



Aims

This is the first meeting in the series, and the aim of it is to help lay the foundation for the rest of the year by taking a global view of the connections between food security, biodiversity and bioenergy. The three witnesses will also begin to think about the research pathways that will help us to prepare for and address the challenges we will face in the future.

Agenda

All the witnesses will give a 10 minute introduction and their perspective on the two core questions followed a general discussion:

- 5:00pm Welcome by the Chair and an introduction to the topic
Each witness gives a short introduction and answers to the questions (10 mins each)
Questions and beginning the open discussion
- 6:00pm Coffee break
Continue the open discussion
- 7:15pm Reception and dinner, which will include a working session

Witnesses

This month, the three witnesses are:

Dr Tina Barsby	Chief Executive The National Institute of Agricultural Botany (NIAB), Cambridge
Ariel Brunner	Head of EU Policy, BirdLife International, based in Brussels
Professor Paul Dupree	Professor of Biochemistry, Department of Biochemistry, University of Cambridge

Questions

This month, the witnesses have all been asked two core questions:

- 1) What do you perceive as being the main gaps in our knowledge?
- 2) What would you include in the 'next generation' of research questions?

Towards the end of each meeting we will turn to next steps and follow-up:

- 3) Making connections: Who needs to come together to refine and shape these ideas?

Each of these questions will be posed to everyone and their answers will then be used as a springboard for further discussion. The main points raised will then sent to everyone to use as a starting point for the next meeting.

Witnesses

Dr Tina Barsby

Chief Executive

The National Institute of Agricultural Botany (NIAB), Cambridge

Dr Barsby was appointed Chief Executive and Director of NIAB in September 2008, becoming the first female Chief Executive in the Institute's 90-year history. A plant geneticist, Dr Barsby has extensive experience in plant biotechnology and applied plant science, spanning both academic and commercial research in the agricultural crop sector, including 18 years with Groupe Limagrain.



She has extensive scientific experience in biotechnology and seed development, especially in wheat and oilseed rape, and has been involved in various cross-sector activities bringing together scientists and breeders.

Tina has a first degree in Agricultural Botany from the University of Wales at Bangor, and a PhD from the University of Nottingham. She spent a postdoctoral period at Kansas State University, and worked at Allelix Inc., Ontario, Canada for several years before returning to the UK in 1989.

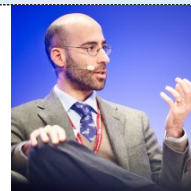
e-mail: tina.barsby@niab.com

Ariel Brunner

Head of EU Policy,

BirdLife International, based in Brussels

Based in Brussels, Ariel Brunner is Head of EU Policy at the environmental NGO BirdLife International. In recent years, he has led BirdLife's work on reform of the European Union common agriculture policy, better implementation of the EU rural development policy and advocating the sustainability of biofuels and bio-energy policies. Before moving to Brussels he followed the implementation of EU nature conservation legislation in Italy and was instrumental in the designation of the country's special protection areas network (sites protected under the EU Wild Birds Directive).



Born in Israel, he holds an MSc in Environmental Sciences from Milan University and he speaks Italian, English, Spanish, French, as well as Hebrew.

e-mail: ariel.brunner@birdlife.org

Professor Paul Dupree

Professor of Biochemistry,

Department of Biochemistry, University of Cambridge

Professor Paul Dupree's research is focused on understanding the biosynthesis and function of polysaccharide components of the plant cell wall. He has made significant advances in the area of understanding and improving plant lignocellulosic biomass quality and quantity, research which underpins development of renewable materials, such as fuels from plants.



The Dupree Lab is one of the six research hubs in The BBSRC Sustainable Bioenergy Centre. This virtual centre is composed of academic and industrial partners, based at each of the Universities of Cambridge, Dundee, Nottingham and York and Rothamsted Research. Their contribution is the BSBEC Cell Wall Sugars Programme - developing strategies to improve plants and enzymes for increased sugar release from biomass. The programme aims to better understand how sugars are locked into plant cell walls. By doing this they can select the right plants and the right enzymes to release the maximum amount of sugars for conversion to biofuels.

His research group collaborate with industrial partners to test their ideas and are also actively involved in increasing both energy awareness and public understanding of the opportunities and challenges biotechnology and bioenergy provide. They are also part of the Leverhulme Centre for Natural Material Innovation, a collaboration between the departments of Architecture, Biochemistry, Chemistry and DAMTP that aims to understand and improve wood properties for building construction.

e-mail: pd101@cam.ac.uk



Full transcript

Transcribed by
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Duration: 1:49:14

Forum Members present

Martin Rees (MR)

Tina Barsby (TB)

Ariel Brunner (AB)

Paul Dupree (PD)

Bhaskar Vira (BV)

Larry Sherman (LS)

Paul Linden (PL)

Peter Guthrie (PG)

Doug Crawford-Brown (DC-B)

Ian Hodge (IH)

Alison Smith (AS)

Maira Faul (MF)

Gemma Cranston (GC)

Therese Rudebeck (TR)

Mike Rands (MR2)

Jonathan Green (JG)

Howard Griffiths (HG)

Rosamunde Almond (RA)

Helen Curry (HC)

MR:	...Rees, I'm the Chairman, I'm totally rather late today and I'd like to welcome you to the first session of the academic year and the first session of the Forum to address our new topic. And I'm particularly grateful to the three people who have agreed to be our witnesses today, Tina Barsby there, Ariel Brunner and Paul Dupree, who hasn't come very far. Anyway thank you very much. There are a number of new people and we don't necessarily all know each other so maybe we should just go round the table first introducing ourselves before we start the agenda if that's all right. I'm Martin Rees, I'm a space scientist and amateur environmentalist.
BV:	I'm Bhaskar Vira, I work on political economy, I'm based at the Department of Geography, I'm Director of the Conservation Research Institute and I'm also involved in the Food Security Initiative. I'm nominally listed on the energy one but I haven't contributed as much as I'd like to, but that's where I come into this.
LS:	I'm Lawrence Sherman, Director of the Institute of Criminology and I'm an experimental criminologist.
PL:	I'm Paul Linden and I'm the Director of the Cambridge Forum and I'm...
MR:	Supreme being it's called!
PL:	Thank you Martin. I'm an applied mathematician, I work on fluid flow and environmental problems associated with them.
PG:	Hi, I'm Peter Guthrie from the Engineering Department and I'm from the Centre for Sustainable Development.
DC-B:	I'm Doug Crawford-Brown from Land Economy and from the Cambridge Centre for Climate Change Mitigation Research.
IH:	Ian Hodge, also from Land Economy. I'm a rural economist I guess, I'm interested in land, property, environmental issues, agriculture, all sorts of things.
AS:	I'm Alison Smith from the Department of Plant Sciences, I'm a plant biochemist, I'm interested in algal biotechnology and I'm representing the Energy @ Cam Strategic Research Initiative and I think I'm the inverse facet because I think I'm down on the food security world but I don't have anything to do with it.
AB:	I'm Ariel Brunner, I'm Head of EU Policy for Birdlife, Birdlife Europe environmental NGO that focuses on biodiversity and bird conservation.
PD:	I'm Paul Dupree, I'm a plant biochemist and contribute perhaps to Bioenergy at Cambridge and I'm interested in the conversion of plants into energy and food as we'll hear in a



	moment.
TB:	So I'm Tina Barsby, I'm the Director of NIAB, The National Institute of Agricultural Botany on Huntingdon Road in Cambridge and I'm involved with the Food Security Initiative and I'm interested in plant breeding and in farming.
MF:	Moira Faul, I'm Research Associate at the Centre for Science and Policy and Senior Adviser at the Humanitarian Centre as well.
GC:	I'm Gemma Cranston, I work within the Natural Capital Leaders Platform in the Cambridge Institute for Sustainability Leadership.
TR:	I am Therese Rudebeck and I'm a PhD student in Geography focusing on water governance.
MR2:	I'm Mike Rands, the Director of the Cambridge Conservation Initiative which is a collaboration between the University and the cluster of conservation organisations, biodiversity conservation organisations based in and around Cambridge. I was originally a conservation scientist and then practitioner and I'm also I think...well not think, I know, I'm part of the Food Security Initiative as well as the conservation world although I've done very little for the food security one and hopefully a bit more for the conservation one.
JG:	I'm Jonathan Green, I'm a postdoc working with Bhaskar in geography and I'm also working closely with CISL on the Natural Capital Leaders Platform.
HG:	Howard Griffiths at Department of Plant Sciences. I'm also now Co-chair of the Global Food Security Initiative and a plant physiological ecologist.
RA:	Hi, I'm Roz almond, I'm a conservation biologist and I help Martin and Paul and I've e-mailed you a lot to help and shape this forum. I'm actually today I'm also Emily Shuckburgh, this laptop is Emily Shuckburgh, because she is from the British Antarctic Survey and she as an experiment, she's joining us remotely so you're being filmed from up there, she can hear the audio so if you could all speak up a little bit and she will ask questions through me and she says hello.
PL:	It's a seance isn't it?
HC:	I'm Helen Curry and I'm a little late today and I'm a Lecturer in the History and Philosophy of Science here and have interests in the history of agriculture and conservation biology, especially [inaudible 0:05:12].
MR:	Okay, well thank you very much and welcome to everyone, welcome especially to those who are here for the first time and welcome remotely to Emily.
RA:	She says she's coming for dinner as well.
MR:	Well I think perhaps to start with it might be good if we ask Roz to give a bit of introduction and background about where we've got to and what we plan for this and the subsequent sessions because we've been going for a year and we finished what was our first study in this is the second one. And so let me hand over to Roz.
RA:	Yeah sure. So all of last year we were talking about sustainability in cities, different facets of sustainability in cities and the aim of this year is really to concentrate more on biodiversity, bioenergy, food security. So in a big sweeping statement I could say it's the land outside cities but really it's thinking about future research questions, future research areas in the overlap between all of those. And so what we've got this time, we met to first start talking about this back in May and based on May we've used that to create a bit more of a storyline for the meetings this year, there are eight or nine of them. The first two in October and November, they are going to be global views, so today we'll be thinking about as I said biodiverse energy, food security to begin with. Next month Ian Bateman from the University of East Anglia and Bojana from the Foreseer Project will help us think about the economics, the policy and the health side of this area, again looking globally. In December



	<p>we're going to be thinking about what we can see from above and so Alan Belward is going to be coming over from Italy from the Joint Research Council in the EU, he is particularly interested in Africa but in remote sensing in general. And Lucas Joppa from Microsoft Research, he is now based in Seattle but he's going to be coming over as well. One of the reasons why we're doing this experiment in bringing Emily in this time is that we're hoping to be able to bring remote witnesses in as well. And I just spoke to Woody Turner from NASA in their Ecological Foresight Programme and he's potentially interested in that in November, so that would be a new way that we could use the Forum that we haven't tried before.</p> <p>In January we're going to be thinking about does the way we think about this area need to change, so Georgina Mace and Charles Godfrey will be helping us to do that. In February Gemma and I have been working together a little bit because what we're talking about overlaps a lot with the Nexus Network and the way in which CISL, the Institute for Sustainability Leadership is bringing business into discussions about this nexus. So in February we're going to organise some meeting, hopefully with the corporate partners as witnesses, but that's quite another area that we can explore, maybe from global to local. And in March we're really going to be going the other way - from local to global. So Barbara Stocking from Murray Edwards, former director of Oxfam will be coming then. Toby Gardner who used to work in Cambridge but now he's based at Stockholm Environmental Centre, interested in land use change particularly in Brazil, he's going to be joining us as a witness and then Melissa Leach from the Institute of Development Studies. So we've got quite a broad programme, each one with three or four witnesses talking about different parts of this area and concentrating to begin with on two questions: the main gaps in what we know and the next generation of research questions and those will run through all of the witnesses throughout the year. So I'm excited about it, I hope it's really interesting and I'm looking forward to the discussion today as well</p>
MR:	Thanks. Do you want to say anything about the final stages of the previous study?
RA:	Oh yeah, sure. I've been thinking about cities a lot too.
MR:	Could we tell just for the new people the aim is to reinform ourselves, it therefore feeds back to different parts of the University, but the aim is also to have some tangible output at the end and it's been Roz who has been distilling all the information we had from last year's sessions into what will hopefully be a report that we can present in a month or two.
RA:	Yeah, exactly. So I've been doing that over the summer and drafting six sections based on the research question, the ideas that came out of all the meetings last year and I'll send that all to you and then we'll hopefully meet to review it on 4 th November, not hopefully, we will meet to review it on 4 th November. So if you'd like to come to that meeting please let me know. And then our aim is to release it at an event on 14 th January. So we had 26 witnesses from business, from policy, from different universities, so our idea is to invite those witnesses back to Cambridge, the guests who took part in the discussions and to have a panel discussion at St Catherine's College on 14 th January where we'll use the output as a springboard to talk about future research in cities. So it's really a starting point if you like and then we're aiming to do that with the discussions, that kind of thing with the discussions that we have this year as well. As an add-on to this year we've also been talking about having a parallel forum, we've been talking about this for a long time but arranging another meeting that runs in tandem with this one for PhD students and postdocs so they can meet each other, talk about this area, use these meetings as a springboard. It was Peter's idea actually, but I think that could be...so we're experimenting a little bit this year, building on what we did before and trying some new things.
MR:	Peter do you want to say anything about that idea?
PG:	Well apart from thinking it's absolutely brilliant! I just think that there is so much energy in the PhD and postdoc community that by giving them a certain amount of freedom, by not having to attend this meeting but to attend a meeting that is closely co-timed with this,



	maybe two days before or two days after it, but leaving then to run the meeting in their own way, we might get some quite interesting counterpointing of views which would be I think quite challenging.
MR:	In a sense it's a pity we don't have students listening to all this but I think the atmosphere changes if you have more people than can fit round a table, so that's the reason for doing it as a separate forum. Well thank you very much Roz for that. So perhaps we can start?
PL:	Before you do can I just reiterate the point about November the 4 th which is that we have produced output and are still continuing to do so with the cities programme and some of us have seen more of it than others. The purpose of the meeting on November the 4 th is really for us as a Forum to kind of agree the message that we want to send out. So rather than just be sort of individuals' collective thoughts it would be nice to have a discussion about the whole thing as a package. And so I would please encourage those of you who are members of the Forum to come along on the 4 th . We're starting a bit later I think, is that right? Six o'clock or something?
RA:	Yeah, we'll start at six, yeah.
PL:	So we'll have an hour's discussion followed by dinner so to speak and we'll circulate the draft outputs a week or so before that. So the idea is that we come together with a sort of...I don't want to say corporate, but a group, a Forum message about what we think is the outcome from that. And that will then be worked on slightly as a result of that meeting in time for the presentations in January, so that's the plan.
MR:	Okay, so let's now move on and what we normally do is we have the witnesses and maybe one or two questions after each presentation, but mainly we defer the general discussion until we've heard everyone and that's going to be the second half of the meeting. I don't know if you've decided which order you should speak in? Tina you're first on the list.
TB:	That's often the case with a surname beginning with B.
MR:	Just alphabetical I suppose. Are you happy to start off?
TB:	Yes I'm happy to start off.
MR:	Oh thank you very much indeed.
TB:	So thinking about being here and thinking about this interest in food security and where did my interest in food security really come from, I suppose it started when I did a degree in agricultural botany. So I've always been interested in crop plants, I've always been interested in food and always been interested in how we get improved crops into farmers' fields. And of course when you're young and you start out and you can see a way to improve a crop, in my case I was working on potatoes, you think that all you need to do is to make that improvement and it will happen and you've produced your plant in the laboratory and off you go, you know, you've got this potato which carries a new disease resistance. I suppose in the 80s, so after my PhD, I realised that it wasn't quite as simple as that because of course that was around the time that GM technology became available to plant breeders. And so I realised at that point that there were other considerations, that it wasn't as simple as making a plant which was resistant to the nematode that attacks potatoes which would prevent the use of a chemical, that there might be concerns that I hadn't realised. And so I started at that point to think 'Well what's the next step?' So to think about plant breeding and how do we multiply up that plant? How do we get that plant into the hands of the farmers? And so developed an understanding of the breeding industry and I went to work for a commercial plant breeder which immediately takes you away from vegetatively propagated crops like potatoes and into things like rice and maize and wheat and oilseed rape which is seed propagated and where people can make money, hence there's commercial activity. And then you're at the point where you've produced these



	<p>plants and you want to get them onto the market and you have to think about how they are sold to the farmer and how does the farmer make those choices. And in Europe and certainly in the UK there is a system which produces...and this is where NIAB's original role was, which produces a list, a recommended list of varieties which farmers are recommended to grow and the criteria that are used to measure one variety against another are exactly the criteria then which drives the plant breeder's motivation. I have to get my variety onto that list in order that I might sell it, therefore my breeding will be about those things which get me onto the list and that's great if you're a commercial plant breeder but it doesn't address what I'd call public goods in this context. It doesn't address for example where you have a disease that is controlled by a chemical then the plant breeder has no incentive to develop resistance to that disease. So there's something there around how research is driven by the market and by how things get onto the market and I started to...so taking from that point then thinking about the involvement of the farmer and how do farmers make choices? Well in this country and in crops which are seed propagated like wheat and oilseed rape and maize, it's because there's this list which helps them to choose and gives them information and helps them to choose. But when you start to look at other countries where the system of producing seed, where the commercialisation of plant varieties isn't so well developed, the questions can be quite different. And it's interesting if you start to look at countries out...well if you look at countries where we know there are going to be big problems with food security going forward such as Sub-Saharan Africa, most of the crops which are grown there are not produced by commercial plant breeders who are driven by that sort of commercial driver to get things onto this list and which they know they're going to sell. And so therefore the incentive to invest in the development of new varieties in those kinds of plants is really not there and so this brings us back actually to crops which are vegetatively propagated because most of the plants which are grown for food and for fuel in Sub-Saharan Africa are vegetatively propagated, sweet potatoes, cassava, bananas, none of them are seed produced and therefore much more difficult for commercial companies to make any money out of. So therefore they haven't had the research investment that we've seen in the seed propagated crops. So the first thing I would say is if there are gaps for me that's where it is. It's in these what used to be called or are sometimes called 'orphan crops', the vegetatively propagated crops and perhaps now even the green vegetables which are grown in those parts of the world and aren't grown here, where there hasn't been any research. So it's actually at quite a big level, if you think of all the investment that has gone into maize and if you were to put that into cassava or into African green vegetables you would undoubtedly have great improvements. So it's something around that.</p> <p>There is another aspect of plant breeding that I'm very interested in and that is how you involve farmers in the breeding process, so I'm interested in participatory plant breeding and participatory variety selection. I'm interested in involving farmers in the collection and preservation of genetic diversity and I know there is some of that going on but it's not organised, it's not done on a scale which is really, really functional and it is not then used as the basis of plant breeding programme which would then allow us to take that material forward to make improvements. So the gaps which lead to the research questions are how do we get the sorts of technology which have been developed for these commercial crops into the hands of the people who need it in other crops where we aren't seeing the investment. That's my starting point I guess.</p>
MR:	Thank you very much. Any specific questions to Tina?
AS:	Could I make just a question? So I'm not certain that I quite understand the comments that you were saying. Basically plant breeding, scientific plant breeding if you like, is driven by or it takes place where there is the potential for commercial gain and quite understandably, why should companies do it otherwise, and they do that with seed crops.
TB:	Primarily, yes.
AS:	Whereas vegetative crops are not explored and yet in Africa and presumably other places there's lots of vegetative crops. So who is going to do that? Because it's a double

	whammy isn't it? They're vegetative and there's no commercial incentives in those countries.
TB:	Or little commercial incentive. So the public sector, the charities and you do see that work going on but it's not on the scale of the investment in maize.
HG:	There is a model which is the CGIAR Institute model which we can probably explore later.
TB:	There is a model but then you get into how do you get that material which has been developed by that public sector, by that research institute, by that charity, how do you get that taken up by the farmer? How do you involve those people at an early stage in the early selection of germ plasm, early collection of germ plasm for diversity and then later in testing that germ plasm because it's known that if you do involve people at an early stage then the chances of getting them to take up these new improved varieties are much greater because they understand the material far better. And also their observations and their knowledge can inform the breeding process in a way which...you know for instance the CGIAR system, yes, it's wonderful but they breed in particular countries and actually getting that germ plasm then out to other countries isn't quite so straightforward. It's pretty much the same in Europe actually, you know if you breed wheat in the UK you won't be able to grow it very well in Spain or Italy and the same applies.
PL:	Can I ask a technical question in the sense that is breeding if you do it from seeds is it technically different from vegetative crops? I mean in terms of improving the crop in some sense.
TB:	All plants which produce seeds...so many of the species which are vegetatively propagated as a crop can be made to produce seed, but some can't, so some potato varieties can't and bananas for example can't. So therefore if you want to genetically change or improve a banana there are very few ways to do it, you actually have to work with what you've got, you can't cross in something from wild species. So you can use some kind of mutation breeding is the only way to do it.
DC-B:	Once you have it how do you then get it out into the field? Is it planting?
TB:	Essentially they make cuttings, but lots of very small cuttings, so they use tissue culture so they actually take the...multiply...it's a clonal propagation system, so you've actually got...
DC-B:	But it's much harder than [inaudible 0:24:48]?
TB:	Yes. The whole distribution of vegetatively propagated crops is quite difficult. There's been research into artificial seeds in the past, we haven't heard anything about that for a long time, but the idea that you would somehow be able to create a somatic embryo which you would package and it would be like a seed. But essentially a lot of the propagation is...well the propagation is vegetative, most of it is not done on a commercial basis and it is passed on from farmer to farmer.
IH:	Can I ask about the collaborative breeding? How does that happen? Is it just spontaneous or is there some sort of institutional structure?
TB:	I'm not actually sure how widespread it is but in the cases I've known there's two things: there's the participatory variety selection, so that is where the institutions such as the ones that Howard mentioned would produce a range of varieties and they would then put them out to a range of farmers who would then select which ones work best in their situation.
IH:	Almost they're running trials on their own farms.
TB:	Feed back the information, yes, so they'd be running trials. The participatory breeding of course just takes it at a much earlier stage where the farmer is actually making selections from amongst a much bigger population and is then...we were talking earlier about citizen science and crowd sourcing, you can imagine how valuable it would be if you could create a massive population of...this would be again a seed propagating crop, send it out to a large number of farmers and get them to feed back information that they'd recorded about that



	material which would then enable you to make choices about what you cross with what to give you combinations that are useful.
BV:	I think as well as Ian's question, are there specific examples of success in these approaches? These more participatory, more farmer inclusive approaches? Are there particular crops where actually you look back and say 'Actually that worked and that's a different model'?
TB:	I think it's one of those areas...I understand it's one of those areas of tension in the world so there have...I know of some work in wheat breeding in India and Nepal where it has been used, but I also know that it's something that is resisted by the establishment. I don't know about the particular countries but you can imagine how fond the plant breeder, whether they're a commercial breeder or a public sector plant breeder, are of this approach, you know of actually involving farmers and users. So there's a real tension and sometimes you find those kinds of barriers so all the ideas in the world you have to be aware of where the barriers are to the uptake of your technology.
MR:	Okay, I'm sure we'll come back to this in general discussion. Maybe we should move on and hear now from Ariel.
AB:	<p>Okay. So coming from an organisation that works on biodiversity conservation the interest in agriculture and [inaudible 0:28:03] attentions with food are quite obvious and are down essentially to the fact that farming is probably the number one way in which we are killing biodiversity today globally. If you look at the problems of biodiversity they are ultimately in different ways down to too many people milking away a too big share of the biosphere of the primal productivity. Then there are other things, toxics and so on but to a very large extent it's one species taking a bigger and bigger share of the ecosystem pushing aside the other species which in a sense is what farming is designed to do from day one. The whole point about farming is that you simplify the ecosystem so that it produces a lot of what you need instead of all the stuff that everybody else needs within the ecosystem. If you look at the drivers to day farming is the number one driver of biodiversity moves around the world. In the tropics simplifying it's mostly about conversion of natural habitats to farm habitats. In Europe a lot of the concerns have been around the intensification of farming although intensification is a very broad term and maybe we'll talk about that later, but it actually hides quite a lot of actual conversion if you look for example the way that grasslands are being ploughed up and transformed into arable farming on a very large scale around Europe. It's not necessarily that defined from what is happening in tropical countries. So that's one set of concerns. The other set of concerns is around the fundamental unsustainability of farming, I mean most farming around the world today is not sustainable not just in terms of what it does to the living world but also in terms of just the narrowest definition of sustainability, you just won't be able to keep it going for a lot longer because in most places where we do farming we are running out of soil, we are running out of water, we are running out of the useful bits of biodiversity like pollinators and beneficial insects and so on. We have developed a huge dependency on fossil fuels and we produce a lot of greenhouse gas, gases that then come back to hit farming in terms of droughts and all sorts of other things.</p> <p>Then the third bit of it is that if we look at the last let's say 50 years in particularly Europe we have also gone into very wasteful ways of using land. We have very fast rates of land ceiling, of diversion of land both from micro culture and from nature, all sorts of other uses and we've had the explosion in the last decade or so of bioenergy adding further pressure on top of the pressure coming from food, again of modern bioenergy because actually bioenergy is the way we are doing energy for as long as humanity has existed until we've discovered fossil fuels.</p> <p>Now all of those tensions have got an extra twist around 2007, 2008 with the spike in commodity prices which came for a variety of reasons and there are big debates about it but it does seem that around 2007, 2008 we have had some sort of long-term change moving away from...basically from 1945 we've been seeing commodity prices going down,</p>



so basically boiling it down to a very brutal message that seems to be a situation where we were producing more food than we needed to eat and it seems that we have gone into an age of scarcity. Now there are a lot of caveats around it but there is no doubt that for example at the moment prices are going down but most forecasts, certainly we've had now what six years of high prices and most of the forecasts are that even if they will go down they won't go down to the level where they were before.

Now this has had several let's say political implications. So one which I would hope is rather benign has been a renewed interest, both renewed academic interest and also renewed investment interest in agriculture. In agriculture in general, in productivity of agriculture, sustainability of agriculture, in agriculture done by the poor, in African agriculture, after decades where agriculture was sort of unsexy it has come back big time I guess. The fact we are here this evening is one of the symptoms of this renewed interest and certainly we are seeing now a lot more people putting investments into agriculture including certain investments which are certainly very necessary and benign such as for example in helping smallholder farmers in Africa produce more food wealth, food security is a big problem.

The other thing that has happened has been a really, really damaging fallout of toxic politics that have come out in Europe out of this debate where essentially the farm lobby, which is one of the most powerful lobbies in Europe and also the West and other places, and I would argue one of the most harmful lobbies around and probably second only to the fossil fuel lobby, has jumped on this and transformed food security into a banner for justifying the business as usual, for justifying resisting any sort of environmental policy and for justification for the pile of subsidies that they've been getting for many years and that were under pressure.

So this has translated in...the most spectacular impact of it has been the collapse of the attempt to reform the Common Agricultural Policy which is something I've dedicated I think a decade of my life to. And we got quite close to getting a moderately green reform of the European Common Agricultural Policy and then it has all been swept away and nothing was left and what came out was a completely fake reform that is probably taking us back to the past. And the whole food security rhetoric has played a very important role in it and now we are seeing this moving forward, so another term that has now cropped up is sustainable intensification which again, you know, when some people say it's probably something we would all agree with around this table but you start seeing it coming in. For example this week the European Council will be voting on the new strategic decisions on the climate and energy package, so basically climate and energy policy to 2030 and Ireland has managed to get in the Council conclusion a sentence that says that one of the objectives of this whole thing will be to guarantee the sustainable intensification of European farming while guaranteeing the contribution of the sector to climate mitigation, which basically is a way of killing any attempt to do anything about methane and Ireland wants to double the number of cows on an island that arguably already has too many cows. But that's how this stuff is filtering into the politics. We are seeing in Spain the government trying to use EU money to put under reclamation 800,000 hectares more of dry land in a situation where they are already facing [inaudible 0:37:19] collapse and a lot of it will be very rich biodiversity habitat, some of the best we have in Europe that will become maize fields or whatever else. And we see a very big attack coming on environmental legislation so all of this is going into other dangerous directions.

Now of course this sort of thinking has quite a lot of fallacies. Part of them is in the notion that we need more food in aggregate globally which is certainly not true on the very short term, it might be true on the longer term but then on the longer term you really need to ask the questions about the sustainability of the way you produce it. But certainly food security is a much more localised and specific issue. So certainly Malawi has an issue of food security, Ireland doesn't, at least today.

The other fallacy is to look at it as if demand was given and all you can do is try to prop up



supply. Well we know that demand at the moment includes a hell of a lot of waste, anything between a third and half the food get basically thrown away. It includes a lot of non-food use, bioenergy, most of which at least or most of the growth of which is generated by public policies, it's not sort of spontaneously happening, we are actually subsidising people to burn food, to burn land. There are a lot of choices we make about how we use land which are either conscious or non-conscious choices which go into the equation of how much land do we allocate for agriculture, how much we allocate for nature and for other things. Then the other thing is that in many cases you have a huge gap between the sort of theoretical models, the sort of flat earth models and the very messy reality of land use and land use is very, very messy. Anyone that has worked with land use knows how messy it is. So for example one idea that I think has been coming out of this University and that is very interesting is the whole idea of land sparing, land sharing debates. The idea of land sparing is that the more your agriculture becomes productive the less land you need to produce the same amount of food and that might release land for nature conservation which is certainly true and gives you some very useful insights, but in the real world there is hardly any mechanism to make the spare land flow into biodiversity conservation. You know if farmers in East Anglia doubled their wheat yield it's not like you get extra reserves in the Amazon or some floodplains get restored in the UK. So unless you find a way to make it then you are playing with notions that don't really work. So whether I think that raises a whole bunch of questions that we deal with on the front of conservation policy and those are a range of questions. I think one is we still don't have a good enough grasp on what is really driving biodiversity decline. We know all the checklists but what is really we're seeing is a sort of quantitative analysis of what matters more. When you compare different we know that certain species disappear because of pesticides and others because of habitat conversion and others because of other things. But if you say 'Okay, what are the three things that if I solved today I would be saving biodiversity in Europe?' it's surprising how unclear this is.

Then there is a whole bunch of questions on sustainability of farming. What is sustainable farming? And there you are getting very, very different answers from different people and even from different academics and I suspect that sustainable farming is very different things in different places really which is partially why it's difficult to get an answer. But also a bunch of questions about the relationship between sustainable farming and biodiversity or major conservation. So how do we combine the needs to save threatened species, to save the sort of commercial use for biodiversity, to get what is now called ecosystem services, of course food and other agricultural productions, and factor into that also other dimensions such as time, so not just the static situation but the long-term one, and elements of risk which are very, very important in the climate change to come. So for example I think it would be interesting maybe to discuss later a lot of the current debate is about yields but a lot of very high yields come with extremely built-in risks and that's something that starts changing the perspectives when you add that. Then there's a whole bunch of questions about scale which is hugely important in land use and in farming and in conservation. So when you look at a field of a farm, of a region or the planet you get completely different things happening.

And finally a particularly European issue is the whole issue of high natural value farming. A lot of the biodiversity, of the valuable biodiversity we have in Europe is linked to those traditional extensive, usually grazing, systems. Those systems are collapsing for a variety of economic and social and demographic reasons and there is a huge question of what do you do with them. For the moment I think what we and others have been trying to do has been sort of propping them up but in many cases it is a doomed enterprise and it does raise questions in terms of the food production also because in many cases those systems produce very little, sometimes very good products, but... So the question of to what extent you let those systems go and there there is a whole debate about re-wilding and so on, to what extent you accept them as a sort of subsidised niche, to what extent they actually can be modernised and brought into the mainstream but then can you keep the biodiversity there. There's a whole series of very fascinating questions there.



MR:	Thank you very much. Any specific questions? There's a lot raised there.
RA:	Emily would like to ask is biodiversity that has a larger ecosystem service to be valued or conserved more? It's an easy one to start with.
AB:	It's an easy one to start with. Well my answer would be no because first of all I believe that we need to conserve biodiversity first of all on moral grounds. There's really something fundamentally ethical about the fact that we owe some respect to millions of years of evolution and the idea that our society that lives on whether GDP will pick up or down in the next couple of weeks can just get rid of lineages that have taken eons to get to us. There's something fundamentally wrong with it and there is an issue around beauty, around what makes us humans and...and I think that's the fundamental answer. The other answer is that we know so little about how the planet works, that the idea that we can micro-engineer it and say 'Okay, the bees are very important, the wasps, why do we need wasps?' and so on. I think every single time we've tried this we fell flat on our face because you then discover that actually that perfectly useless bit of biodiversity is hugely important for something else. So no, I think that's not a useful way to go. Now that said there is some tension there. You might be able for example to conserve all your more vulnerable bumblebees by having certain nature reserves done in a certain way, then you still have an issue of how you pollinate your crops if you lose all the pollinators and there might be a reason to do something for pollinators even though you only get the common ones and that sort of thing. But that's where the issues of scale and so on become important.
IH:	The price question I guess is difficult. If you...I'd say two things: if you put a trend line through real prices between 1960 and 2014 it's still actually going down and the OECD predictions for the next 10 years are pretty flat actually. But having said that I think there probably is a kink, I suspect it's at 2000 rather than 2008 because they were rising a bit earlier. There are two things I wanted to bring up: one is you talk about Europe but you've talked about other places and my sense is that they're different, I would make a distinction between an old world and resettled world and that if you like Europe or Japan or one or two other countries is sort of an old world and actually in that context things like high nature value farming are there because of the agricultural system. So actually in those cases, since your first statement that agriculture is the number one killer of biodiversity, I sense it's the opposite in some places and some contexts and actually echoes your point about it being very specific locally. So that's sort of an aside. But the question I was going to ask you, you talk about wasteland and I was wondering what you had in mind when you say that land is simply being wasted when it's transferred to other uses and I guess as sort of an almost economist I think well maybe those other uses have some value to someone and how do we compare them? So a very specific question.
AB:	Yeah, very fair point. So the second one, yeah, you are absolutely right. I was talking about waste from the point of view of the sort of food and conservation debate. I mean obviously houses, motorways, golf courses, rubbish dumps, I mean all of those things are done for a reason.
IH:	Someone keeping horses? Is that okay?
AB:	Keeping horses...
IH:	Sorry, I assume we don't eat them, sorry...
AB:	University grounds, I mean you know, that lawn there could be a vegetable plot. That's...now obviously that's not to say that all of those things don't have a value and you are right if you are looking in economic terms, they almost all have more value than agricultural rate and certainly more value for the nature, which is why what we are seeing is the city getting [overspeaking 0:49:38].
IH:	By that you mean more financial, more monetary return rather than value?
AB:	Yes, absolutely, but I mean we live in a society which confuses prices and values quite

	systematically so...
IH:	Hopefully that's something we can unpick.
AB:	The two things tend to coincide sadly. So that...yes, the issue of the old world and new world, you are totally right, I mean there's no doubt that the situations in which agriculture has arrived all of a sudden very recently it tends to basically destroy biodiversity in places where agriculture has grappled with the local ecosystem over 10,000 years, you do get a lot more of biodiversity that depends on agriculture. But also in those cases the agricultural sector is where...I mean if you look at all this high natural value farming in Europe it is being lost because of changes to the agricultural system, so it's not about saying you know agriculture is bad and an enemy of biodiversity if all the tension is there always. But even in those cases where we have biodiversity that depends or has depended for centuries, for millennia on certain agricultural practices, those agricultural practices are changing very fast and biodiversity is not able to cope with the rapidity of the change.
LS:	Is there research evidence that supports any kind of general consensus that there is a strategy for sustaining biodiversity in feeding 7 billion people? Even if it's something as radical as we should all live on fruits and nuts so that we can have lots of trees that grow fruits and nuts and keep the birds going as well as us and we might do much better off that we don't eat wheat. I think there's pieces of research that point to all of those things but how developed is the biodiversity advocacy community, not in terms of its lobbying power but in terms of its scientific evidence or how you can put it all together?
AB:	I think there's a big hole there to be honest. So there is a lot of studies in recent years, there's a lot has been coming out and so we do know about the different footprints of different types of food, we know that meat takes a lot more land and so on, and that has now been refined and people are looking at different types of meat and one thing is grazing cattle, another thing is cattle that eats feed and so on and so forth. I think you are right that we are still completely missing any sort of intellectual consensus there about what would be a desirable way forward. In there part of the problem is this sort of the flat world versus the wrinkly world because there are some of those exercises out there but you end up with things that are utterly meaningless and yes, if the whole world was vegetarian this would make environmental crisis a lot less secure than it is today, but anyway, okay...
TB:	But you'd still have the big problems...
AB:	Where do you go with that?
TB:	You still have the big problems that you've talked about about nitrogen fertiliser and pesticide use and the dependency of the crops that we grow and as African agriculture develops you can see it going down the same route...
AB:	The same route, and it's very...
TB:	...which is why...you know you said the investment in African agriculture was benign, I'd be worried about it. But I think I would argue that genetics is the way to go, targeting and understanding genetics will be the way, the place that we find those solutions that don't impact biodiversity as much maybe.
MR:	This is a big question, I think we'll come back after the break and have more on this big question. Any other specific questions to...?
GC:	I just wondered, one of your opening remarks was about the continuous decline of biodiversity, soil quality and water which we're all seeing, but I was just wondering where you think the limit is, where the kind of catastrophic failure that you think is going to exist that is going to really get politicians, get business, get supply chain managers to actually sit up and listen and start making appropriate strategies because at the moment they seem to be such incrementally downward spirals rather than huge shocks that it's quite difficult to think this is the action that one needs to take. How do you see that being resolved?



AB:	<p>I've seen a really, really nice cartoon the other day of the classic boiling frog that sits...so they have this frog sitting in a baker on flame and it's holding the thermometer out of the water and I really, really liked it because this is sort of what we are doing at the moment. So it's not just that we are in the situation of the boiling frog where because all of those changes are quite gradual and we keep adapting to them and keep on saying 'Well that's not that bad, I mean it's a...' But now I mean we are also seeing massive disinformation campaigns where we are actually trying to actively negate the evidence to what is happening, so it doesn't look good to be honest. On your question about pressure, that's the whole debate about tipping points and so on and the truth is that we don't know. It might be that we will at a certain point hit something really nasty and some sort of non-linear behaviour of the system and then you get Armageddon, or it might be that we just keep sliding down the slippery slope and things will just get nastier. I think things are already get pretty nasty in some places, I mean in terms of for example the situation around water and the combination of running out of water, having degraded your soils and having created an agriculture that depends on a lot of water. I mean you see what has happened in some bits of the US, some bits of Australia and so on, you are already seeing farmers going bust and ghost towns and things like that. For the moment it's still all localised enough and so on that you can put the thermometer away and say this is not happening. I think there are some frightening prospects out there, including by the way linked to the genetics issue, because I mean when you look at how much of the food we are eating is a handful of varieties of a handful of plants, there you know Armageddon is around the corner because the day you get some nasty virus that instead of infecting people infects let's say wheat, you know, you will be screaming to get Ebola back because that's really frightening stuff.</p> <p>Now fingers crossed it will never happen, but the things that are happening in terms of loss of forests, of mangoes, of...you know the constant erosion of biodiversity and so on, that's...even if there aren't any tipping points...</p>
TB:	<p>The answer to her question I think is that they are already. The companies, the supermarkets, because their supply is already being affected because of things like you say, the loss of mango, the citrus, you know this citrus disease that is...</p>
AB:	<p>The bananas...</p>
TB:	<p>I think they are...I think we're already there, they are already starting to say we've got to be more interested in biodiversity for the reasons you've said and conservation so that we can have a supply of the products that we need in the future. I think they're there.</p>
MR:	<p>This is a general issue we'll come back to. I think [inaudible 0:58:26] and hear Paul and then we'll have the break and the general discussion afterwards. Any other very quick questions? Okay, so Paul, the floor is yours.</p>
PD:	<p>Thank you. We're going to switch tacks now a little bit and talk about bioenergy, lignocellulosic bioenergy, so this is bioenergy from plant cell walls and I'm a biochemist and not a policy expert so I'm going to explain a little bit my views on the development of bioenergy from plant cell walls. So what you need to know is that all plants have around every cell a plant cell wall which is three quarters made of sugar and these are made into long polymers and these give the strength properties to the plant, so the wood can stand up, the straw can stand up and this also provides part of our dietary fibre. But it's three quarters sugar and in many ways this sugar is identical to the sugar that we eat and that's a point that I'm going to come back to in a minute. And this is of course renewable carbon, so this is made from CO² fixed by energy of sunlight, so when we burn this it is the energy from the sunlight released again and the CO² is released back out to the atmosphere. So I think an important point to realise as well is that there is a lot more of this sort of material in the plant cell walls than there is of starchy easily digestible biomass. So when we hear about first generation biofuels they are often made from food, they're made from sugar, from sugarcane, they're made from starch, from maize or of course oils from oilseed rape, but there's a lot more sugar available in the other parts of the plant. So in principle growing</p>



plants to harvest the cell walls would give you more productivity on a certain area of land than growing a foodstuff. And also many of these crops don't need as intensive agriculture as the food crop, so they don't need as much nitrogen fertiliser. I think another point to make is that these materials can also be co-products of food production. So here I'm thinking of straw as a co-product from making grain, so wheat for food. For every tonne of grain in production of wheat, grain, you have a tonne of straw produced and in the case of sucrose sugar production in Brazil there are millions of tonnes of bagasse, this is fibre left behind from the sugarcane, some of which is burnt to make electricity, some of it is burnt just to get rid of it and some of it is just left to rot. So there's a large amount of this sugar available that is not effectively used.

So coming back to the focus of the work we do here in Cambridge just briefly, it is to understand the genetic basis for the way plants make these polymers and put them together in the cell walls so that we can understand why they're so difficult to digest. The reason we don't eat grass is because we can't digest it, we prefer potatoes and rice and we can digest it, but there's a similar amount of glucose in there so the issue is why can't we get it out? Why can't we digest it? That's the sort of question we're interested in. There are genetic approaches to improving that situation and the paper that was circulated is one small piece in the research to look at this, how we could perhaps breed plants or genetically modified plants so that these parts of the plants are more easily digestible - that's one approach. And of course you can use industrial approaches, so you can use steam to cook the straw and the wood, or you can use acids and alkalis. Then these sugars are available and there are now commercial scale refineries using straw and similar types of plant material to release the sugars, so you add digestive enzymes from fungi, you release these sugars and then these sugars can be fermented to ethanol and there are commercial scale refineries now producing 50 million litres a year of ethanol on one site. So this is now feasible but is it commercially viable is one question? Let's think about some of the issues around it. But before we go onto that I just want to point out that there is another interesting aspect of this, in a way it's turning the food versus fuel issue on its head and once you have cooked and digested the straw you have a sugar syrup and in principle this could be used as a food or an animal feed. So you could in principle increase the amount of feed available for animals by making these non-digestible parts of the plant digestible. So you could use perhaps that syrup directly or you could use that to grow fungi to feed the animals, there are all sorts of things that have been considered, and some co-products in the ethanol production pilot plants produce side streams of sugars which can be fed to animals, so there is an interesting issue here about what to use these sugars for.

So of course there are issues and we'll have some interesting discussions I'm sure about this. So what are the effects on land use of using this biomass? What are the effects on the soil of removing straw? For example when you're growing arable crops how much of that is actually available for use and are there indirect effects on land use by providing a market for this type of bioenergy? Of course another important question is what is the effect on greenhouse gas emissions of doing this? One of the big drivers is not just increase in security, increase in amount of energy available or food available, it is replacing fossil fuels by replacing the fossil fuel carbon with a renewable carbon and there is discussion to what extent this is actually true because it depends how you have grown the plants in the first place. But of course if you're using a product, a co-product that is otherwise just going to rot then there perhaps is only a benefit in using that rather than letting it release the carbon dioxide and the heat in a compost heap.

Another issue is can these biofuels be economic without government incentives and what is the effect of the government incentives on developing this type of industry. I would also like to come back to this point about using these sugars for animal feed and developing new processes to make animal feedstuffs. What type of animal feedstuff should we aim for and what effect would that have on current land uses to grow animal feed? Because as we know a large proportion of current land use is to produce meat, so it's either growing the animals or growing plants to feed the animals and so potentially you could have a beneficial



	effect on land use by using these other co-products to produce the animal feed. So I think I'd better stop there.
MR:	Thank you very much. Any questions to Paul?
IH:	Paul, here's a question, do you have an answer to your question about potential cost? I mean is this something that is likely to be able to produce ethanol competitively with petrol? I mean I'm not quite sure what we compare it with.
PD:	It's not far off at the moment, it's not beyond all doubt and there are now therefore commercial scale factories, refineries being built and in production but they don't tell you exactly how much profit they are making, they are probably not making profit at this stage. They are also making electricity during the process and they are selling the electricity and there are incentives of course for renewable electricity and that might be what makes it commercially viable at the moment in Europe.
AB:	Is this in Brazil?
PD:	There's one in Italy, Crescentino in Italy that I'm thinking of, but they're building some in Brazil as well at the moment, they're coming on stream now.
IH:	I guess with all these things there's a sort of past dependency around it, we've come across it two or three times already I guess where you get stuck into a particular chain and because the work has been done in a particular sort of way we're not comparing like with like I guess in terms of technologies.
DC-B:	Is it more efficient to make ethanol out of it than it is to burn it locally for producing electricity and putting it into the grid?
PD:	It depends how you define efficient really because you get more energy out if you burn it, so you capture more of the energy, converting it to ethanol is not an efficient process in terms of capturing the energy that is there, you lose a lot, you lose a lot of the carbon as CO ² , you lose a lot of the energy in heating up the process. But the value of that ethanol is different to the value of electricity because it's a liquid fuel and you can use it as a transport fuel...
DC-B:	I understand the process, what I'm really raising is the sustainability of a planet with electric cars and subsidising electricity for petroleum if the electricity is generated where the stocks were cut so that every farm becomes an electric generator. Rather than we transport this stuff it just puts it into electricity, it puts it on the wires and then you've got electricity for your cars and everything else. Is that a more sustainable vision than ethanol potentially? Or don't we know? [inaudible 1:10:05].
PD:	I'm not sure that the answer is really clear, I've heard different arguments about that, but I think there's also a limit to the amount of electrification you can do of transport. You can't replace all transport fuel with electric engines. So you can do it for cars but you can't do it for aeroplanes and you can't do it for ships and so there will be a demand for liquid fuels and how do you decarbonise those. So there's a reason for doing it that goes beyond simple calculation of conversion efficiencies.
AS:	And I thought there was also a requirement for scale in terms of the actual plant for the lignocellulosic ethanol, there is a minimum that is necessary to have the scale in terms of the processing. I could be wrong but I think in some lifecycle assessments there is a minimum amount of biomass that you need in order to be able to have a net energy balance.
PD:	I think you're right but because this process is developing all the time now I'm sure that those calculations will change. You're right at this stage the scale is huge, 50 million litres a year, that scale or even 10 times larger than that would be the scale that you would have in Brazil with a sugarcane mill. But whether it could be downscaled, in principle it can be quite a small scale but it's probably more expensive.



MR:	<p>Okay, shall we take our scheduled break now and then we'll come back. We've got lots to discuss, again these tensions between the different producers.</p> <p>...more than half an hour left for general discussion. I think it's clear there's a great deal to discuss and I don't know, I think Tina expressed some views over the coffee break and I think you want to bring up issues about biodiversity and feeding 9 billion and all that.</p>
TB:	<p>Yeah. Well I think you made a very good point, you know, has anyone thought about how we...or is there data that says this is how these two things will be reconciled. But I suppose for me it was coming back to the 'Well what can I do in this...?' You raised so many things, so many barriers, so many difficulties, I had to come back to thinking well maybe I'll just go back to my potatoes, make a blight resistant potato which will mean that farmers won't need to use pesticides on that crop, it will mean that the farmers who can't afford or can't access that pesticide will be able to grow potatoes, so that little bit is the bit that I can do. And I think sometimes by thinking about too many issues at once we lose track of what we actually are able to do because the problem is so daunting. So that was one thing. I was also quite interested in the use of statutory instruments like CAP in moving things in the direction we want them to go. You know what they've done might not have gone far enough but it has gone a bit further, a little bit in the right direction. Has it or not?</p>
GC:	<p>Has it gone backwards?</p>
IH:	<p>It didn't go anywhere where we might have liked to see it but it seems to me it hasn't necessarily gone backwards, has it? Why has it gone backwards? We've taken some of the single farm payment and we've made it conditional. We've reduced Level II, expenditure has probably declined a bit which is a bad thing.</p>
AB:	<p>I can answer that. So okay that's...so it becomes very complex and it's not fully implemented so we will know in two years' time.</p>
IH:	<p>That could be diluted as we speak.</p>
AB:	<p>But the greening that you referred to, so that we are attaching to the main subsidies some rules, they've dug so many loopholes in it and the member states including this country are maximising the use of those loopholes. So from our analysis stays a doubt whether any farmers out there will help to change anything big. So it has become a huge greenwashing operation. It's still early to say that it will have achieved nothing nowhere, but it will achieve very, very little in very few places and combine it with the fact that budget for world development has gone down. Now again, the programme for development is still happening so we don't have the programmes for another few months so it's early to judge, but what we are seeing on the ground is that the greening of Pillar 1 has been used as an excuse to cut expenditure on agri-environment because then agricultural ministers are all saying 'Oh you've got now a third of the income subsidies that are all for the environment, surely that's enough? You don't also need the world development money'. So the world development money is being piped evermore into irrigation and drainage and things like that which in many cases are actively harmful. And we are seeing a return to coupled subsidies, so to old-style production subsidies which are usually going for the wrong things, plus a few other nasty bits and pieces, plus cost compliance becomes really jargony. But cost compliance to ensure the rules attached to the subsidies that were already there have been massively weakened. So the rhetoric is that we've done a green reform and okay, it's a step forward, when you start counting the step forwards and the step backwards and doing the counting the impression is that we are lucky if we stay where we were.</p>
PG:	<p>I wanted to pick up on Tina's point of view, you know, sort of going back to the bunker and doing [inaudible 1:16:31]. My friend in Engineering, David Cebon, spent his career optimising the performance of lorries [inaudible 1:16:42] and he can get...he reckons now if he spends the rest of his career working on the same thing he'll get another 1% or 2% of efficiency out of the brakes and the aerodynamics. He's done...he feels as though he's got to pretty close to the optimum, given the situation as accepting the status quo, and being impatient he has now said so what am I wasting my time for in optimising a system that is</p>



	<p>completely stupid? So why don't I focus on making sure that volume limited goods, in other words non-bulk goods, are not hauled around the country in lorries which are about on average about 85% empty, and for half the journeys that they all take they're 100% empty because there is no navitage, there's no return trip arrangement, because independent operations don't collaborate because of the God of the free market. So now he's moved into a completely different field of saying 'I was happy where I was because I could do sums and I could do adding up and I could do measuring and brakes and things, you know all of that was fun but it was pointless'. Listening to your three brilliant presentations I was struck that you all seem to be accepting the status quo - actually you did make this point earlier, so I slightly withdraw it - but the status quo is that we have to feed 9 billion people and the demand is the demand and we can't move away from meat and dairy and we...you know. So what do we do to respond to this existing world that we live in and don't change anything? Don't frighten the horses by saying if we go on as we are there is no future and so we continue to optimise the system rather than to say 'We can't make the system work in the medium...even in the medium term, we have to do something differently'. We throw away 48% according to [inaudible 1:18:58], 48% of the food that we buy in this country before it's eaten and in Africa about half the food that is grown never gets to market. So you might even have a factor of four available there which takes us way beyond the 9 billion we have to feed without doing anything else other than organising ourselves and having different instruments, economic, social, reputational, organisational, societal. You're already where you need to be in terms of food production and actually the same applies to energy production. Why are we all complicit in optimising a system that is broken?</p>
MR:	<p>We are going to have to worry about things like climate change and droughts and all that so the buzzword, the buzz phrase 'sustainable intensification' which I learned first from David Baulcombe's Royal Society report, is something which perhaps is still worth striving for, even if it's not absolutely necessary, because you could then use less land for the cultivation. So I wonder if anyone has any feeling for how far we can go in that direction. Although the low hanging fruit in this game is reducing waste.</p>
TB:	<p>There'll always be wasting agricultural systems just because of the fact that you're growing things outside and things go wrong, so we'll always have to deal with waste. I know what you're saying. I think sustainable intensification, you know, I know but I don't really understand why it's a very emotive and sometimes very unpopular phrase and I think it's because it's been misused and misunderstood because it really did mean producing more with less and it doesn't necessarily mean more quantity, as we've just heard. You know people are starting to realise that nutrition security if you like is as important if not more important than food security, you know, you can't eat only bananas for example. So all of those things play into this.</p>
AB:	<p>I think your challenge is very meaningful. So I have two answers to both of you. I mean one is the importance of policy, policy is what drives what...policy in the broadest term, policy can be legislation, it can be market incentives, it can be companies' own decisions of behaviour, whatever it is, but that's exactly why you need it. Because yes, we can all sort of retreat into doing our little thing but there are big problems out there and those problems are shaped by our societal choices and they can be affected, it's difficult to affect them but the fact that we have built a society in which we throw away half the food, in which some people are basically eating very low quality calories and hardly anything else and getting ill because of it, while other people can get, including myself, getting their fresh basil [inaudible 1:22:45] airlifted out of the Israeli desert and growing what doesn't exist and so on, without even knowing it until you read the... It's a choice and there are reasons to it and there is way of changing, no easy ways which is why I think it is important engaging. And there in terms of if you think the academic world there are some questions there about what matters and what doesn't because yeah, I mean there are a million things happening out there but probably there are a few of them that can make a really big difference. I think your lorry example is really important. Where is it that I can change the system? Because I can get all the lorry drivers in Europe to learn eco driving and make sure that they brake</p>

	<p>more and it would be a humongous effort and maybe even the nap that allows them to optimise their [inaudible 1:23:46] would achieve a lot more. So these sort of big questions then go down to very specific ones. The other reason I think for not disengaging with the big picture is that you risk link damage if you just look at your little bit of the story and we've seen it...I mean biofuels we were discussing over there is a prime example of how a nice idea promoted by a lot of very well-meaning people have led to pretty horrific consequences overall because they were not seeing the bigger picture and because the policy framework was wrong and because it got captured by vested interests and so on and so forth. So when you say if I produce a potato that is blight resistant that surely is a good thing? Well maybe, could be in the case of potato, but you know your blight resistant crop is likely to open a new agricultural frontier because you will finally be able to plant it in the rainforest where it was not going before, as it is to make...</p>
TB:	But that's not a reason for not doing it.
AB:	It's not a reason for doing it but it means that now if you are a [inaudible 1:24:57] that's perfectly legitimate and it's a very great contribution to humanity to develop a pest resistant crop, but we need to understand that if that pest resistant crop does not come with a few other things, you know, land tenure of farmers, extension services, land planning and so on, it risks not making the difference that it can make and in some cases it might lead to all sorts of unforeseen consequences. So even if you are looking at a very narrow job it is good that either you or at least someone is looking at the bigger picture.
TB:	There needs to be a context and you know if you think about if somebody decided that renewable energy was no longer a good thing would you stop working on cell walls? Probably not.
PD:	No.
LS:	<p>If I could go back to my last point about waste being the low hanging fruit, as well as the earlier point about tipping points and where do we take radical action, there's two things in British history that bear on this, most recently is food rationing during World War II where there was a shock. Everybody accepted the need for food rationing and under the right disastrous conditions in our lifetimes I can imagine that happening again. The question is what would you do with a rationing system of tickets in relation to things people only buy so much of and things that you can have a lot more of. I heard all about this from my wife who grew up with it in England and was surprised when her mother said they didn't have to bring tickets to the grocery store one day because rationing was over. But it goes back earlier in British history if we think of the strategy Henry VIII used to get over lean years which was food storage. So waste is actually the opposite of food that can be preserved and <i>The Times</i> story today by this doctor who has this show now which did a very interesting experiment on reheated pasta having a slower release of glucose, he had a list in today's paper in <i>The Times</i> of all the things that you can eat in your kitchen that have been there for a long time and it's okay, and the things that you can't and that you have to be very careful about. So if we go back to rationing that was really about meat because everybody wanted meat so...what we really may need to feed 9 million people is an emphasis on growing the kinds of foods, including nuts, that once they're harvested they last for a very long time and can be stored against the fluctuations of the production of other food. And might there also be a way to get around this problem of huge energy expenditure to get fresh food from where it's grown to where it's eaten within a very short period of time, which is also a cause of waste, as [inaudible 1:28:23] understand. So if we're to go back to this question of a strategy why wouldn't it be important first of all to set a priority on a strategy that might be less subjected to Lilliputian barns for the big Gulliver that we want to have in the middle of this table that is somehow pointing as a way forward as opposed to all of us sitting around saying 'We're about to go over a cliff! We're about to go over a cliff!' Because I sense a lack of a clear alternative that you could mobilise people about and something around being disciplined in the food we grow and the food we eat in order to save the planet and to feed us and avoid starvation could be a compelling story. But in a</p>



	way we know too much about too many details and not enough about maybe two or three big strategic choices that have yet to be articulated but it would seem to me that a research strategy that maybe used the Delphi technique to try to identify some strategic choices might be a really valuable contribution here that would connect food security with general sustainability issues in relation to energy.
MR:	Doesn't GM come in here in that GM can prolong the life of certain things.
IH:	It seems to me that the obvious question then is why is food so cheap that we waste so much of it. I guess we look after things that are valuable. Now that's not the case in the developing world, I guess that's very different but in a developed world where we are saying we waste after we've bought it well it's obviously too cheap.
LS:	But is it cheap for reasons that aren't sustainable and if we then take a long view do we say this [inaudible 1:30:14].
IH:	Maybe but the first response would be to say well we should make it more expensive and then people will look after it and then we deal with the other issues.
HG:	But that does fly in the face of what dominates the food production and distribution and it's not really the farmer because every farmer will tell you they don't make any money, the wheat breeders will tell you...
AB:	It's not always true.
HG:	But that's what they all say and the wheat breeders will tell you they don't make any money either so what you've got to tackle is the people who are making the money which is the marketing and the distribution who are also encouraging folk to consume items to in excess because the more they sell the more...
IH:	It's too easy to blame [inaudible 1:30:49] you can't just do that.
HG:	So then you've got to come back to tackling the human nature which is owt for nowt and here's me Borough, you know, which is we always want something for nothing. So the solutions I think you've got...it's all very well but your solution would be sort of trying to encourage some sense of austerity that should be imposed which would then cap that kind of availability. And rather than that I think we have to move...you can't do it with a stick, you have to do it by encouragement. You've got to do it by education of the issues.
LS:	That stick of fear.
TB:	The price of food is bound to go up because of what we were discussing at coffee. You know the supermarkets if you like are starting to have problems keeping things on the shelves. They're going to the producers, you know they're saying we want you to produce...oh and by the way we want you to produce it sustainably because we know that one of the reasons we're not able to put that food on the shelves is because you've depleted the soils, you've done all this stuff, you're not getting the yields and we know that we're going to run out of water and nitrogen and all of these things. And so the producer is saying 'Okay, great, who is going to pay for all of this?' And in the end the price of food is going to have to go up for that reason because there won't be anywhere else for the money to come from.
AS:	And how do Aldi and Lidl manage? That's what I want to know.
TB:	Well they'll just be cheaper than the others.
AS:	Well how do they do it now?
IH:	They're not providing the same sort of service that other supermarkets...
HG:	Much narrower range.
AB:	And clever logistics.



AS:	Well is that some way that we can harness the logistic know how and this is in terms of distribution and supply and so on, so it goes back to only buying or only supplying tomatoes at the time of year when they're available instead of growing them in greenhouses with excess energy.
AB:	I think a few health warnings before we again fall for the sort of flat world where you say people should not eat meat and they should eat nuts and then store it and ship it and so on. So there are a few problems with it but one is that food has a unique cultural component, people eat what their mum told them to eat when they were kids. But then they watch a few celebrity chefs and widen the range but this is...and you see them in just going to any ethnic community in London and they ship all sorts of weird stuff from the other end of the world, including very poor people, so people would rather starve if you're going to eat their food. So that's one thing and that's true, you know, that's why people buy [inaudible 1:33:53] out of season and whatever. If you have a southern Mediterranean background it really is a very, very important question for you to have your tomatoes [inaudible 1:34:03]. So that's one thing that goes against the sort of social engineering...now it doesn't mean that you cannot change what they do but you have to keep that in mind. The other thing is food is inextricable from social justice because, yes, you can make food more expensive and maybe food should be more expensive, if you just make food more expensive you have the bottom part of society starting to starve which is problematic and a biased point of view.
LS:	[inaudible 1:34:36] India, onion crisis.
AB:	So and the third thing is that the way price signals are transmitted around food is for a variety of reasons even more problematic than it is in other fields. So for example if you make meat more expensive it's not obvious that people will be eating less meat, it's quite probable that they would be eating meat of worse quality and probably less sustainable meat, so you need to be careful. So I think there is no escaping having a package of rather sophisticated policies that try to deal with those things, such as food waste, such as footprint of food, such as trying to shift diet. But before you get there, there are a series of research questions about what is actually desirable and at the moment there isn't a very clear consensus about what is actually desirable.
LS:	But everything you said would change under a cultural shock, under grave fears of starvation and I would argue that that's the window of opportunity for which the research should be aimed because we don't know what is the optimal sustainable plan that could be proposed and maybe you get half of it or maybe you get 20% of it, but at least you know where to go. Which is where we know where to go with gun control, we just can't do it for all the reasons you describe, kids grow up with daddy showing them how to use guns and so the American people won't accept gun control now. But we get close with shocks and all it takes is 200 kids to be killed in a school in Connecticut and we almost get to the point where we might adopt a new policy. And how many people have to starve before we can adopt a new policy on food, like preserving apples for a year and doing other more sensible things. If we have the knowledge ready to go when the time comes I think it makes sense to be bolder and more comprehensive than the current way knowledge is developed.
MR:	Moira?
MF:	So I suppose my question is around how do we communicate or think about any of these things with people who disagree with us and what is the research showing us on that? Because one of the things in climate change communications that came out at...gosh, it would've been very early 2000 there was this notion of climate porn where it was actually saying there were certain people who would be affected and would take action and would think like we want them to think if we tell them 'The world is going to end, everyone is going to die, there will be a big storm and everyone...and the world will be covered in ice', and that would only reach a certain number of people and the number of people that that affected would not be a critical mass which has I think been proven fairly correct as a prediction. And that actually by then continuing to give the people who have not already

	<p>been convinced the same message you're actually alienating them further as well as getting into issues of message fatigue etc, etc. So my question is how do we actually reach people who disagree with us? Fear is one way, it is not necessarily the only way or the most productive way or the most...</p>
LS:	<p>Sustainable.</p>
MF:	<p>...sustainable way. Because you know there are political consequences, what are the political consequences of a narrative of fear, they are usually authoritarian or some kind of...yeah, usually authoritarian, beyond paternalistic, we know best and we should be doing whatever it is, they are actually authoritarian which has been seen with security situations left, right and centre. So there is a question of actually saying how do...what is the research that says how do we educate people, how do we communicate with people who simply aren't as convinced as we are and otherwise you just end up shouting your values at someone who doesn't share those values as opposed to actually engaging them in a participatory process where you can actually work something out together.</p>
BV:	<p>Certainly I think Moira you raise a very interesting question about societal shifts don't have to follow shocks and shocks are one way in which society shifts. But there are other examples from human history, we eradicated slavery, we didn't have a shock which led us to that, there was moral reasoning, we argued, we debated and we shifted the system even though economics might have been against it. There are all sorts of examples like that. So I don't think the shock is the only thing that allows societies to move, it might be one but there are other ways in which one can do this and that's about persuasive power, about getting a critical mass of people on board, all of that which is about public reasoning. So I think that's important. I wanted to come back to the three witnesses, I know I'm conscious of our time because one of the questions we wanted you to tell us about was let's say you had a magic wand to design the next research programme, what would you...? Not I'd like to do my work on my potato blight problem, but where would you allocate a significant amount of research attention, given your perspective that you shared very generously with us today? What are the kind of burning issues that need researchers to focus their attention on? I think that's one of the things that the Forum is trying to think about.</p>
MR:	<p>We should ask them to answer that question but perhaps I could put a footnote and say can you, especially Paul, be futuristic and say what about biofuels from algae, what about artificial meat and things of that kind? So perhaps there is in the long run some hope from these advanced technologies. That's just a footnote to what you were asking and so I think in the last five minutes I think we should ask if our three experts do have any suggestions about what the focus should be. Who wants to start?</p>
PD:	<p>Well I suppose I will continue along the vein I was arguing before, despite having been shot down. I think it's too easy to say that there are downsides to biofuels for example, therefore we shouldn't do anything. I think that we should look for the opportunities, we should see that not everything is black-and-white but there are areas of light amongst all of these difficulties and we should look carefully for those and I think that particularly usage of waste materials is an opportunity and there may be others in certain niches, certain places in the world where things can be done effectively. So I would hope that we would be able to develop refining technologies that would be able to use those waste materials and produce high-value fuels or other commodities that replace fossil fuels and I see that as an achievable goal. So that's not just ethanol, that is high-value materials. And I would like to come back to the point about food, as you say, artificial meat. Once you have these sugars from crop residues for example you can grow fungi, you can make artificial meat out of it or you can feed animals and I think that is really an undeveloped area of research. In the shock in the Second World War I heard that in Scandinavia they didn't have food for their cows and so they used residues from the paper manufacturing, from trees and they said the cows with the cellulose from the pulp and it wasn't very nutritious but that is a stab in that direction and of course it hasn't continued, but I think that there are opportunities there.</p>



AB:	That just makes me think about a funny story. My father passed the war in a village where funnily enough they had the opposite problem, they had too much food because they couldn't go to the markets and plains were striving and so on and at a certain point they had this gigantic glut of cabbages so all the farm animals were all eating cabbages and one of the consequences was...
PG:	Did they continue?
AB:	...so just about the point that you know there are all sorts of things that work in theory but then they have all sorts of...
PD:	But this is the point. You can always think of reasons why not do something, you can always think of reasons.
AB:	And I fully take the point [inaudible 1:44:06].
PD:	But that doesn't mean that you shouldn't pursue those lines and see where the opportunities are.
AB:	<p>Absolutely. And I fully agree on the waste agenda. I'm happy to throw a few more on the table, I think I touched on them earlier but...so one I think is trying to understand what matters, you know where are the big wins? So certainly in terms of biodiversity understanding what are really the problems around land use that we need to crack. Because otherwise we get into all those endless discussions about soccer fields, horse paddocks, whatever. If you start quantifying and comparing probably there are a relatively small set of things where we are losing biodiversity and if we get clarity about which are those that would be a big thing. But I think it goes beyond the biodiversity conservation agenda because other agendas in all this food thing. I mean what are the leverages where if you've got societal change you would make a difference I think. So already identifying those is a really big one.</p> <p>The other one is developing sort of holistic sustainability scenarios for farming systems because personally I don't believe there is an answer to what is sustainable farming, the world is just too diverse. But you can ask yourself what is a sustainable future for East Anglia or for the Scottish Highlands or for the Western Isles or for...you know whatever it is and I suspect you get two very, very different answers in different places. But I think if you could go to farmers, to decision-makers and so on and say 'Look this is where we are today and it's horrible but this is where you could go tomorrow and that's much nicer', then that might help you also generate this sort of more positive social dynamics. I want to maybe put those two on the table as well.</p>
MR:	Tina?
TB:	I'm afraid I'd stick to genetics because I think that whatever...whether you're looking at a cataclysm or whether you're looking at an incremental shift our life depends on plants whatever we end up using them for. So I would like to put us into a situation where we have the range of tools, a whole range of tools with which we can manipulate plant genetics available in all of the crops that we need to feed...to feed us and to develop energy from. So that the tools are there when we've made those decisions, or the decisions are forced on us, then at least we're able to react.
HG:	Can I just add also your point about local, so regional and local development, protection of germ plasm and use in these programmes. So in a way it comes back to your regionalism as well, so there are similarities in the way that we need to encourage those resources to be marshalled.
MR:	I'd like to give the final word perhaps to Alison [inaudible 1:47:28] as the sort of convener. There'll be more discussion over dinner but I wondered if you had any sort of closing message?
AS:	Well I think...I was actually just about to say...I'm busy writing these things down because I



	suppose it's our job I guess. I was just about to say I think maybe the 'G' word which nobody's mentioned needs to be considered and that's globalisation and whether...because we were just talking at the coffee break about the civilisations coming and going and actually...and there have been lots of them and many of them have been precipitated by problems with the climate which then leads to famines and so on, but Ian pointed out that they are very local and then the rest of humanity continued. Whereas we're so global, we're all intimately connected with one another, so maybe trying to think of solutions which are not there to solve everything in one go is probably a bit more realistic.
MR:	We're on this crowded together, well we'd better [inaudible 1:48:41], we're all in this together. Okay, I think we should probably adjourn for a drink now unless Roz has any bureaucratic thoughts?
RA:	No I don't think so. No, no bureaucratic thoughts at all. Dinner is downstairs though.
MR:	Yes, okay. But thanks in particular to our three witnesses, thank you very much indeed.
END OF AUDIO	