

DYANI LEWIS

Now, Rich, in many places around the world, prior to agriculture there were vast swathes of grassland with wild ruminants. How do we actually know that modern livestock produce more of these missions than say the wild bison did when they once used to roam North America and Europe?

RICH ECKARD

Yes, the argument is made quite frequently about have we just not replaced those native wildlife with domestic ones. In Africa, certainly you can make some argument around that although there are some good numbers now that suggest the total ruminant population in Africa is actually larger than the native wildlife that used to be there prior to Western colonisation. In North America again, large herds of bison were replaced by livestock. But again the total livestock numbers are higher than the original bison population, so the methane profile is higher. Australia and New Zealand are quite unique in that there were no native ruminants prior Western arrival and development. So the methane profile from livestock both in Australia and New Zealand is vastly different to what it was 200 years ago.

DYANI LEWIS

Rich, you’ve been looking at ways to minimise these greenhouse gas emissions from agricultural systems. So if we start by looking at methane are there measures that we can use to prevent methane production?

RICH ECKARD

Yes, there are a number of methods we’ve worked on and reviewed over the years and they range from breeding methods, feeding methods and rumen manipulation. So we can manipulate the microbes in the rumen of the animal. However, we’re looking at research that is only in its infancy in understanding the complex interactions between billions of microbes in the rumen. And only in the early stage of that research have we identified the populations of microbes that don’t produce methane and the others that do. For example, the kangaroo produces less methane than a traditional ruminant like a cow or a sheep and understanding why that is and can we actually learn from that.
So how do you go about manipulating the populations of microbes in a rumen?

With great difficulty. There are chemicals that can do that, so feeding sulphates and nitrates for example, all these techniques work on starving the methane-producing microbes of the energy they need to produce methane and that's usually hydrogen. Methane is carbon and hydrogen together. So if you starve those microbes of one of those two, you can't starve them of carbon because the rumen is just completely carbon from a forage-based diet. But you can actually restrict their access to hydrogen by putting that hydrogen into more productive processes. So if you take that hydrogen and put it into making more energy for example, because all our carbohydrates are based on carbon and hydrogen as well. And if you can put it into the carbohydrate pathway then it's more productive and you get more energy out of each amount of food that you feed.

Presumably this doesn't impact on how much nutrition the animals get from their diet, does it?

No, it actually makes them more productive. And so some of the nutritional strategies we're looking at have actually gone down that route. What can we feed animals so, in the short term, we can get a reduction in methane? And certainly feeding animals on dietary fats, for example, that has a number of effects, not the least of which is increasing the fat content of the diet as a source of energy. But we've discovered that by feeding some of the bypass products of other processes like biodiesel-extracted canola for example, we can feed the residue, which still has enough oil in it actually reduce methane in the animal. So it's not only a slow release form of energy going into the animal, it has some protein in the meal so we get a milk production response out of that. But for every extra one per cent of oil that we put in the diet of a ruminant, we get about 3.5 per cent less methane.

So what about the animals themselves? Are there some ruminants that produce more methane than others?
There’s clearly genetic differences between animals and we hope to capitalise on that as well. Some animals within the same breed, within the same genetic type within a breed produce more methane than others. We are still in an early stage of understanding why that is. We can identify some traits that are there but we don’t have any easy markers for selecting those animals. At the moment it’s a very expensive measurement process to measure each individual animal to understand which are the low producing methane animals and which are the high producing. In some cases they’re not consistent. If they’re on low quality diet they might be low methane producing, but put them on a high quality diet and that difference disappears. So it’s still in the early stages of understanding that. But we do have about a 10 to 15 per cent difference between animals within a breed in their potential to produce methane. We also think that there is potential to actually raise animals with different methane profiles. Because a lot of the microbes in the rumen interact with the genetics of the animal. And that interaction can be capitalised on in how we actually raise the animals. So if you raise them through a lineage of low methane producing mothers you can end up with animals that produce less methane. The issue we’ve got there is the environment that they live in is prolific with microbes. So if you change the microbial profile of it, it can just recolonise from the environment. But the microbes that produce methane are quite unique. They are, archaea is the term we use for them, and they are phylogenetically very different from the rest of the microflora that exist in the rumen.

DYANI LEWIS

I'm Dyani Lewis and my guest today is agricultural scientist Rich Eckard. We're talking about the contribution of farming practices to global warming here on Up Close coming to you from the University of Melbourne, Australia. Now, Rich, what about nitrous oxide then, obviously livestock produce a large amount of nitrous oxide or are responsible for nitrous oxide production as well?

RICH ECKARD

The nitrous oxide from agriculture production would come from any form of nitrogen that’s put into the system. So it can be fertilisers, it can be legumes that fix nitrogen from the atmosphere and obviously the animals themselves. What they do is all the surplus nitrogen that they eat is excreted, so it goes either out in dung or in urine. Now urine is usually the highest concentrated source of nitrogen particularly as you go into the move intensive grazing systems like dairy systems where the urine is very concentrated. In fact, the content of that is very similar to urea fertiliser. So you can often get up to 1,000 kilos of nitrogen per hectare equivalent being deposited within the urine patch in a dairy system for example. So it's not surprising that a lot of that is actually subject to loss either as an ammonia gas, which then can precipitate back down to earth, into the soil and become nitrous oxide, or is directly de-nitrified in the soil and lost as nitrous oxide.
DYANI LEWIS

So is there anything we can do to minimise the nitrous oxide?

RICH ECKARD

The research has been quite positive around this. Around the fertiliser technologies we have coatings that we put on fertiliser that are inhibitors. What they do is they just inhibit specific microbes in the soil and prevent them from converting that into nitrate, which then becomes nitrous oxide. Some more exciting technologies around the animal where we can spray paddocks with these inhibitors to keep the urine in that form and stop it going to nitrous oxide. But more recently some work out of New Zealand has suggested, and we're starting a project up with them at the moment, looking at how we can actually feed animals on some of these products that actually keep the urine in the ammonium form and don't allow it to go to nitrous oxide as well. We favour this feeding technology because it costs a lot less than spraying the whole paddock or putting a coating on all the fertiliser. You're actually targeting the active ingredient, where you need when you need it at the quantity you need it.

DYANI LEWIS

So if these kinds of inhibitors exist, why aren't they being used?

RICH ECKARD

At the moment there just hasn't been a driver for it. Nitrogen fertiliser is quite cheap, obviously if you're getting nitrogen from legumes it's derived out of the atmosphere, you're getting it for free. Because of that the losses that have been occurring in our agriculture systems have not been of an economic value to farmers. But typically in a grazing system, this might sound terrible, but in a grazing system you are losing up to 60 per cent of the nitrogen in the system that's cycling. It never actually completes the cycle. So if you look at the cycle at any one point of the nitrogen that's actually transferring into the animal, more than 60 per cent of it is actually lost before it actually completes the cycle. We think these technologies will really help to improve the efficiency of that cycle. So not only from a greenhouse gas point of view, but all our research is focused on what is the productivity benefit. Because we've got to keep in mind we want to reduce greenhouse gas emissions, but we've also got to feed a growing planet. So we will have to actually increase agricultural production not reduce it.

DYANI LEWIS

So by making things more efficient, you're generating an economic imperative in a
There’s two issues here. A number of countries are looking at policy mechanisms to reduce greenhouse gas emissions. New Zealand has an Emissions Trading Scheme, Australia has a Carbon Farming Initiative, in Europe they’re looking at controlling nitrogen inputs into agricultural systems. In North America they’re looking at similar policies, so there are emerging policies to actually drive the incentive for farmers to reduce emissions and by doing so become more efficient. But also in terms of the cost benefit to farmers, our focus is very much on why would a farmer adopt this technology. So we’ve got to make sure that it has an economic imperative to it as well, a productivity benefit and outcome where they are more nitrogen efficient and it’s going to cost them less. Notwithstanding that we have to double agriculture production by 2050 to feed the world, we’ve got to become more efficient with the inputs that we’re putting in.

Rich, you’ve mentioned population, I was wondering is it likely that we will even be able to address these agricultural emissions as long as our global demand for food and in particular our global demand for meat production continues to increase?

It’s a very difficult question that. The simple answer is no. We have to more than double food production by 2050. In fact if you look at the estimates from the United Nations Food and Agriculture Organisation, they are suggesting a 70 per cent increase in food production by 2050 to feed 9.5 billion people on the planet. If you look beyond that, that’s not the peak. The peak is now suggesting to be about 14 billion on the planet by the end of the century. So a simple equation tells you that if we have to increase food production by that volume, there will be a net increase in greenhouse gas emissions from agriculture. You can work it back from the minimum protein required per human being in the world, back to the volume of food that’s needed to produce, back to the amount of nitrogen that we need to actually input to create that protein. Just simply calculating through there will be a net increase in nitrous oxide as a result. Notwithstanding that though, I think we are confident that we can reduce the amount of emissions per unit of food we produce and so produce that food with less emissions than would have been the case. I think that’s our responsibility primarily. We cannot achieve a net reduction in emissions. Some countries might be able to achieve that, but at the expense of their capacity to export food to the rest of the world. So I think the realistic target is emissions intensity, so reducing the emissions per unit of food we produce. Where it comes to livestock there are some realities there where livestock do produce more emissions per unit of
food than cropping for example. But it's a very complex issue because cropping does
involve cultivating the soil. So you're losing all the soil carbon that is stored there as
well whereas livestock systems that soil carbon stays and actually builds over time in
permanent grasslands. So it's not a simple equation saying just get rid of livestock.
At the same time the global requirement for livestock is still increasing and the
demand will be there, although the demand might actually not be in the Western
world so much it might actually be in the developing world.

DYANI LEWIS

So many people are turning to vegetarianism to lessen their impact it's a little bit
more complicated than whether this is actually a good thing, is that right?

RICH ECKARD

Entirely correct. I always say the percentage of the world's population that have the
privilege of choosing a vegetarian lifestyle is quite limited. Limited to the affluent
Western world and it's not a population group that are increasing rapidly. So most of
the population increase is going to take place in Africa and Asia, India and China in
particular is where the largest growth will occur in the future. If you start looking at
these demographics around the world, you see reasons why livestock production is
still going to remain integral to those systems. You take India for example where the
cow is sacred, but they still eat other meat sources, so that's unlikely to change. In
China, most of the Chinese population don't even eat ruminant meat, even though
the demand is increasing, they're mainly on white meat sources so fish and poultry,
that's their dominant protein if they have access to protein. That's likely to continue
into the future so that's not going to change much of the ruminant methane profile
there. South America you've got a strong cultural background to ruminant production
and meat consumption. In Africa it's their wealth source. They keep livestock for their
bank account and for draft and for transport. So there's other reasons why they keep
livestock other than just food production. So when you boil that all down the drive
towards a more vegetarian lifestyle, we have to say, for your personal footprint it will
reduce your personal greenhouse gas emissions' footprint. So it's an entirely valid
choice for those who want to make that choice. But if you are thinking that it's going
to take over and become a global phenomenon, it's really only a minority of the world
that even have the choice of going in that direction. So we've got to be realistic about
what we can achieve there.

DYANI LEWIS

I'm Dyani Lewis and I'm joined on Up Close today by Rich Eckard who's telling us
about farming emissions and what can be done about them. Now, Rich, what are
other things that consumers can do to make environmentally prudent choices when it
comes to shopping at the supermarket?

RICH ECKARD

There's a lot of choices that we can make, as I said, you can look at a more vegetarian lifestyle, slightly lower red meat consumption in your diet, notwithstanding that it'll probably be healthier for you. At the same time, you know dare I say those who like their red meat, kangaroos don't produce as much methane as other traditional livestock. So if you have to make a choice that's a valid choice as well. The whole issue of food miles has probably been overplayed. Food miles is the concept of if a product has to transport a longer distance to get to you that it has a high emissions' footprint. That's not necessarily true, we've actually looked at that. The New Zealand Government looked at it very intensively because there were criticisms of food produced in New Zealand transported all the way to Europe that it had high food miles. But when you actually complete a full lifecycle assessment, which is counting from cradle to grave all the different sources of emissions, once you produce milk powder and put it in the hold of a ship, the transport across to Europe is negligible. So you can actually produce food in New Zealand with less greenhouse gas emissions than you can if you produce it right next to the supermarket in London, just because of their energy costs and their structure of their agriculture. So food miles is not actually a valid choice to make necessarily there are other choices we can make.

DYANI LEWIS

How about something like frozen food?

RICH ECKARD

Obviously there's extra energy required in refrigerating particularly meat products when they transport around the world. Again the New Zealand Government looked at this very carefully and they discovered that lamb produced in New Zealand, that is slaughtered and transported refrigerated still arrives in the UK with a lower total lifecycle footprint than lamb produced in the UK. It's the economies of scale once you've put, you know 1,000 animals into the hold of a ship, the actual embedded emissions per unit of meat transported across the ocean actually becomes negligible.

DYANI LEWIS

All of this information is rather hard to grasp as a shopper in a supermarket to determine what impact each individual item of food actually has.
RICH ECKARD

The market research would suggest that consumers are still not buying on things like food miles or embedded CO2 emissions. They are mainly still buying on price. If there’s a driver from a group like Walmart for example it’s more a company strategy. It’s more the Japanese Government for example that is wanting to have recognition and labelling on their products as to what the embedded emissions are. It's still not driven by the consumer, they still are buying on price.

RICH ECKARD

Now when it comes to food in comparison to something like buying a large car, I mean is buying food that has an environmental footprint in a way justifiable?

RICH ECKARD

Well certainly I would say that agriculture is probably your most legitimate form of emissions because my view is you can turn the lights off and you can walk to work, but you have to eat. At the same time there’s alternative technologies emerging for electricity. We have renewable energies, but the price is still too cheap to get fossil fuel energy, coal-fired power is still too cheap because it historically was subsidised by governments to build all these power stations. So we’re paying a far lower price for that than we should. The same with transport emissions there's hydrogen cell cars emerging. There's electric cars emerging, so other technologies are coming about and notwithstanding it’s more healthy for us to cycle to work or walk to work. But in terms of agricultural emissions, there is minimum amount of emissions that has to be produced to produce the food that we eat and we have to eat. We can make choices within our diets, as we talked about earlier, but at the end of the day there will be emissions from agriculture because of food production.

DYANI LEWIS

We have spoken about the contribution that agriculture makes to climate change but I thought we could look at the flip side now of how climate change is impacting on agriculture?

RICH ECKARD

It's quite an issue for us. We've been looking at how agriculture will be affected around the world and there's no doubt that in many countries agriculture will either be positively or negatively affected. If you look at the Northern hemisphere, say Canada across Siberia, Northern Europe, with the warming of those regions, because there’s such a large land mass there, even just one kilometre further north that might be
viable for agriculture can mean a huge increase in say grain production from those regions. So there could be benefits there. Some of the tropics we're looking at getting far larger rainfall events. Now that can be positive and negative. There can be floods that destroy agricultural land, but certainly in some of these Southern hemisphere countries like Australia there are going to be fairly substantial impacts. More so as you go inland in Australia, so we could actually see a contraction of agriculture production in Australia towards the coast. In some cases that can be of benefit where you're actually moving grain production from lower rainfall regions to perhaps slightly higher rainfall regions. You might actually with warmer winters get more production than you would have otherwise. But notwithstanding all of that, an increase in temperature our current systems might be able to handle one degree. But once you start talking about two degrees average increase in temperatures globally agriculture production will be severely affected. Notwithstanding that we've got to actually more than double the production.

DYANI LEWIS

How do we go about gathering the information to be able to predict some of these region-by-region differences that are going to occur?

RICH ECKARD

There's a lot of research going on in that area at the moment using global circulation models. These are very complex models that try to predict all the circulation patterns, the currents, the air currents the temperature changes. Some of the sophisticated models include all the natural disasters that take place as well, so they are accommodating volcanoes and disasters like that, monsoons, cyclones and from those we can actually get them to predict for us what the future climate might be in a region. We then downscale those emissions and add them to local weather data to try and predict what might happen in a region. But at the end of the day most of our modelling is starting to say, well let's just say what if the temperature went up two degrees? What if rainfall went up 10 per cent or down 10 per cent and just exploring the resilience of the system within a region. So there you can answer the questions using modelling. Will this grass be the best species to grow in 50 years time or do we need to look at another grass? If we bring another grass in there to feed those animals, is that going to be as nutritious as the one we've got there? Those are the kinds of questions. So in a lot of the temperate regions of the world, the regions where the grasses could be challenged by say a two-degree increase in temperature and it's easy to bring in some of the more tropical grasses. But the tropical grasses are less nutritious and so you can produce less animal product from them, they'll grow more but it's more fibre not more energy. So that balance is quite important to look at and that's what we've been looking at and helping the agricultural industries understand what the implications are for that.
DYANI LEWIS

Does some of this information get fed back into changing the way we make our decisions to plan for the future as well?

RICH ECKARD

Very much so - this research has to then feed back into the plant breeders to suggest if you want temperate species to survive in an area where the temperature is going to increase, do we switch to a tropical species? Or do we just breed a species of grass that is more temperature tolerant within the same variety of grass that we've got? Or do we breed a grass that has a deeper root system so that it can actually access moisture deeper down for that longer dry period that we might have each year? That's the important direction, so we're sending the information back to the plant breeders. We're sending the information back to the industries to advise them on where their next investment needs to be or where they need to think about system changes.

DYANI LEWIS

So finally, what is your own prediction for the future? Are there going to be major changes in farmland practices, perhaps the species that we breed and what we eat? Or will we essentially be just tinkering around the edges?

RICH ECKARD

In some cases we can afford to tinker around the edge for at least until 2050 because our analysis would suggest that much of the grain production systems and much of the wheat production systems, much of the grazing systems that we currently have will still be the same species in 2050. So most of the dairy production say in Southern Australia and New Zealand would still be based on a species perennial ryegrass and it will still be the most productive species. Although possibly slightly less productive than it would have been So we won't be switching species in that time horizon. But when you start going out to 2100 that's when we need to start having different species coming through. That's when we need to have far more structural change. That's where in Australia we'll probably find most of the production moving coast-wards and generally production being more severely affected. That's when the real crunch will come because that's where we have the 14 billion people on the planet. So there's going to be a need for what we call sustainable intensification. This is a term coming out of the United Nations at the moment, the Food and Agriculture Organisation has coined the term sustainable intensification. So it's implying can we produce food more sustainably but inherently understanding we'll need to intensify the systems we currently have. So each hectare of land is
producing more than it currently does but with less impact on the environment.

DYANI LEWIS

Quite a few challenges ahead of us it seems. Rich, thanks for being our guest today on Up Close.

RICH ECKARD

Thanks, Dyani, appreciate it.

DYANI LEWIS

Rich Eckard is Associate Professor and Reader at the Melbourne School of Land and Environment here at the University of Melbourne. He's also Director of the Primary Industries Climate Challenges Centre. Relevant links, a full transcript and more information on this episode can be found at our website at upclose.unimelb.edu.au. Up Close is a production of the University of Melbourne, Australia. This episode was recorded on 19 January 2012. Our producers for this episode were Kelvin Param and Eric van Bemmel, audio engineering by Gavin Nebauer. Up Close is created by Eric van Bemmel and Kelvin Param. I?m Dyani Lewis, until next time, goodbye.

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