



Sense, Science and Sustainability

Can genome editing and agroecology exist within
the sustainable food and farming mix?

Webinar

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TRANSCRIPT

Pat Okay, welcome everyone who's joining us for this discussion this morning. The question that we're posing today may seem simple enough: can genome editing and agroecology exist within the sustainable food and farming mix? But within that question there are multitudes. Genome editing, for example, claims to be a game changing technology that unlike older style genetic engineering produces nature identical organisms that can tackle everything from feeding the world to fighting climate change. All that's required to liberate this awesome power is the removal of restrictive regulations.

Agroecology also promises to be a game changer. But what was once a whole system approach to farming has become so atomized in its definition and its practice that it's become a kind of pick and mix menu, allowing farmers to choose the bits they like and discard the rest and still call themselves green. A practice, by the way, which is also at the core of what is known as sustainable intensification and an approach favoured by many policymakers and here in the UK by our National Farmers Union.

Sustainability is a word that for 40 years as defined the definition that everyone can agree on - and as a result, made discussions around how we achieve it very complicated.

So, what is sustainability? What is agroecology? What is a GMO? Are there limits to the uses of any or all of these approaches and how can coexistence between different approaches to agricultural work? These aren't just abstract questions. These are the questions that fuel the discussion about how we reframe, and refit our approach to agriculture in a way that's more productive, less harmful and more nourishing to us all.

My name is Pat Thomas, and I am, amongst other things, a director of Beyond GM here in the UK. At Beyond GM one of our goals is to raise the level of the debate around genetic engineering and food and farming. We have a large public platform because the voices of the general public are most certainly marginalised in this discussion. But we reach out to a diversity of others as well and the main vehicle through which we do this is our Bigger Conversation initiative, which brings many more varied perspectives into the discussion. These are not always easy conversations but we pursue them, because the question of how we produce food is too important not to.

We have been very fortunate to work with our co-hosts today, Natural Products Global, who helped bring these conversations into the natural and organic arena, for instance through panel sessions at Natural Products Europe and the Nordic Organic Food Fair. And in having these very public conversations we have found a mixture of confusion, concern, consent and a clear desire to know more. I should say, from the outset that we are not looking for a discussion that falls along the same old fault lines. What we're aiming for is something that does justice to the complexity of the issue, and the changing nature of the dialogue. Something that leaves everybody - panellists and audience - with a little bit more food for thought. And happily we have a panel that is absolutely up for that challenge today. I do have a small announcement, and that is we've had a very last minute change the panel, Sheila Dillon has unfortunately not been able to join us today and sends her apologies. But my colleague Lawrence Woodward has agreed to step in, in her place.

Our format today is fairly straightforward. Each of our panellists will be given the opportunity to speak from their own perspective. We will follow up briefly on any issues raised in those introductions and then throw the platform open to our audience to ask their own questions and make their own comments. And just a word about our audience today, which is impressively diverse. We have attendees from the biosciences from organic and agroecology, from academia, from the natural product sector, from the media, and also from all points on the map, and we welcome you all. We ask you to be respectful of what will be differences in the way that you approach these subjects and we encourage you to post questions and comments throughout this session. You can do this by clicking on the Q&A icon at the bottom of your screen and typing your questions and comments into the side panel.

My colleague Jim Manson, who is the editor at Natural Products Global, will be keeping track of questions and comments, and where we have several who are saying the same thing we will try to group these together for the panel to give more opportunity for further questions and more follow up. And by the way, if we have a technology fail, and I disappear from your screens. Jim will step into my place until I'm back with you again.

I'll introduce our panellists one by one. And we are beginning today with Philip Lymbery a lifelong animal welfare activist global CEO of compassion in world farming, visiting professor at the University of Winchester, president of the euro group for animals in Brussels and author of the bestselling book, Farmageddon, Philip, welcome.

Philip Thank you so much for your very kind introduction and for having me here. Morning to you all.

So it's a big question. Can agro ecology and gene editing, sit together, I guess, in a nutshell, my answer would be ideally not. But hang on a minute, let's just think this through industrial agriculture increases the risk of future pandemics and needs to be tackled as a global priority.

Those are not my words, but those made only last week by the ruling Council of the European Union as countries emerge from COVID induced lockdown policymakers are starting to wake up to the multi-pronged threat from industrial agriculture, a threat where thousands of animals are caged crammed and confined producing the perfect breeding ground for disease. Highly pathogenic strains of avian influenza or swine flu are just two examples, the latter of course causing a pandemic only a decade

ago, killing some half a million people. Industrial agriculture is not only the biggest cause of animal cruelty on the planet. It is also a major driver of deforestation, pollution, and decline in the world's wildlife.

The question is, what do we replace it with, and does gene editing, have a role. To answer the first part, in this age of pandemic climate and biodiversity emergency, factory farming is a major contributor to all of these challenges now facing humanity.

There is an urgent need for a wholesale move towards a future fit food system based on regenerative agriculture. A switch to farming systems that work in harmony with nature, building back soil health, bringing pollinators and other wildlife swarming back, conserving water, being kind to animals and protecting the future of all. It means ending factory farming, drastically reducing the number of animals farmed and restoring them to mixed rotational farms. This is a major shift that is unlikely to happen overnight.

So to tackle the second part of the question. In this shift to a regenerative future, with more planet friendly diets, Could there be a role for GM or gene editing. Some have already tried to present GM crops as feeding the world sustainably, when nothing could be further from the truth. The majority of GM crops like cereals and swine are used to feed factory farms, which makes it harder to feed the world. Factory farms, squander food they don't make it; enough food to feed billions of people.

But what about gene editing, could that have a place?

Now, Compassion in World Farming has a long-standing concern over the use of biotechnology, of all forms. in farm animals rooted in the reality that most genetic modification and more recently gene editing has been carried out for purposes detrimental to animal welfare. It's a subject we've held conferences on, written books, ran campaigns. GM tends to concentrate on inferring resistance to diseases that are inherent on factory farms or increasing production still further, exacerbating animal cruelty and locking in the industrial model.

Yet, let's be careful to avoid being absolutist on biotechnology. We should recognise that there could be, there could be altruistic developments in the future that could conceivably be beneficial to animal welfare and to society at large.

To my mind gene editing is unacceptable in farm animals except in the most exceptional circumstances where there is demonstrably no detrimental impact to animal welfare at all. Where no less intrusive method is available to achieve the same outcome, and where it doesn't lock in the use of industrial livestock production systems.

Now, having said that, let's look at what I think could be a genuine possibility. An intractable problem for the commercial egg production, be it organic, free range or battery, is that every year more than 5 billion male chicks are killed soon after hatching. Born of the laying strain, they won't put on enough weight for the, for the meat industry. Born male they're useless as egg layers. So the macerated, suffocated, gassed; a huge waste of life. What if, what if chickens were successfully gene edited so the

only eggs with female embryos are viable. The male ones simply didn't develop beyond the earliest cellular level. If successful, this technology could be a revolution, ending at a stroke, the killing of birth of 5 billion sentient creatures a year. Of course, ultimately, I'd like to see regenerative agroecological farming systems where only dual purpose breeds of chicken are used and thereby usurping naturally the need to grind male chicks to death or suffocate them, soon after they struggled from the egg.

However. If a gene editing solution could work without downsides for animal welfare and society, then I'd take it over the cruelty and waste of life all day long. A waste of life that currently blights egg production beard industrial free range organic. So let's stay focused on the end goal of creating a humane and regenerative food system that can save a future for animals for people and the planet. And along the way, let's avoid a pursuit of perfection that might otherwise get in the way of much needed progress towards a better, safer, cruelty free agroecological world for us all. Thank you.

Pat Thank you Philip, that was fascinating, and I think probably unexpected for a lot of people who are watching today.

We're going to move through our speakers fairly quickly and then we'll follow up on some of the points that you've made. Our next speaker is Wendy Harwood who is the head of crop transformation group at the John Innes Centre, one of the UK's leading plant science institution. Wendy works in the development and application of genome editing technologies in crops. Wendy Welcome.

Wendy Hello. I hope you can all hear me. Thank you very much, Pat, for that introduction. Um so, yes. So when I just want to move from focusing on animals to focusing on our crops. As Pat said I'm a plant scientist. I've worked for many years on GM technologies. And over the last few years really focused on gene editing technologies.

And I think it's probably not an exaggeration to say that genome editing is really revolutionising plant science. So, I also have to admit, beginning that I'm as well as being a scientist I'm also partly a farmer. So family farm is in Essex, and so I'm well aware of the challenges facing our farmers, and in the UK this year has been particularly challenging. And so I work at the John Innes Centre in Norwich, and I picked up a quotation from a slide that our Director Dr Dale Sanders used just last week. And it was looking at you know what's really crucial to us in the work that we're doing. And it's moving towards sustainable agriculture in a way that protects biodiversity. And I guess that's something that pretty much everybody would sign up to.

And so the question is can gene editing contribute to that goal. In terms of the way that we develop our improved crops. And so I think plum, plant breeding is without a doubt led to an incredible range of food crops that we have today. I mean if we just look at for example at the brassica vegetables that we have available to us, huge variation cauliflower, broccoli, cabbage, all derived from a sort of a wild, cabbage, that looked very little like any of the crops that we have today. And this just demonstrates the success of plant breeding and this has all been possible because breeders have had access to variational diversity that they were able to pull in, and to develop these crops that we have today.

So because agriculture began, thousands of years ago, as early farmers selected the best plants to multiply up and far more recently breeders have used a variety of methods to increase that pool of variation that's just so crucial. And some of those methods are random. So for example mutagenesis which has used either chemicals or radiation to treat seeds and deliberately make changes to the DNA. And some of those changes have been valid and a lot of them are not useful. And this is, this has led to many crops that we grow today.

So, um, since the 1980s we've had GM technologies which has allowed that specific variation to be brought in directly into the crops. And one thing to mention with GM technology, yes we can introduce specific genes, they're introduced in a random location in the plant.

Because over the last few years we've had genome editing and this is an incredibly versatile and a rapidly developing technology, and one of the huge advantages of genome editing is whatever change we want to make using genome editing technology we make it at a very precise place in the plant's DNA. So that is the key thing that is different about genome editing.

So, so far genome editing has been used mainly to produce small mutations, which to all intents and purposes are exactly the same as the types of mutations that can be made using older mutagenesis techniques or indeed mutations that could occur naturally. So, that's the main way it's been used to date, and if we use it in that way then the fine plants that we end up with do not contain any added DNA, any additional DNA there is nothing there. Just a small change, perhaps, a single letter of the DNA code.

But I think it's important to say at this point that actually gene editing can do much more than this.

It can - and the technology is developing incredibly quickly - it can switch, a single letter in the DNA code to another letter. It can replace a specific region of DNA or a gene with another version of the same gene, so maybe it's something in a wild relative that's been lost during the breeding process, maybe it was a disease resistance gene and we want to bring back in. Genome editing gives us a way of doing that. And so, genome editing gives us a way of introducing specific traits to our crops, and that with the other methods would have been very, very difficult, extremely time consuming or impossible to achieve. So it's just giving us that additional layer of opportunities to increase you know to introduce the very variation that we need and the diversity that we need. And it's also much faster than some of the older breeding methods and that's important as we have to respond I think very quickly to some of the challenges that we're facing.

And so alongside the development in the genome editing there's also been if you like a genetics revolution and this is important to mention because genetic knowledge is really crucial to allow us to identify the specific changes that might be an advantage to make using genome editing techniques. So for example, we now have the complete genome sequence, even of some of our most complex crops like wheat - and not just one sequence we have a number of them. So we have the tools to really begin to understand what is crucial to the way that certain genes work and the way they're controlled.

So, I don't have time to give loads of examples but just as an example, how is genome editing being used to date, it's being used to give pest and disease resistance so for example mildew resistance in wheat, it's been used to generate stress tolerance or drought tolerance.

It's been used to look at nutritional quality. So, reduced gluten wheat and plants with increased omega three oils. And it's been used to reduce food loss and so making products apples and mushrooms that are non-browning. So I think, just to sum up my quick introduction, I feel you know genome editing has enormous potential and, you know, it's not an answer in itself absolutely, but used alongside all of the other techniques available to our plant breeders and I really believe it could play an important role in achieving the more sustainable agriculture that we need and protecting biodiversity as well. Okay, thank you.

Pat Thank you, Wendy that's very interesting and it's interesting that you talk about it in terms of its evolving potential rather than something that is just, you know, a thing in itself, it is a science that is continually moving forward. Our next speaker is Guy Singh-Watson, a huge figure in the organic farming world he's a British farmer and founder of Riverford an organic farm and UK wide organic vegetable box delivery company delivering to around. 50,000 customers a week I think in the UK, Guy, welcome.

Guy Hi, almost 100,000 now.

Pat 100,000! What do I know?! Thank you, Guy.

Guy Thanks Pat and thanks Wendy, and yeah so I am an organic farmer, for 30 odd years, and I've also spent quite a lot of that time kind of communicating directly with our customers, and I think I have a fair sense for how to do that and the things that concern them and so on. And I've also worked a bit with farmers in Uganda through the charity Send a Cow.

About 20 years ago I did actually take the government's court to challenging the legality of some GM trials bordering, our farm.

I'm actually not adamantly anti GMO though I did campaign fairly hard at that time largely on the basis of were the benefits justified by the risks that we were all obliged to take and. And I guess to me it has moved on. I am listening to Wendy and I'm, you know, I'm not adamantly against the technology and I can see that it could bring huge benefits, especially when you know addressed to those sorts of, you know, mildew in wheat. I mean if you, you could give us a, a blight resistant potato I would find it very hard to argue against that. My arguments, really are more around the system, which seems to, to date anyway, go with GM technology.

So my first point really is farmers get squeezed from the market end largely by supermarkets and their margins and the share of the food pound spend has just gone down and down in the UK it's about point 7% of GDP. And that makes it very hard for farmers and very hard for farmers to farm in a green way which can sometimes be more expensive. If we get squeezed from the other end through patrons and seeds, and this happens in my sector we already have patented varieties of tenderstem broccoli for instance where you can spend, you know, a large portion of what you get to the crop goes back to the,

to the seed company and, you know, whereas previously we were growing varieties where the seeds were really an insignificant cost. And, and that goes hand in hand with a global food trade where I think, I think Monsanto own about 23% the top three have roughly 50% of global trade the top 10 have 75%. I mean, those that does imply a degree of sort of market control which I think inevitably is going to increase farmers' costs and we have seen that happening around the world with GM and farmers, getting into debt and there being a lot of problems associated with that.

And I think with that sort of global dominance, I mean it is absolutely inevitable but there is a sort of one variety fits all approach. So it becomes increasingly difficult for farmers with different needs be that based on their farming system, their soils, their climate, to get the varieties that they need. I mean these large global companies are not going to breed varieties, specifically for their needs. I mean there is also unquestionably GM crops, be they soya, maize, cotton have tends to go hand in hand with the type of agriculture which has been so damaging by which I mean large scale, agriculture perhaps soya in the Amazon monocultures grown on a huge scale essentially input intensive agriculture, compared with what I would call knowledge intensive agriculture. And unfortunately, that is all directly in the opposite direction to watch most advocates of an agroecological approach, would be calling for. That is not an inevitable result of technology but to date, you know, in 20 or 30 years that is unquestionably the direction that GM has led us.

I think the agricultural system almost goes hand in hand with the, with the varieties that you're growing, and in my own industry I see that happening with strawberries, you know, not GM strawberries, but I think this will accelerate the rate that, you know, really you can only grow them in a particular very non-agroecological way now because the varieties that we have available are only suited to that, and those are the systems that all the technologists will be familiar with, and it then it becomes a sort of self-fulfilling prophecy and it's very difficult for the those around the edges and this inevitably adds costs when you are effectively a niche, a tiny part large market

My last point which I think is probably going to be really irritating to people like Wendy and I do sympathise with them, is that I think we really do need to be careful what we asked for. So, you know, again, and Wendy mentioned brassicas actually and they've been all bred from kale like plant growing on the shores of Western Europe. And you know, over the last 20 years it's become evident that they have incredible health benefits, some people would describe them as a wonder food by virtue of the glucosinolates and the isothiocyanates, that will give them that better flavour but they're also the ones that protect us from cancer and give us the benefits. And the first thing a plant breeder will do and they do this with Brussel sprouts, is to breed out the bitterness. So, you know, and that removes the benefits so I just think, and we say the same thing with fruits getting ever sweeter, having ever lower levels of fibre, ever lower levels of tannin and not good for our health, and declining vitamins and minerals and vegetables too, so I think there is a real view GM and genetic genome editing has the ability to give us what we want and what supermarkets can make profit from selling and what farmers can sell to supermarkets, but that is that really to our benefit?

That's almost like a really almost a philosophical question I think it's really tough and probably grossly unfair to put that on a scientist who is developing the technology, but there do seem to be negative consequences associated with breeding techniques. Okay, I'll probably use my time. Thanks Pat.

Pat Thank you Guy. Yes. The thrust of what you're saying is, you know, what are we using it for, should it be more targeted and we can we can pick that up a little bit later. Jack Heinemann, is our next speaker. Jack is a professor of genetics and molecular biology, Director of the Centre of Integrative Research and Biosafety at the University of Canterbury in New Zealand. He was also one of the lead authors of the ground-breaking International Assessment on Agricultural Knowledge, Science, Technology and Development, IAASTD for short, report from 2008. Jack welcome.

Jack Kia ora and thank you for having me. Hello to everyone else around the world. I'm coming to you from New Zealand where it's dark and cold, but this is a really warm room to be in.

I'm very pleased to be part of this panel, been so impressed with those who have spoken before me already. I want to just put into the mix, a couple of different thoughts. I think Guy was really helpful to me for what I wanted to say, because one of his comments was, it might be unfair to ask a scientist to think about some of the real world complexities that farmers, but also everyone else, has to deal with when it comes to food and agriculture. I am also a scientist, I'm a genetic engineer. I was of that generation who entered university in the 1980s, early 1980s. Just as the blush of the first generation of GMO tools were becoming available. And I sat in my large lecture theatres in an agricultural University in the Midwest of the United States, and was thinking maybe I would be pre-med. When I heard my lecturer say to me, well, not to me but to the other several hundred in the same theatre, say, 'Listen, if you really want to do something for humanity, you will go into genetic engineering and you'll engineer corn plants to fix nitrogen and you'll, you'll create soybeans that can grow without water'

And, and these, these were the kinds of framings that led a generation of us and multiple generations of us to look to genes, as solutions to problems. As Pat said I was one of the authors, on the one of 400 authors, on the International Assessment on Agricultural Knowledge, Science, Technology and Development, and that was an eye opening experience for me as a genetic engineer because I was exposed to so many different, not just worldviews but expert views in economics, intellectual property law, so many different strands that influence what we think about these technologies.

And one of the traps that we can fall into when we talk about a technology is we can narrow our vision to very precise kinds of questions and frames, in which the answer then is almost given to us. So if, for example, I'm locked in a room with my arms chained, and I'm offered a solid gun, as a way of escape. Obviously I'm going to choose the saw to cut the chain rather than the gun to end my life, both of which would be avenues for escape.

But the options I had were dictated to me by someone leaving the saw and the gun. And I don't think we have to talk about these technologies, just from the viewpoint of the science of these technologies. We can talk about them in the grand mix of other social chains that we create for ourselves when we talk about these technologies. And by that I mean, not all of them are equal in the in the eyes of the intellectual property rights instruments.

It might be that you have the idea that we can use some of these tools altruistically or produce tools that will be of use to small scale farmers. But if we're going to use the tools of gene technology, those

tools are subject to the strictest forms of intellectual property rights protections. As such, they concentrate wealth through the concentration of capital, and they concentrate political influence and power as well. So when we compare agroecology, breeder or seed produced to these gene editing technologies, we're not comparing apples with apples. Agroecology is not the kind of science that tends to generate this kind of power-producing pathway and thus, when the options are put on the table, the options, all seem to favour, gene technologies.

I guess as an example of what I mean by this is also revealed in the IAASTD. We found that over the last four or five decades, public research funding has flowed away from ecological solutions to farming problems, more and more towards breeding solutions to farming problems, to the point now where private sector funding, at least in Western countries, exceeds government funding for research for agricultural solutions.

And when private funding dominates and in a system, it's going to also be favouring those types of technologies and solutions that it can capture through intellectual property rights and get its revenue back. Food production is still overwhelmingly done, not by the large farms in western countries 80% of food, still comes from small scale farmers around the world. And so far, breeder-based or seed-based or gene technology-based solutions have not shown themselves to be particularly well adapted to solving the needs of food production. So we must ask ourselves: is this the best technology for sustainable food systems and sustainable farming?

Do we need to focus our technology on what we're making to breed versus, possibly, focusing our technologies on something like food waste? We know from the UN studies that it's food waste; that if we could capture back the wasted food, we could, we could feed already more than 10 billion people on earth. So this scenario that we need to be altering genes in order to feed the world is a scenario that is a solution when you're only given that as an option; you're only given greater production as an option. You're not also given the option of looking at how it is, we, we feed people and feed people well, and in different ways, in ways that are less damaging to the planet.

My final reflection is this and I just wonder if we've all become a little bit too enamoured with such movies and TV shows like the X-men, where, where you can, in theory, breed somebody who can defy the laws of physics and we stop tethering ourselves to this real world where. Ultimately, you can't be so drought tolerant that you can grow on the moon. This is just not within our genomes to do, and no double stranded break-repair mechanism is magically going to give a wheat plant the ability to grow on the surface of the moon. There are going to be limits in genes and breeding. You know I'm a geneticist I don't deny the power of what we can do through breeding.

But what we could do through breeding still, I'm unconvinced is more, than what we can do through agro ecology, by manipulating in a positive sustainable way the environments in which we grow food, rather than continuing to make those environments extreme and adapting evermore extreme genotypes of plants and animals to those environments.

I'm really looking forward to hearing back from the participants in the seminar so I'm going to hold my comments there, and I look forward to also talking more with the panellists. Thank you very much.

Pat Thank you Jack that's fantastic it raises some really interesting questions. We have one final speaker this morning, and that is Lawrence Woodward, Lawrence is, as you know, stepping in for Sheila Dillon. He's the director of Beyond GM, he was a co-founder and director of the organic Research Centre of Elm Farm and is acknowledged for his pivotal role in the strategic and practical development of the organic sector in the UK. Lawrence, welcome.

Lawrence Thank you, Pat, and it's a pity Sheila is not here but we have discussed with her the kinds of things she wanted to say and some of the points that she raised with us I'll mention, and bring up.

In fact Sheila's comments mesh very well with comments and concerns that have been raised by consumers and citizens. And of course, we are both consumers and citizens. Some of these concerns and issues have been raised during our Bigger Conversation programme.

In the discussion in our Bigger Conversation programme, when we're talking to consumers/citizens, these are not people who are necessarily professionally engaged in food and farming and as such, they don't qualify to be the stakeholders that are usually consulted in government consultations. Nor are they the, what I call 'professional consumers' who are also consulted in government consultations, as 'the voice of the consumer' or the citizen. We've been talking to people who are concerned about food and farming, from a variety of perspectives, even if they're not professionally engaged. And the points we've come up with, that we've received from these people, and Sheila's points are really very interesting.

First of all, and this is not necessarily in the order of importance in which the concerns are expressed but it's to build a pattern.

First of all is the point that Sheila wanted us to make is the whole discussion about food and farming and the ways where it goes in the future is out of kilter, because of the power and the structures of the food industry and the food industry' relationships which stretch right across the board from straightforward lobbying through research funding and relationships with research institutions and universities, through the presence, the corporate presence, on advisory and regulatory bodies and how will the influence and to some extent many call so called expert panels. And also, the influence in the creation of what we might call media 'group think' you just look at the media on new technology, and there's a uniformity coming from science correspondents, coming from media editorials and coming from people who used to be called environmental correspondents. There is a group think, and that matches the group thing that comes from policymakers and researchers. It's, it's a process that gets in the way of mature discussion.

And this leads to a confused situation, about what we mean about fundamentals and critically, what we mean by this word sustainability. We can all agree on the words the words, we use to describe sustainability everybody agrees on. But do we agree about the values that underpin those words. It's critical. It's a critical question because any consideration of new technology and the technologies that we are proposing to use, need to be viewed through the perspective of what direction do we want food and farming to go in. And what do we as a society see about the methods, about the vehicle, as to how

we get there. To mix the metaphor, and to go back to I think Jack mentioned it, the idea of the tool in the toolbox. Well this raises the questions: whose toolbox is it? whose are the tools? who decides on the appropriateness of which tool? The answer to those kinds of questions, though, arise will come from, what do each of us mean by sustainability, do we mean the same thing?

And in these kinds of questions, relating to the direction of food and farming and the methods used citizens and consumers are largely excluded from the decision making process. And even when they are consulted, there's little power, they have little power, and people feel excluded from debating and discussing what really matters. So we have a, kind of, 'what does it matter?' fatalism amongst many people. And on the other side, we have a high practivity in some groups, which again leads to a group think, but in this case a sort of activist group think. All of which prevents a proper conversation about the pros and cons of this technology. And it surely is wrong for us to debate or discuss a technology, which is so powerful, and such a potentially potential game changer as genome editing without having a proper conversation. Making these kinds of decisions on the basis of conflicting groupthink is not a smart thing for us to do in society.

So in our discussions with consumers and citizens around genome editing, we've identified some key points and key issues.

The first thing, and this is significant and possibly a surprising one is that there is a significant level of 'Let's wait and see' about genome technology. There is a significant number of people who are, if not wholly positive are not prepared to reject this technology out of hand.

A significant number of people do see the potential benefits of the technology as outlined by Wendy. And even people who believe that we do need the kinds of transformation that Jack Heinemann talked about, that we need this massive agroecological transformation, still see the value in mitigating the food and farming systems that we currently have, somewhat in the way that that Phillip outlined.

But even for those people who are sympathetic or willing to give genome editing a shot, there is a significant concern and a question about whether actually this technology will lead to more corporate control and a more intensive and industrialised system. So whilst there's a willingness to be sympathetic, that sympathy evaporates if there's a sense of, it's only going to lead to more of the same.

There's also significant health and environmental concerns around the development of genome editing technologies, and especially the question of risk, both to human health and to and to environmental health.

This is again an issue because there is a lack of trust, really, amongst people about the regulatory process; whether we have robust enough regulation and health checks.

It also comes down to the issue which some people are concerned about, about the values and views of life. Whether or not we should be using this kind of technology in terms of what is life. There are significant numbers of people who believe, for example, in the boundaries and scope of organisms. How far can we go, even if we had the technology? Should we be destroying, for example, ideas of

'animalness'? And, if we believe in that kind of thing, where do we draw the boundaries? That comes back to choice. Again, the question of choice, even amongst those people who believe that genome editing might offer some [benefits], the question of choice, and the ability of people - whether consumers or farmers - to choose these methods, which leads to concerns about transparency, about the need for labelling and about the ongoing need for regulation. Even amongst the scientists we've talked to by the way we find very few scientists who believe that genome editing should be totally deregulated. So there is a real concern about the need for some kind of regulation and indeed, ongoing monitoring. And where, again, a real concern about the impact of genome editing technologies, on systems like organic or other ecological systems that do not want to use those things. So how can these systems coexist? Can that coexistence be equitable, or does one technology, with its corporate control and power within policymakers, will that dominate, will that allow equitable coexistence?

So there is, with all these questions of confusion and concern about how we how we are not that difficulty. There is a concern about the role that researchers who own patents, who are receiving money as GE developers who are presented as independent experts. All of our publicly [funded] taxpayer institutions in the UK now receive significant amounts of money involved in the rollout of genome editing or GM technologies. So who do we look to as an independent expert, when we no longer have really independent taxpayer funded institutions? So these are these are real questions that we're were coming up with in our, in our discussions.

So, in summary, I guess the question is most concerning citizens and consumers is does genomic medicine actually move us in a better, i.e. a more healthier, more environmentally friendly system? Does it allow expression of values such as equity and accessibility? Does it moves in that direction, or does it just give us more and more of the same. People are looking for trust, consumers and citizens are willing to be engaged, if they give them the chance and the opportunity to engage properly in this dialogue about choosing the development or regulation and indeed policy in terms of funding or not funding this technology. Thank you.

Pat Thank you, Lawrence greatly appreciated. Just to make a bit of housekeeping announcement, a few of our audience have asked about the chat. We are going to turn the chat on but we wanted to give a chance to let our speakers be the focus of this introductory session. Speakers if you could turn on your cameras, that would be great so we can all see your smiling faces.

A couple of issues came up for me, before we before we throw it open to what have been some really very good questions from our audience. On the one hand, there is a notion that genome editing can take us away from industrial farming as Philip was saying but there was a contrasting view that it simply can't but it entrenches that, and I'd be interested to hear a little bit more from the panel on that.

And the second thing of note was that what we're talking about today is incredibly complex, and the tendency when we're looking at sustainability is to reduce it down to component parts that perhaps don't always connect up well together. And whether it's fair for just scientists who are working in this field to have all the burden of deciding what sustainability is or whether it requires a bigger, I'd say a Bigger Conversation, but essentially that.

So I'd like to open it to our panel, if I may. Just, you know, raise your hand so I can keep track of who wants to answer what, and I'll, I'll let you know. Okay, Phil if you have a first comment. And then Wendy.

Philip Thank you, Pat and thank you to my fellow panellists for a fascinating conversation already. I wanted really to address your question, Pat, about could gene editing entrench industrial agriculture; and let me be absolutely clear my view is that there is a huge danger that it could be used to entrench the production-led intensive mentality. And it is exactly the conversation that Jack was unpacking that, you know, what of the tools that we're looking at here and we have to be clear that the problem of sustainability of feeding the world is not one of production.

We already produce enough food worldwide to feed 16 billion people on the planet. The trouble is we waste, more than half of it. A big slice of that is wasted in terms of food waste in our homes, in supermarkets, in the supply chain. But the biggest single portion of food waste on the planet is in feeding human-edible crops, much of it GM produced to factory farmed animals. And in this respect, simply breeding more productive crops in a wasteful production-led system will not go anywhere towards creating greater sustainability. Thank you.

Pat Thank you, Phillip. Wendy.

Wendy Okay. Yes, just to make a comment here. I think we're very much focusing today on this technology of genome editing. And I think it's important to just say at this point that it is just a technology. And actually what we do with it is of course incredibly varied. So, we could, you know as Philip has said you know go along the route that he suggested. Though I think it also has the opportunity where we can use it in a way that is far more sustainable and that is going to offer us some real advantages. So I think it's important to, rather than, I know it's a difficult thing to do, but rather than just thinking about genome editing as a huge package, we really need to think how we're using it. So what is our aim, what's the outcome we really want?

And if it turns out the genome editing is the best way to get to that outcome. Absolutely, we should have the ability to use it. If it turns out that there's another better way of getting to where we want to get to, absolutely fine. So I think we really have to focus on the, the characteristic the trait that we want in our crops, that we need moving forward, and focus on that. And perhaps focus less on the technology that we use to get there.

I'm not suggesting that we don't need regulation. I agree with the point that was made, that some form of regulation oversight is going to be needed. But that should really perhaps focus on what change have we made because we can have exactly the same plant produced in many different ways. So, it really doesn't make a lot of sense to then start regulating them in different ways if they are, to all intents and purposes, identical.

Pat Okay, thank you. Guy you wanted to say something.

Guy Okay, I hope you can hear I completely agree with Wendy it's not the technology itself it's how it's used and how it's applied. However, I am assuming that this is a technology which isn't going to be accessible to small farmer-led local plant breeding programmes. My assumption, I mean, correct me anyone have bad evidence to the contrary, but my assumption would be, like previous GM, will end up being controlled by large seed companies and if they don't actually develop the patents, they will quickly buy them up, I mean in just the same way that we've seen as with the digital revolution where we have a very small number of companies buy up everything that has any commercial application. So those large companies are going to be interested in selling seed in large quantities across the globe with very little, you know, respect for local conditions and needs. And, I mean, I'm afraid that almost inevitably plays into the model that we've seen before with GM, you know, high levels of, high-intensity high-input agriculture, the absolute opposite of agroecology.

I agree there is no intrinsic reason why the technology should be used in that, in that way, but I find it really difficult to envisage it working in a different way. I mean, you know, Monsanto, DuPont, Syngenta they are controlled by their shareholders. They are, they are legally obliged to maximise their return on shareholder capital that's what they exist for and that's what they will use the power to do; and that is the direction that all our academic institutions seem to gone in globally, I would say. Where they have to be more and more dependent on industry funding, and closer and closer to industry and I would say more distant from the needs of the taxpayers that are actually funding them. So I mean rather depressingly I see it as almost inevitable and I really hope that someone else on the panel can tell me I'm wrong that it won't go in that direction.

Pat Jack.

Jack Guy, I'm not going to tell you you're wrong. I really want to emphasise where we agree. And I want to thank you for framing it the way you did because what you said was, let's identify the problem and the outcome we want, and then, let's find the pathway to a solution. The best solution for that problem and, and in that I also entirely agree.

The problem is here that we've started talking about a technology, and now we're looking for all the problems that fit our technology, rather than we've started with framing the large problems; the issues of sustainability and climate change, food distribution. These are some of the big problems.

What we then made is in many countries and ideological decision that we're going to solve those through private sector market-based solutions that require the concentration of capital in order to deliver solutions. And once, once we've made that kind of choice, then we start to focus again now on particular widgets, and the widget we're talking about here is genome editing. It certainly is, in some ways of framing it, as benign as the most banal of descriptions of it.

Sometimes, if you use genome editing, you might get a single nucleotide change. But in the vast majority of cases that we're going to be talking about. It's not single nucleotide changes that are either the goal or demonstrably the outcome. So if we start to get into those kinds of discussions, of course we're going to put forward the least complex examples to make our points, and the least complex examples are not necessarily our future, when we're using these kinds of technologies.

What I think we have to accept is that there will be different pathways for sustainability just because we're in a big world. The IAASTD recognise this said, you're going it you have countries, like in the Americas that are vast monoculture based simple kinds of rotation systems, corn on corn or maybe you interrupt it with the, with the great biodiversity of soy bean in between, once in a while. And as Philip said the vast majority of what comes out of those monocultures we use to produce cheap meat. Cheap initially, but expensive environmentally in the long term. And in the United States, there's a law that requires a good proportion of the corn to not feed animals, but to feed gas tanks on people's cars. So that's where all of that's going. And we might say, we could with genome editing make corn, a little bit more robust or a little bit more drought tolerant - and that might be true. And it might be in comparison to the corn that's grown there now, in the way it's grown.

But it doesn't mean that it is ultimately the better solution or the better pathway to sustainability than if we had a far more complex rotation pattern in the American Midwest. If we didn't and, and this is where I'm going to become impractical and reveal my, my roots, because I don't think we only have to talk about what technologies we have. I think we can also talk about consuming less meat, consuming less fossil fuel, requiring the kinds of inputs that we currently require for the productivity levels that we have in agriculture. We can also make those social choices.

They're not easy to sell. So if you're going to ask somebody to sell that kind of solution that ain't gonna happen, I know. But we may have to make that those kinds of choices, as a community. As Philip was also mentioning, if you're if you're given two very bad options that is grinding up little boy chickens, I guess what are they roosters, grinding up little roosters versus having them never be born, that sounds nice if those are your two 'Sophie's choices', right?

But on the other hand, if we're talking about modifying animals, such as say removing horns on cattle, particularly cattle that we're going to keep in high density, culture, so that they don't hurt each other. Well, now we're making also a value judgement that that they don't feel a biological pain by not having a behaviour that's linked to having those horns, just because they were born without them. And I'm not sure that that's entirely true. I mean, one way to solve gun crime is to breed people without fingers so that we can't pull the triggers. But I do think we would feel the pain of all the biology we lost by not having opposable thumbs and hands. So when we look for these solutions we're also imposing on the world, what we think is acceptable to those whom we're imposing that solution on, whether it be genetic or technological.

Pat Thank you Jack. Okay, a couple of things Lawrence you haven't spoken yet I know you want to speak. Next we have a huge backlog of questions, Philip Would you be able to hang on? Yes? OK Lawrence if you could, could sort of make your, your bit, and then we'll move on to the audience questions with Jim.

Lawrence Yeah, I just like to pick up on Jack's categorization of himself as being unrealistic. I've known him a long time and yes he is often unrealistic as well as being realistic. He dresses them up in different ways. But I'm noticing a few of the comments on the chat. The reality is, if we talk about major transformation whether we call it agroecology, regenerative or whatever, if we just talked about that,

then we are being unrealistic, because the real situation is here now, we have genome editing it is in existence.

Australia has deregulated some forms of genome editing, we are discussing deregulation of genome editing in the UK. So we do have to face this actual situation we cannot just talk about overall overarching global transformation. We've got to consider how we can structure our relationship with this technology as it exists now. There is *de facto* a policy within Europe and within the UK, of coexistence. Whether people like it or not, all the policy is geared towards the coexistence of conventional agriculture, organic, agroecological agriculture and agriculture, which may or may not use GMOs, and the new gene editing techniques. The issue that we're actually facing is how we regulate the space between the two. How we regulate and deal with the boundaries and also, I would say, how we have to discuss, who's making those decisions as to where taxpayer-funded money goes. And in the decisions about where taxpayer-funded money goes taxpayers have got no say there is no citizen engagement in that kind of process.

So in the UK, we have a regulatory process, an advisory committee, the Advisory Committee in Releases into the Environment [ACRE], which will talk about the technologies, the techniques relating to a specific application. But it will not talk about whether it's worth pursuing that line. So, whether or not we as taxpayers should spend money on genome edited camelina to feed an intensive salmon fish farming enterprise, whether that's the use of our money, leaving aside the risks, we're not allowed to talk about it. There's no forum for discussing it. Similarly, there's no forum for us to discuss whether or not we have got a good enough risk assessment process, and whether or not we have proper ongoing monitoring of this technology as in real life it's out in the environment.

So I think we need to really focus on those questions. If Phillip says there is a role for some genome editing in industrial livestock to mitigate the impacts of that, Phillip then is to say, who makes the decisions as to when the exception is used. What are the boundaries? What's the transparency? What's the labelling and what implications does that have to other kinds of production systems? And we have to really move down to these onto these nitty gritty questions because they hear their facing us now.

Pat It's easy to see how quickly the conversation gets bigger. We've had a number of questions put to us, I'd like to get Jim, if you could come in, I know you've been watching them, and trying to make sense of them. It's very wide ranging. Can you can you put some questions to the panel from the audience please.

Jim what I was just going to do, since there's been a sort of small tsunami of questions coming in as we've been speaking, is just pick up initially on some of the pre submitted questions, and that might give you a chance perhaps just to scroll through some of those other ones. But I'll come back to those as well. I'm just sort of trying to batch these up by theme. These questions were actually captured anonymously as opposed to the ones that we've seen this morning but on the theme, I guess, of ownership, two or three questions.

One being, most new technologies can be used for good or bad purposes. The first wave of GMO research has primarily been applied to produce herbicide resistant crops so Monsanto could make farmers dependent on their seeds as well as chemicals. How can we assure that gene editing will be used to benefit farmers and consumers, rather than giant agro-chemical corporations? Another shorter one, global solutions to the numerous challenges facing humanity, or only seriously pursued if someone can make money out of them in the longer term has this been good for anyone? And then a final question on the same theme which sort of slightly turns this around, some of the biggest concerns around GMOs and new gene editing techniques are essentially political and social, for example, the issues that have been discussed earlier on corporate ownership IP food sovereignty and so on. And the question is, if I guess this is a big if, if development and funding of these techniques were entirely decoupled from the private sphere, and only sanctioned within the public sphere with beneficial outcomes, in effect, becoming public goods, would that alter the personal views of any of the panellists?

Pat Okay, that's a lot. Anybody want to start. Guy?

Guy Were this technology to be controlled essentially in the public sphere removed from, you know, the profit incentive, yeah I would completely change my view of it. And I think we should just add too, the unintended consequences of all the legislation, which probably most of those in the cautious/anti camp [would like to see]; the more rigid legislation you throw in there around introducing a new seed variety - and this applies to all, you know, even non-GM seed lists - the more expensive it is to introduce a new variety, the more difficult it is for small players to stay in that market. I think we need to be wary that. AS so often happens, the unintended consequence of legislation designed to regulate the activities of corporate entities, is that it can strengthen the hand of that corporate entity. I know that's a bit off piste from the question but I think it is a point worth noting. But yeah it would completely change my view of the technology. Totally.

Pat Thank you Guy. Wendy.

Wendy Okay yeah just. There's so much going on there but just a couple of comments, and so the first thing to say, with gene editing, the ways we use it it's just incredibly diverse far more diverse than anything we've ever done with the older GM technology. So, part of what my group does, we run a platform so we interact with loads of different people worldwide and the range of projects and things that people are using this technology for is huge and in many cases, they are actually it's just being used as a research tool to answer questions, which then once they've got those answers like okay, what does this gene actually do, how important is it, then might lead to another pathway through to a product that might not actually be gene edited. So it's important I think to mention that.

And, the main gene editing technique that we use is CRISPR-Cas9, and the intellectual property around that is pretty complicated. But I do know that there are a number of small startup companies that have the licences in place to use this technology, and they are using it in a way that, you know, for crops that are not the big crops that are currently been out there, that have been genetically modified. They're using it for smaller crops, for more specific purposes. So although it might be difficult. This is happening it's not just the big multinationals that are using this technology have access to it.

Pat Jack I think you had a question.

Jack I did. I just wanted to turn that question on its head. So the question was if this were all a state-owned enterprise rather than a multinational corporation what I changed my views. And I guess what I would say is that a monopoly is a monopoly and it will be driven by the same kinds of incentives, whether it's private or government.

Currently in countries like New Zealand, and I would suspect in many countries around the world, the single largest investor in gene technology is the government. It puts in far more money into research and development, pre-commercial, than most of these companies put in afterwards. So the public is, or the public governments are, already addicted to outcomes from this technology. So it wouldn't necessarily change my view on how it would ultimately be used.

I want to agree with Wendy. This technology is fantastic for answering research questions, just as the older genetic engineering techniques have been a tremendous resource to understand how genes work. There's no disagreement there at all. The question here is their application in a commercial sphere, and whether or not it leaves farmers with the same options, or better options, than they have if we invested in some other kind of pathway.

Now, one of one of one of the issues is that, well, because it might be cheaper and faster to use genome editing, - which, in my view is still just a form of genetic engineering - that smaller companies and perhaps more niche operations could emerge. But this isn't unlike our history. Small companies using genetic engineering techniques of yesteryear also emerged and once they had something that produced a profit they were bought by the large ones that's why the seed market consolidated is because more and more of the patent sphere was taken up by big companies going after the small companies, as they did this.

So even if a small company were to develop something, it would still be using the same kind of intellectual property rights instruments, which are themselves, the market. The market is for those fundamental patents to be collected up and to be used.

So my question in reverse would be to say, could we agree that if you do anything with genome editing, you don't get to use an intellectual property rights instrument?

And this thing would go away tomorrow because it is about concentrating capital, and the use of gene technologies is the most efficient way in agriculture to concentrate capital. There is no other input to agriculture that I've seen to be as effective as gene technologies. And thus, it's not equivalent to the other kinds of technologies in our social basket, because they don't concentrate capital, even if it turns out they can produce better solutions.

Pat Philip?

Philip So, thank you, Pat just wanted to pick up on the some of the questions in conversation and wanted to just bridge back to Lawrence's point about regulation and I believe that any application of

gene editing should be very strongly regulated, and it would need to be screened by a comprehensive and inclusive bioethics panel to make sure that the plethora of societal downsides to animals, to the environment, to people, that could possibly come out of this is screened comprehensively

But let me be very clear what I'm not batting for is the comprehensive use of gene editing. What I'm saying is that I can see that in the shift that needs to happen from industrial agriculture to a regenerative, agroecological system, if we, as, as a, as humanity are to have a future, if we do that, then there could be potentially some targeted laser-like applications. And I point to the gene editing of chicks to avoid the 5 to 7 billion chicks being killed every year as they hatch out as probably the clearest example, in my book. And if it were to be used, then of course it should be labelled, but I think also we have to be clear that labelling in the current system is barely there.

There is no labelling on eggs of any description that tells us that the chicks have been ground to death. The male chicks have been ground to death, of the females that produced these eggs, so labelling has to be clear and expose things that that that matter to people.

I want to just finally pick up on it I agree entirely with Wendy's points that we should identify the problem, then look for the solution, and that the problem isn't the lack of production, it's how we are producing and, and why we're producing so much. I do feel that the technology isn't the only solution, in fact, it is a solution that is already overdone. In moving to a more harmonious with nature, way of producing food, we also need more nature fit diets, which will include, in my book, much less meat and dairy. If we are to have agro agroecology, regenerative farming across the world. We have to have far fewer farmed animals. We have to reduce the amount of meat and dairy we're producing by at least half, probably more. And in that, I think there is also another technological development that we shouldn't forget that isn't about gene editing but it is about the use of cellular agriculture, about growing meat from stem cells, which of course has the potential to have huge animal welfare benefit in that you can have meat, without the slaughter.

Pat Thank you, Phillip. Lawrence I know you wanted to say something, can I just interject very quickly. As far as possible. I'd like to keep our discussions around sustainability, agroecology, coexistence, that sort of thing. As I say it's a conversation that gets really big really quickly. We've had a few audience members want to know a bit more about sustainability and you have all touched on that but let's try and keep it focused with the limited time that we have. Lawrence.

Lawrence To pick up on something Jack, said he, which I think is important people forgetting that the huge amounts of money going into the development of these technologies does actually come from taxpayer-funded research institutions.

Where I would disagree with him, or add to his point, that these technologies create capital. It's actually not the technologies themselves that need capital, it's the allocation of intellectual property rights through patents or, or other things that create the capital, and there is no reason why that should be.

I mean I know, as Wendy said somewhere on the chat here that we do live in a capitalist world, but it's not actually that long ago, where taxpayer funded institutions, John Innes Centre, Rothamsted and so

on, were actually public interest institutions. They, they put their knowledge out there into the public so anyone could use. What's changed is locking them into a particular form of commercial rollout; and what's got worse with that is that commercial rollout is governed by a particular vision of what our food system, and therefore our farming system should look like. And what that is. And now we can see no real alternative. Even the alternatives tried to fit into that model

So okay I'm getting all this up in the air stuff, but coming back to the sort of reality, is that if we, if we withdrew patents from all independent, from all taxpayer-funded research institutions we will make a massive difference. If we force government policy, in order to consider questions in terms of goal and direction in relation to food and food production and agriculture, for, to use this phrase 'public good' - and by the way, as an aside, how the government can say health is not a public good is beyond me but that's currently what our government says - but if we, if we have a policy of funding research and development towards those wider values and engaged citizens in that creation of those values in that direction, this technology and its value or otherwise falls into place; it finds its place within a much more equitable open, and potentially more regenerative framework.

It's not actually as difficult as it sounds, we change the intellectual property rights and if we make government funding answerable to the public, and using a transparent and open discursive policy setting framework, as opposed to expert panels and narrowly defined stakeholders, then actually we can begin this transformation, and maybe this technology has a role in that. Maybe not, but it will find a role if it has one.

Pat Thank you, Lawrence. So what I see coming through from our audience is a huge amount of very questions, some of them on older style GMOs, which is not necessarily the focus of what we're talking about today, but there is a thread of concern, running through about not having any choice and not having any control and I think that has segued with a couple of questions around sustainability.

One suggesting that the word itself has become problematic and stripped of all of its useful meaning and if that's the case, how do we build a sustainable food system? Another one has more radically suggested that the word sustainable has become too elastic, referring to environmental and social and economic and health issues, and that is what's muddling our discussions and making it difficult for different sides and different people coming at it at different ways to define any agreement. And the question posed is whether the term sustainability should be protected in some way or limited in some way to refer only to environmental sustainability. So greenhouse gases contamination with pesticides fertilisers and biodiversity score sheets. Does anybody have any thoughts on that?

I think that we can go round and round the houses with the discussion, that everybody's saying that their version is best. But a lot of our panellists have said you know let's start in basic principles. So let's start with basic principles. Philip.

Philip Well, I think actually that sustainability itself is, is not good enough. Actually it's old hat, we need to move on from there, because my basic understanding of sustainability is our ability to do tomorrow what we do today. And in terms of food and agriculture, being able to do tomorrow, what we do today is not going to be good enough. Being able to just do that when there is increasing demand, i.e. billions

more people in a resource shrinking world, simply doesn't add up as a maths equation, and that is why we need a regenerative food system, which instead of holding the line, holding on, holding the level of an already diminished food system, we need a regenerative system which is putting back building soil fertility, bringing back pollinators, preserving water and wildlife and enabling us to produce more in the future in ways which are genuinely in harmony with nature and protecting our very life support system. Because of course we rely on the ecosystem, for every breath we take every drink that we have, and every bite of food that we eat.

Pat Thank you Philip. I'm interested in a few questions that have come up on - and Lawrence you mentioned it too - about limits, where do we draw the line is there is there a point when you would say only natural approaches - and I hate that word, by the way - but only, you know, agroecological, 'natural' approaches to breeding will work and GE won't; or is there a place where you say, look, only gene editing will solve this problem? Where do we draw the lines and what are the limits because sustainability isn't about having it all. Sustainability is about making choices, and those choices will probably vary according to where you are and what you're trying to do. Does anybody have any thoughts on that? Guy?

Guy And I am really trying to avoid using the sustainability word. The only sustainable farming I've seen has been, you know, highly-integrated, small-scale agriculture in Uganda I've also seen some very unsustainable approaches in Uganda, and it is, you know, an absolutely integral part of what they do is knowledge-intensive and seed-saving and you know varieties to work is an absolutely integral part of that and it is a whole system, it's the only the only example of agriculture that I've seen globally that gives me any hope at all and I think it's the only one that I've seen that that really warrants the use of the word sustainable. Nothing, we do no farming I've seen in this country, is sustainable including my own.

Pat There's trade-offs, right?

Guy Yeah, you know there's less bad. That's about as good as we can say in the West with our developed agriculture and know we are bought into this paradigm of 0.7% of GDP going back to farmers and I think it's going to be virtually impossible to farm in a sustainable way with such a paltry sum going into looking after our countryside, which of course should be the purpose of agriculture as well as producing food.

Pat And was it Jack and then Lawrence?

Jack I do believe it was Lawrence and then Jack, so

Pat OK, Lawrence and then Jack. Thank you Jack.

Lawrence Well, I was very happy to cede the place to Jack, but the problem with a sustainability thing is so many people, so many things have been gathered together under that umbrella name. And I just want an answer to your point Pat about limits and boundaries, is just to draw two things out.

One is, in terms of plant breeding and using GM, the only approach to plant breeding that actually does set a limit is biodynamic/organic plant breeding. There's clearly the definition and the terms of that those approaches set out that breaking species barriers by going into the plant below the level of the cell is completely out. So they have defined and set a scope and a boundary.

That clearly means that techniques that go into a below, below the cell level are completely out so any benefits from that are missed out by biodynamic plant breeders. So there needs to be a whole flow and there is developed a whole flow, a supply chain using those plants and retailing those plants that flow from that.

And so if we want to alter look at alternatives and developing alternatives in this world that moves on to something else, then we have to look at those the consequences and the logic and the coherence of that kind of supply chain through making technological choices.

The other technological choice we need to consider, which is very confused, is the use of this word agro ecology agroecology is defined by some of the early pioneers, Miguel Altieri, for example, in South America, sees agroecology as a socio-economic movement. It's deals with food sovereignty and rights and so on. The use of the term agroecology in the UK and in many parts of Europe is not that. It's a menu of agronomic techniques, and in fact the much vaunted 'agroecology in 25 years' plan separates that. [It] talks about agroecology as a menu of techniques. If you look at agroecology in that way there is a role in a place for genome editing because it does not deal with a whole other structures.

So, if we want to find something that's different from the word sustainability, and we have to, then we need to be clear about the other terms that we use, and what flows from the use of those terms. Very often the technological choice what has to flow from them is the whole supply chain right down to knowledge and understanding and descriptions that consumers or citizens can use to buy or support and empower that that choice.

Jim Just a quick point. We are running into extra time. Just to let you know. And just to follow on from Lawrence's point on agroecology, there was a question specifically and we got a Guy here as well on organic, which was that agroecological seems to have supplanted organic as the most widely used descriptor for low-input sustainable agriculture, but a lot of systems that are referenced broadly under that umbrella, things like nature-based solutions, sustainable intensification, climate smart agriculture, conservation agriculture, etc. are relatively untested models organic surely should be the benchmark for sustainable agriculture and the favour of policy as a model for policy makers, but the 'O-word' is increasingly missing in action in some of these reports, should the organic sector be concerned about this?

Guy Well, I mean, organic is defined in law. There is a trusted system whereby a food citizen/customer can, and you leverage their wishes about how they want animals to be treated and the countryside to be treated through that their food purchases agro ecology is not you know it is agroecology, certainly in the UK, is a concept. You know, it's something to aspire towards and maybe adapt our techniques, a little bit, and move in that direction is not a proven system that can feed significant numbers of people – yet - I mean I hope one day that it might become so and probably in order to do that, it will require an

economic definition and a protected sort of brand in the same way that organic has done. so I think they, they're kind of apples and pears a little bit.

Pat Thank you Guy. Just to let everybody know we were scheduled to end at noon, we're going to end at 12.15. So, there's a lot to take in. We have had so many questions that we will be publishing them, certainly on the Bigger Conversation website and Facebook page and we will be encouraging people to please continue the conversation there. As Jim said it's been a tsunami of questions and concerns, but something that came up just now is the idea that the ethical and societal concerns about using genome editing on plants is very different from that on animals. And the question of whether these conversations need to stay separate in order to avoid conflating different but very valid concerns. I wonder if anybody has any thoughts on that? Jack, and then Wendy.

Jack Yes, I think that's an excellent point and I'm, I was remiss in not sort of mentioning this earlier gene editing, in the sense of having tools that direct a change at a particular place in the genome weren't invented and just the century. So if you go back to reviews on genetic engineering in 1980 they were already referring to gene editing, and there were techniques for that, such as oligonucleotide directed mutagenesis. So gene editing is not new, it is part of the framework of our genetic engineering for a long time.

What's new is the number of species that our current tools allow us to manipulate in the same kind of targeted way. And, as Wendy mentions, the rate at which we can do those modifications and all the different species that we're talking about. And we do tend to conflate when we get into this conversation about genetic engineering or genome editing, we conflate, the largest commercialised visible product that is agricultural crops, with all the different ways in which these technologies are applied. They're applied in medicine, and they're applied in research, they're applied in microorganisms, all the way through to elephants, right? So we can do, and we do different things with these technologies, not just make GM plants. And people do react to them differently because they're in different frameworks for, that reason.

I think though because of the way that this this particular panel was assembled the focus has quickly been on plants. But emerging kinds of applications of this technologies technology won't restrict us to plants, and are even also becoming far more integrated into our other chemical-based solutions for agriculture, such as topical applications of double stranded RNAs, or even potentially topical applications for uptake of genome editing nucleases. So, in time, what we're talking about is not just the creation or not of different organisms, but who gets to create them, whether or not we'll be able to catalogue them at the time of their creation, and the technology is becoming in a sense, are evolving in a sense, to the place where we can do environmental genetic engineering. Not just genetic engineering in a lab, in which we look backwards to assess the safety or otherwise, of the organism we made, but we're actually going to be able to do this in the field. And then I think the conversation takes on far new dimensions than what we've covered here so far.

Pat Thank you. Wendy.

Wendy Yes, I agree with Jack you know the, as I said this technology is moving very fast, and some of the applications, he mentioned, will certainly be a possibility in the future. And you know our, our crops are unique and the issues are unique because gene editing can be used in many different ways. There are huge medical applications. And I think generally people feel more comfortable, you know if they can see that real medical benefit than perhaps they do if it's engineering in a crop plant. But I think I just come back again to the, you know, again, we're very focused on the technology here but I think in all of these cases our focus should be on, OK what is the outcome that we really need, that we desire, and that's going to be really valuable. And if genome editing is the only or the best way to get there, or the fastest way to get there, and we need to get there fast, then we shouldn't be putting artificial lines to say no we cannot do this because we've put this line here and we're not going to cross it. Even if, you know, it's in an organic system and there's a really strong need for something which we can only do with an edit, you know, maybe we need to look really carefully that and say OK, perhaps this is something that we shouldn't put a line here, and we should consider that this might be a sensible way forward.

Pat Phillip, yes.

Philip On the, on the animal side I think that there is a real danger that gene editing will be used to prop up industrial agriculture factory farming, for example, trying to infer resistance to disease - diseases that essentially inherent in the industrial machine. So using gene editing, for example, as a substitute for current methods which includes using 73% of the world's antibiotics in feeding farm animals. So what we need to do, in my view, is to make sure that we don't simply use this technology to lock-in factory farming, to lock-in cruel and unhealthy and unsustainable systems, and to only use these where there is a genuine societal and animal welfare and environmental benefit that takes us towards what I think, policymakers are increasingly waking up to which is the need to move away from industrial agriculture. And ideally, and I'll come back to the point I made at the very beginning, ideally, I would like to see a non-industrial agricultural system or regenerative farming system with, with much reduced animals; animals kept in future-fit, nature-friendly, animal welfare-friendly systems that are naturally resistant to disease in mixed rotational farming systems, without gene editing. Thank you.

Pat Thank you Philip. We are coming to the end of our time. There's, I think, a real frustration on the audience side and panellists side because there is so much to say. But one thing that we all seem to agree on is that we need to look at what we're trying to achieve. You know, what is the problem we're trying to solve, and what is the best way to solve it. That's come through very strongly through all of our panellists and it's a question that is run through all of the many questions that we've had here today. And once we decide what that problem is, and it may be different from region to region or country to country, if I if I've taken Guy correctly, then, then we need to ask ourselves, what is the best way to solve it.

At the moment that question is being asked by people like yourselves is being asked by people like our audience. It's certainly not being asked in the policy realm. The policy realm is very much from, guided by things other than agriculture. It's guided by trade, it's guided by economics, it's guided by things that don't necessarily have anything to do with feeding people and so the question is how do we get together - and it's something to ponder now as we're running out of time - how do we get together to

make a recommendation from all of us who are seeking 'sustainability', that this is the way we should approach the problem and not the backwards way we've been doing it before.

I hope that everybody has got a little bit out of this today. I've been thrilled to have such a wonderful panel with us today, and I am sorry to those of you who didn't get all of your questions asked. As I said, we will we will post them and we will continue the conversation on the Facebook page of a Bigger Conversation, and Natural Product Global and ourselves will continue to write about this and pursue this conversation because it is an extremely important one and the thought and the emotion that has gone into the questions that we've seen today suggests that it is something that needs a much wider airing. So with that, I'm going to leave you and say thank you, everybody, for coming. Thank you to our audience for asking such brilliant questions. And let's do it again.