UK Research and Innovation

# Briefing: How can we trust the data and computer models shaping our food systems?

Based on an AFN Network+ webinar, held 28.11.25

# Table of Contents

# About the speakers & this briefing

## About this briefing:

This briefing is based on a webinar discussion with Paul Behrens and Juan Pablo Cordero, and chaired by Sarah Bridle, given to the AFN Network+ community on the 28th November 2025. It is written and edited by Nina Pullman, food system writer for AFN+; the transcript has been lightly edited to paraphrase in parts. You can also watch the webinar.

## About the webinar topic:

Many decisions about our food system are being made based on data and computer models, including how we should respond to climate change, what subsidies governments should provide, and what changes supermarkets should make. But how do we know if these numbers and models are reliable? When should we trust them, and when should we be asking more questions?

Transparency is often suggested as a solution, but what would that actually look like in practice? Can we imagine a world where researchers, policymakers, and practitioners share their data and models openly — combining their insights to create something more powerful than any one group could achieve alone?

Our panel brings together expertise from energy systems, astrophysics, and food system modelling. They'll share how they build computer models to understand our food system, the practical challenges they face, and what they've learned about using these tools to inform real-world decisions.

## About Paul Behrens:

Paul Behrens is a British Academy global professor at the Oxford Martin School at the University of Oxford. Paul's research focuses on the implications of rapid food system transformations in a rapidly changing world. Paul is working on integrated models to assess the environmental and social impacts of such transitions on both consumers and producers.

His research and writing on climate, energy, and food, has appeared in scientific journals and media outlets such as the BBC, The Guardian, Thomson Reuters, Politico, Nature Sustainability, Nature Energy, PNAS, Nature Food, and Nature Communications. Paul's popular science book, The Best of Times, The Worst of Times: Futures from the Frontiers of Climate Science describes humanity's current trajectory and possible futures in paired chapters of pessimism and hope, on topics including the economy, energy, land and population.

## About Juan Pablo Cordero:

Juan Pablo Cordero is a postdoctoral researcher in the department of environment and geography at the University of York. Juan Pablo is lead developer of the Future Food Calculator, which challenges you to choose interventions that get the UK to net zero by 2050 without reducing our self-sufficiency.

Juan Pablo brings a background in quantitative, open-source, collaborative code development from a PhD in astrophysics, and is interested in the development of scientific software, big data research, visual representation of data, predictive numerical models and the effect of measurement uncertainty on model parameter estimation.

## About Sarah Bridle:

Sarah Bridle is professor of Food, Climate and Society in the Department of Environment and Geography at the University of York. Data geek turned food systems researcher, Sarah is working to democratise quantitative discussions about how we change the food system to address environmental challenges. Sarah researches the environmental impact of food, and also the vulnerability of our food system here in the UK.

Sarah was Food Systems and Land Use Fellow in the Chief Scientific Advisor's office at Defra in 2021. Sarah's popular science book, Food and Climate Change – Without the Hot Air, investigates the climate impacts of different dietary choices. Sarah dreams of a world in which food data and code are open source and interoperable, like it is in astrophysics, so we can address the urgent challenges facing food and the environment.

# Summary of key points

## Key points from Paul Behrens

### Food system models vary in terms of structure and what data they require

- There are various types of models used to predict and analyse the food system.
- Crop models look at specific climate scenarios but they are limited by what can be included in the model. For example, it is difficult to model how much wheat can be produced in 2050 with a temperature rise of two degrees.
- Input-output models look at the impact of a certain product, or the embodied carbon in trading that product.
- Integrated assessment models encompass multiple sectors, including energy, food demographics or economics. This is the most complex type of model as it tries to account for both human behaviour and physics.

### Data collection is limited by self reporting and variability

- Despite its integral importance to models and modellers, data is often undervalued across organisations, so there is rarely sufficient investment in data collection.
- Many models use FAO datasets, which often rely on countries' self reporting. These datasets often vary widely in terms of quality as a result.
- Data can include trade data, custom records and exports, which are often under-counted. Other examples include Life Cycle Assessment and emission factors, which typically come from different sources.
- Life Cycle Assessments tend to be focussed on high income regions.
- All of these limitations mean there is uncertainty in modelled future scenarios.

### Social, political or farm-specific contexts are difficult to model

- Outputs from models are often reported with implied precision rather than their ambiguities.
- There is limited data for how social tipping points might affect consumer preferences, or how a political situation might create famine conditions in a certain region.
- New crop varieties, supply chain issues and political influence are also very difficult to input into models, but have significant impact on food systems.
- This lack of certainty is evident in how climate impacts are worse than expected, as evidenced by recent IPCC statements.
- Farm-based models exclude specific contexts, for example a model looking at farm net profit over time might assume the same production system, and doesn't consider regionality, debt or the time taken to transition.

### Models are useful, but it's crucial to be clear about their assumptions

- It is harmful to take findings from a model as fully representative, which is sometimes what happens in media or communications.
- For example, stating there is a risk of food insecurity from stringent climate change mitigation policy is far too broad given the modelling that is available.
- 'All models are wrong but some are useful'. This quote by statistician George Box reflects how assumptions should be explicit.

### Scientific consensus can help strengthen the findings of a model

- For example, if plant rich diets are coming out as important across various models, it is probably a significant finding.

## Key points from Juan Pablo Cordero

### Astrophysics has normalised open source collaborative working

- Academic research is highly accessible and transparent in astrophysics, whereas in agri-food it can be difficult to understand what modelling is being done and difficult to understand what assumptions are being made.
- Agri-food is a complex system without full understanding of how individual parts work together. It is also highly localised, with different visible impacts depending on location.
- The public marvels at astrophysics but doesn't perceive it as having an impact on them, whereas agri-food is seen as having a massive impact on everyday life.
- Agri-food modelling is an opaque system, which has driven the vision for a new way of food system modelling.

### The Future Food Calculator is a new open source food system model

- A new package of open source code called AgriFoodPy was the basis of the Future Food Calculator, which in turn was fundamental to the analysis in the AFN Network+ Roadmap and report.
- AgriFoodPy is a Python package that combines different models, for example emissions from forests can be combined with an atmospheric model.
- It is an interactive, open source tool, where the code and assumptions that underlie the code and model are completely accessible.

### Collaboration and transparency are a key aim of the Future Food Calculator

- Data collection was a challenge in building the calculator, as combining different models required building translation bridges to create interoperability.
- In addition, the project has tried to include different actors within the food system, including farmers, policy makers and scientists.
- The aim has been to generate trust in the project, and how the philosophy of open source is the way forward.

### The Future Food Calculator will be extended to include nutrition data

- The calculator already includes some nutrition data around desegregation of proteins, fat and energy from the FAO database.
- There is limited additional analysis on whether the resulting diets are nutritionally complete.
- The calculator is due to be expanded in 2026, which will identify nutrition, and the effects of changes in nutrition on health indicators.

## Key points from the audience Q&A

### Standardised reporting of assumptions would help improve clarity

- All models need to be interpreted in terms of their aims and the assumptions they make. Simple models are worth doing, if these limitations are recognised.
- Scientific consensus and meta analyses can help counter limitations of models, and inform wider discussions and policy developments outside of papers, where caveats are listed.
- Standardised reporting of assumptions would also help counter misrepresentations of models in wider debates.

### Corporate lobbying is a challenging area to model, though it is possible

- Lobbying and corporate influence has a huge impact on food policy, but it is extremely difficult to quantify and input into a model, to accurately predict its long-term effect.
- Social sciences or investigative journalism can help inform models and measure corporate influence.

### There is a mixed appetite at Defra for open source models

- There are conversations between academics, industry and public bodies about how to create more cohesive and accessible systems.
- On the other hand, there are limitations in how much data Defra can share, since it collects economically-sensitive data from farms that cannot be shared publicly.
- That said, there is a case for Defra to share more higher value data, because of the importance of transparency around land use decisions in the UK.

### Data transparency could increase evidence-based policy decisions

- By making assumptions and models accessible and reproducible, policy decisions would be more trustworthy.
- This could also move decision making away from blaming, towards a results outcome.
- There aren't enough financial incentives for academics or experts in the food system to work on standardisation of data collection. More funding is needed for data sharing work.

# Webinar transcript

## Paul Behrens and Juan Pablo Cordero discuss the limitations and uncertainties of food system models, emphasising the need for transparency and consensus. Juan Pablo also introduced the Future Food Calculator, an open-source tool for assessing food system interventions.

### Speakers: Elta Smith (ES), Sarah Bridle (SB), Paul Behrens (PB), Juan Pablo Cordero (JPC).

ES: Hi everyone. Thank you so much for joining today's webinar on whether, and when, we can trust data and computer models that shape decisions about our food systems. I'm Elta Smith. I'm a food systems and food policy researcher and a member of the AFN Network+ team, and I'll be your host today.

We are absolutely delighted that AFN+ co-lead Sarah Bridle is going to chair our panel discussion. Sarah is Professor of food climate and society at the University of York. Sarah researches the environmental impact of food and the vulnerability of our food system here in the UK.

Sarah has also been embedded in government as the Food Systems and Land Use Fellow in the Chief Scientific Advisor's office in Defra. And with great pleasure, I'm going to handover to you, Sarah, to say more about today's topic, and to introduce our first panellist.

SB: Thank you so much. I'm really passionate about today's topic, about how we can harness the power of computer models to make better decisions on food system transformation. And I'm really delighted to be joined by two experts on this topic, Professor Paul Behrens and Dr Juan Pablo Cordero.

And I'm sure we're going to have a lively discussion, particularly because I can see that we've got such a fantastic audience joining, and I can see some real data geeks on there, but also some people really rooted in the real world applications of this. I'm hoping that we're going to have lots of challenges and a really lively conversation.

Before that, our panel is going to set the scene briefly by sharing some perspectives from their work. So first of all, I'm really delighted to introduce Paul. Paul Behrens is a British academy global professor at the Oxford Martin School at the University of Oxford. And Paul's research is on the implications of rapid food system transformations, and he is working on integrated models to assess the environmental and social impacts of transitions.

Paul has written a fantastic popular science book as well, which I really recommend, which is looking at crises, but also the optimism that we can have about those. So thank you so much for joining us, Paul, and over to you.

## There are various different types of models that all have their respective strengths and limitations

PB: Thanks so much, Sarah. So nice to join you all today and talk a little bit about the food system and food system models, and how they can drive major policy decisions. But really, what are the blind spots? Where are they reliable? And how do we highlight, as modellers, what we don't know in the system? So I just want to highlight a few different types of models that you might come across. And today I'm going to be talking about some of the issues that you might face when trying to integrate these models into policy.

The first one is something like crop models. So climate impacts on global agriculture emerge earlier in a new generation of climate and crop models, and that's an important point, because actually what we see often is that we've underestimated the impacts. And in part, that's because of the things that we can include in models. So things like, how much wheat can we grow in 2050 if the temperature rises two degrees?

Then we've got things like biophysical models. These are the ones that I work on a lot, which is input-output or life cycle assessment models, and that's more about what is the impact of product X, a specific product on the shelf, or, where does the food go? What's the carbon embodied in trade? That's more of the input-output approach. And I put an example of one of our papers there, in terms of looking at how plant-rich diets can change food resilience. You can include projected food demand or population projections in building models. They have the systems, or these integrated assessment models, which then go broader than just the food system, and attempt to model across lots of different sectors; energy, food demographics. So they say things like, how diet changes, land use, climate impacts and economics interact together. And I think this is the most uncertain, because it's basically trying to model social and human behaviour along with the natural science.

## Data collection is another area of weakness as datasets can vary widely in terms of quality, geography and dynamic contexts such as politics or consumer preference

So on top of that, we've got our data dependencies. And often we're talking about the food system. We're talking about data from FAO, and so these are often self-reported by countries. So we have to be aware that the capacity and the quality of those data vary widely.

There's arguably not enough investment. There's never really enough investment in data collection, in food systems. I mean, it costs money. People don't like to pay for it. The FAO is always finding it hard to bring the money together to get these data. And I think we all undervalue these data a lot, and modellers, we need them.

Then we've got things like trade data, custom records. Now it's important to note here that exports are often undercounted. Then we have life cycle assessment (LCA), emission factor data, and these come from a mix of lots of different types of sources and assumptions. The thing with LCA is it can tend to be quite patchy in geographical scope. So there are regions around the world which don't have the focus that other regions do. So it's generally quite European, high income nation focused, although that is getting better over time, and there's lots of efforts going on to improve that.

And then we have things like surveys. So this can be behavioural surveys or farm business surveys. It’s important to remember here that, although they're very useful, extremely, extremely useful, people often don't recall correctly.

And so we often see very large differences between what people record for their behaviour and what they're consuming, compared to, say, what the food availability is from FAO stats and on farm surveys. These are not perfect, either. These often have cut-offs for small farms. For example, in Europe, we've got some really nice data, but they do have a cut off of about five hectares, and so we don't get these smaller farms in these surveys represented, and so all downstream models inherit these uncertainties.

And this brings us to a macro issue here. So we've got an uncertainty problem for future scenarios. So we've got the known unknowns, or a measurable uncertainty. Then here we can say things like, the estimated yields for some products globally, under a two degree scenario, ranges from some areas, from some values, and just still to note here that there are many factors missing, but at least we've got some estimated range. And we can’t validate these models against historical data. So there is some measurable uncertainty there.

When we get to broader things in food systems, there's things that no models really do. Things like, what if consumer preferences shift faster than our models predict? We can bring that in, and we can build scenarios around that, but we don't have good evidence for how social tipping points might change consumer preferences. What if new crop varieties emerge that we didn't model? Well, it's very difficult to parameterise new crop varieties. It's very difficult to parameterise old proteins, for example.

What if political class creates famine-like conditions in regions? And again, these are very big, broad food system questions. So models can't quantify some of the really important things that we worry about. But I think this is a bit of a trap in a warming and uncertain world. Climate impacts are hitting harder than we thought. You can see that through the IPCC statement, over the years that actually the risk has gone up for lower temperatures. And models often emphasise precision.

## Climate and food system scenarios are so affected by these unknown measures, that predictions can be significantly understated

I should mention that I'm a modeller and we're as guilty as anybody else. It's very difficult to fully capture all of the ambiguity of models, of what they can't do, as well as talking about what you can measure. But the big surprises do come from these unmeasured unknowns.

Just to take an example of integrated assessment model picture, this is from a recent study, just out last month, and it's a review article about integrated assessment models and how complexity and uncertainty in food system transformation modelling comes about. And you can see here, things that to some to some extent, that these models don't include. We can see quite a large amount of omissions around here for a lot of the value chain sectors.

Now you can also have a look at this paper, and you can see, actually, there's quite a lot of omissions there for the political influence. I would also argue that they're being a little bit optimistic with some of these and the ways in which these are modelled. So I would say that the picture is actually probably a little bit more full of gaps than this. But regardless, the point is that actually, you're missing a lot of these different important factors on food system change.

I'm not just critiquing one form of model. I'm just going to go ahead and critique our models here and do the same thing. We've been looking at socioeconomic changes in the food system. And one thing that we've been doing is having a look at what farms make if you exclude subsidies. And what you can see here is we've got the baseline for this for the UK. So this is the farm net profit, excluding subsidies currently, and for different levels of plants, risk shifts. And you can see that income goes up.

But of course, in our modelling, we're assuming the same production factors. We're assuming basically the same system today, but you would just shift it from one to the other. So we're not looking at how long it takes for farmers to shift, what debt they might have. We're not looking at the security of the demand for the farmer. We're not looking at the regional farm level. This is a national level. So there are all these assumptions that we make, that we have to be really clear about.

## Models can be useful but it's important to be explicit about the assumptions the model is based on

So advice to everyone today is that these models can tell you really interesting things. In this particular case, you can say all other things being equal, if we were to assume that everything were the same in production and consumption in prices then it would look like this. So farm income could go up if we do this. But then also saying that there's all these other factors that we need to bear in mind. And the world is infinitely complex in that way. And so when you look at what most models don't include, with things like pests, extreme weather events, infrastructure damage, I mean, I don't know any mainstream food system model that would be able to simulate the blocking of the Panama Canal, for example.

For input-output models, the ones I've been talking about, we don't take into account elasticities, so we don't have this economic response for integrated assessment models. But I just showed quite a lot of different

things are missed in integrated assessment models. And actually it's harming the way that often they're taken in the media and communicated.

When you read a paper, what are the input assumptions? Can you find them? Are they justified when you can find them, and are they caveated for what you can actually take from the paper? And can the model really capture what it's saying it's delivering? So I took the authors off [the paper] here, but this is one that I think it's just too far to state. It was basically a paper saying the risk of increased food security under stringent global climate change mitigation policy.

Now that I think is a statement that's far too broad to be made given the modelling that's available for that. But these are interpretive things. This is not necessarily a scientific question. It's an interpretive thing about what you think is fair to say and what isn't fair to say. And, of course, there's discussion and disagreement that can go on there.

And in what ways are policies modelled? Do you have shocks? And how have models been tested? All models are wrong, but some are useful. This is a famous George Box quote, but they force you to be explicit about your assumptions. So it's not just saying, look, I think this. You are being explicit. They integrate multiple sources of information, so it's not just one line. It's better than guessing. They're only as good as the data that's going in.

They can't predict many real world events. And assumptions often matter more than the calculations themselves. Some advice may be to look for consensus across models. If plant rich diets are coming out as important across lots of models, then it's probably telling you something. Include other scientific perspectives, and not just technologists, and include lots of different perspectives across lots of different types of modelling, like multi breadbasket failure modelling, as well as the coupled model into comparison project modelling.

And on top of that, keep an eye on the real world. What's happening, what are you seeing actually unfolding in the world? Because there might be different factors that are becoming more important as time goes on, that the models aren't capturing yet. And a transparent discussion of limitations. Finally, I think this adaptive management, where you're constantly testing your assumptions, constantly self questioning and constantly updating, is really important.

## The Future Food Calculator is a new open source tool that is modelling food system scenarios

SB: Thank you so much, Paul, that's fantastic. And lots to think about there. We're looking forward to discussing lots of things that arose in that but before we do, we're going to hear from Juan Pablo. So I'm really delighted to introduce Juan Pablo Cordero, who's a postdoctoral researcher working with me.

We've worked together over many years and Juan Pablo is lead developer of the future food calculator, which is about challenging you to choose interventions that get the UK to net zero by 2050. But what I think is quite exciting is that Juan Pablo is bringing a background in quantitative open source development from astrophysics, which is also where I come from, and so I am really excited to hear your perspective. Thanks very much. Juan Pablo.

JPC: Thank you so much, Sarah, for the invitation to participate in today's webinar. As you mentioned, I am really passionate about software development, open source software, and I wanted to take this opportunity to present to you a quite unique perspective. As you said, four years ago, I was finishing my PhD in astrophysics. I was part of a big international collaboration, hundreds of members from dozens of institutions and countries working on the most precise measurements of the universe and cosmology.

And the success of this project was partly based on the fact that the code and the modelling that was done was completely interoperable, completely open, and the many bits that were part of the analysis, like image analysis, source selection and the actual sampling and stochastic sampling to get the parameters were part of this interconnected and very tightly functioning machinery that was open source. You can see the code. You can look at it. What you look at on the screen is actually the GitHub repository of the vi code.

And there were many collaborators, and this was particularly unique in the sense that everyone was open about their assumptions. Everyone could see exactly what was going on, and this is not just useful internally in the collaboration, but something that other groups could look at, and they could scrutinise the results, and they could look exactly at what we were doing. And four years after that, I moved to agri-food, and it was a complete cultural shock, and I was immediately faced with this stark contrast between astrophysics and agri-food.

## Astrophysics has normalised open source working, whereas agri-food modelling is complex with low transparency

Well, astrophysics is a highly complicated subject on which there are many functioning parts. We know exactly what they are doing. Whereas agri-food is a complex system where we don't know how many pieces there are, we don't know how they interact with each other. I like to think of the analogy between the Swiss watch, which is astrophysics, where there are many parts highly, highly detailed, and each part fills a specific task, but we know where they are and we know what they do.

Whereas in agri-food, it's a massive system that we don't know how it works exactly, and we are trying to make sense of it. Obviously the challenge that these two disciplines are facing are completely different regardless of where you are. Astrophysics and the sky looks exactly the same regardless of where you are looking from, whereas agri-food research is highly localised.

The challenges you're facing depend on where on earth you are. The public view we have on these two topics is completely different. What people wonder at the marvels of the universe, this is not something that's going to have a massive impact on your everyday life. Whereas agri-food, something that highly affects you. The ramifications themselves, policy. In terms of the urgency of the research that's been done in these two fields, it is distinct and obviously the biggest difference that I was able to see related to what I do was the modelling itself.

And whereas in astrophysics, it is highly accessible and transparent, it's reproducible. Literature can be accessed, and you can see exactly what papers are coming out. It's not the same in agri-food. It's a bit difficult to understand what's going on, what modelling is being done. And once you find the models that have been used for policy, it's quite difficult to get to the assumptions.

It's an opaque system, and that sparks a vision on what we would like the agri-food modelling to be. So this transition from astrophysics to agri-food, made me think it would be really nice if we could have something similar in agri-food, a system where everyone knows what assumptions have been done, a system that is interoperable, so you build your model and you want to test it in a different data set.

A really nice analogy of what this ecosystem would look like is Lego bricks, where you have these different pieces that do play a role, that do let you compute something, let you understand something of your data, and you can put them together. You're able to build something big. You are able to rearrange it depending on what type of analysis you want to do and what we're trying.

## The Future Food Calculator came out of this vision for more collaborative and transparent food system modelling

What we have been trying to do in the last few years, not just to build the individual bits, but also come up with an ecosystem and a framework that's well defined. So you don't only have the bricks, you have a description that tells you how they're built, how they interact with each other, and that's something we wanted to replicate, that's done in astrophysics. Advocate for well standardised formats, appropriate ways to deal with data, so it's shareable, so it's interoperable.

And that's what I've been doing for the last few years. We developed AgriFoodPy, a Python package that, in essence, allows you to put together different models. It's the glue that puts the different models together and allows you to interoperate between different models. So the idea is that if you have a forest model that outputs the amount of emissions or sequestration that's coming from forests. If you have an atmospheric

model that computes the temperature anomaly as a function of what came from the forest model, you're able to do so with AgriFoodPy.

And AgriFoodPy is the basis for this project that we have also been working on, which is fundamental to the analysis that was done on the AFN Roadmap report. It's the Future Food Calculator. It's an interactive tool that helps you challenge yourself to identify what are the required transformations to the food system, so we achieve high self-sufficiency and reduction on emissions.

It's an open source model that means that all the code that has been built to construct this tool is accessible, and the assumptions that are under this code are completely open. And this is just an example of the kind of things you can do once you have an interoperable and standardised system of code and an ecosystem that allows you to build complex things.

So if you want to visit the Future Food Calculator, please have a play around with it. We're very proud of what we've done. And the idea is that we integrate different modules. They work. They can be removed, they can be changed. So each of these blocks represent each of the models, and each of the inputs are going into the calculator, and each of the assumptions were represented in these figures.

So if, for instance, you had a different interpretation of how forests should be modelled, or you have a different implementation and how atmospheric effects are coming to play into your food system, you have a different model on population growth.

The idea is you're able to replace different blocks and put your model in it, as long as you adhere to the format, the specification of the data that we use. We use this model in the iPhone report. So we were able, for each of the four reference scenarios, to compute the projected emissions and self-sufficient solutions for the different scenarios. So please go ahead and play with it, and for the very beginning of these efforts of building this ecosystem.

## Data collection and trust were key barriers in developing the Future Food Calculator

We have been faced with many challenges; before, during and after, the implementation of these tools, getting our hands in data has been extremely difficult. Not all data is available. Not all data covers the same space, not segregated at the same level, so it's not presented in the same format, and people building models are not using the same programming languages, so building this interoperability has meant building translation layers between the different models and different ways people do their job. Building networks has been quite challenging.

We are trying to bring different actors from across the food system. We're talking about farmers, policy makers, scientists. We want them to trust what we're doing and convince them that this philosophy of open source is the way forward. And the biggest challenge of them all is to generate trust. Consider the amount of information and opinions that are going around. Not just the agri-food Roadmap report presents a series of recommendations, but there are many groups with different views on how the food system is to be transformed to be resilient.

Providing an additional data point within this sea of opinions is challenging; presenting transparent assumptions is going to build on this trust, and it's going to allow your assumptions to be trusted. Our model is, as Paul mentioned, inherently wrong. It's a series of assumptions.

I think the historical code description of our lifestyle is a very good analogy, and it's not perfect. It's trying to make sense of the limited amount of data that we have and the limited knowledge that we have, and these assumptions respond to these limitations. So obviously, when crucial policy depends on a model that is uncertain and is limited, it is reasonable to expect that people are going to have trust issues with this.

The core is that this is opening the discussion and is inviting people to be part of the discussion by opening the assumptions and showing everyone this is what we're doing, and this how we're doing it. If you have a different opinion, let's build on top of that. Let's build this ecosystem together, because we're not closing our assumptions, we're opening for everyone to participate.

SB: Brilliant. Thank you very much indeed, Juan Pablo.

## Questions from the audience

### SB: Is it worth doing simplistic modelling, that might miss some vital areas that are important for decision making? Or is it only worth doing a comprehensive computer model?

JPC: It's absolutely necessary that we start simple, but we recognise the limitations. But I think it's absolutely necessary to spark discussion and to understand the general trends and directions in which the effects of our interventions are moving the system, obviously, as long as we recognise that this is a limited view, and that's not going to give us a precise answer. All models need to be interpreted in terms of what they're trying to achieve and what assumptions they have access to.

### SB: How can some of these caveats about the models be embedded into the wider discussions and into policy development itself?

PB: Yeah, so it's a really crucial question, and I think this is one of the reasons why we start to then move towards this idea of scientific consensus and with new studies and meta analyses. Because there's things that we can do on paper by paper, and report by report. You could have things like standardised reporting of what assumptions you're taking, and what assumptions you're not. I mean, put it this way, the paper that I showed that was reviewing an integrated assessment model. That's already a massive paper, just to try and map what's going in and what isn't going into those models.

So there's huge efforts to understand those things. So maybe we do need to go towards that more transparent, maybe stricter, or more regular set of different assumptions, that are being listed in a more regularised way. But I think more generally, it is this scientific consensus. If multiple studies are showing the same outcomes for very different modelling types, then you can definitely be more secure that that finding is something that's more likely a scientific consensus.

And if you then can also couple that with things like expert elicitation, where you talk to a broad swathe of different food system researchers, then I think that's where you're then getting somewhere. Because I think then you're actually capturing a broader set of different food system interests, other than even just the modellers, but also people who are working in other areas of these systems.

### SB: Does the Future Food Calculator have nutrition data in, and if so, what's the reference database?

JPC: It does have a bit of nutrition in it, coming from the disaggregation into proteins, fat and energy from the FAOSTAT database, although there isn't much of an additional analysis on whether the resulting diets are nutritionally complete or not. We are looking to expand the calculator in another project we'll start working on next year, which will identify not just nutrition, but also the effects of changes in nutrition on health indicators, something that we are looking forward to integrating in the calculator and in our ecosystem of models.

### SB: Surely one of the greatest risks regarding the future of the UK's food security is the overwhelming activity by companies and lobbyists, influencing the government and MPs to ignore data and make decisions suited to those companies?

PB: Well, as that review paper shows us, we don't do that. That's not taken into account. And actually, I'm not aware of any models that are currently doing that from any sort of modelling pedigree, except for potentially some agent-based models. And so this is where, instead of having your food system data, and you put it in various formats, and then you project it forwards, or you do scenarios, this is where you actually take a different philosophy and you centre the agent in the model.

And so you have a description of how the agent would behave in a situation, and you have lots of descriptions of how different agents interact in a time series. Then you can start to see those feedbacks. The issue that you can also come in is that agent-based modelling is constrained by what parameterisation can you use for it?

What information do we have on how agents behave in the real world? And it's their data to actually allow us to calibrate those agents. And this is one area where it's highly uncertain. We know there's a massive influence, but parameterising that is extremely difficult.

And so I think that's why there is a massive role for social sciences in the food system, obviously, but very definitely in this area. And it's also why I think that it's important to have this broad perspective. Yes, all the modelling is really important, but this broad perspective of investigative journalists of how the food system is influenced by companies, and actually how these are targeting different interest groups and how these arguments might be being used.

There has been great work by investigative journalists looking at how these companies are changing the information space that people experience, and that clearly has a massive real world impact.

## SB: If you were building a model from scratch, what would be the key priorities in terms of the structure, openness and being able to collaborate?

JPC: The first thing is to follow well defined community guidelines on how to contribute. There are many industry standards which are obviously field dependent, but a few of them stand out. I think collaborative development that allows multiple views to be considered equally with equal weight, within the inclusive world that we are aiming for is fundamental. A well defined set of standards. How do we transfer data and how do we describe it?

Well defined metadata is also fundamental. I don't think there needs to be any imposition in what sort of programming language or approach to modelling, and as long as it's well documented and it's well justified, our model is similar to an economics input-output model.

But some people might prefer to do things differently, stochastically or more Italian, less linear. As long as it's well documented, as long as it follows a well defined and justified structure and series of community-agreed guidelines. Those are the fundamental steps. From then on, as long as you stick to them, every change and every feed is going to be well understood and well agreed upon, because you have set your rules from the very beginning.

That touches a little bit on the ecosystem part. Not everyone is a code geek. Not everyone knows how to program, how to implement a model or how to describe it. Those guidelines need to have the different actors in mind. So when we build code, we need to make it so it's easy to explain someone's unknown code. That's also an important step.

Because if we centre ourselves only on the technical aspect, and we have a very polished set of community guidelines that only touch on the infrastructure but not on the actual dissemination of the ideas, then that's from the beginning. So it needs to include the ability to be explained to the general public and to other actors that might play an important role on the whole system.å

SB:  I just wanted to say a little bit about the standards, because I think that's such an important point that some people think, oh, you know, open source, open access. It's a free for all. But actually, I just want to evangelise about the Jimmy Wales book I'm reading at the moment. I don't know if you've come across that one, but it's about Wikipedia, really saying about how, as trust in governments has been going down, over the last actually, a lot more than the last five years.

Then actually the amount of trust in Wikipedia has been going up. Even now we know when we have all this misinformation. And his book is really brilliant at explaining there's a lot of processes and a lot of rules actually behind the editing of Wikipedia, in terms of community guidelines.

And so people might not be aware that's, for example, how the internet was built, by a lot of people working in a particular way with community guidelines that created a culture that really fostered trust. So standards are really important.

## SB: How do we take the world of modelling and its language and make it relevant for farmers and farming bodies? Or is modelling purely focused on policy making?

PB: There's an interaction, of course, isn't there, between the policymakers and farmers and the farming interests, and then the academics. And there's a lot of different interactions here. I think it is a skill in itself as well. I mean, we're asking modellers to do an awful lot here: build the models, do the programming, integrate the data. But then also think about the ways in which the findings are then communicated.

I keep coming back to this idea of breadth again, but do you think that's really important? To give a concrete example, the work that we do is a very macro level of how the agricultural income could change for the whole country under these dietary shifts, under certain assumptions.

But how that relates to a specific farm, and a specific farmer, is a very different question. And so I think that the macro-scale models, that were some of the ones that we've been describing today, do tend to end up being more policy. And then you're basically saying yes, but you need to think about what happens in very local contexts on the basis of this modelling.

And I think that's how we can be most responsible and also be very receptive to the feedback of different regions and different production across different countries. So I think it's a skill in itself, actually, because I think it's tricky, but I think it's something that we always have to be very careful of.

## SB: Could you explain what you mean by agri-food?

JPC: From a purely etymological aspect, it's a bit of a controversial topic. What's the boundary to agri-food in our particular implementation? Our particular view of agri-food includes everything from production to consumption, and this includes the interaction of food with land, the interaction of food with people, the interaction of the food systems themselves.

So in our calculator, we consider population emissions, trade, production, consumption, that includes diets and health. Now, what is in the calculator right now. It's not a definition of what agri-food is, and obviously we hope to expand what's in the calculator. But in general terms, what we believe agri-food is, is all the systems that relate to production, consumption and the effects of food on people and the system itself.

## SB: Presuming that some actors with vested interests might not want to engage with open source, do you see us shifting the norms and systems to convince them, or should we just form a coalition of the willing?

PB: It depends on the best interest you're talking about. Some vested interests do actually want to have more transparency. And I know that they're being forced, whether they want to or not, they're being forced into it by various reporting directives. So I mean, there's that.

And so I think, if you think about shifting norms, and I think these policies and regulations coming in for transparent reporting is forcing actors into this to be honest, and it does have to be more open. As well as what we've been talking about today, Hestia, which is an open LCA database, has been doing great work here in terms of transparency as well. And they work with various people, but the fundamental thing is that it's open.

And I do see there is a vision. And I think it is being driven quite a lot by different EU directives on transparent reporting. And also, if you think about what's actually happening in various areas of the carbon border adjustment mechanism, you can only really do that, and there's money on the line if you are transparent and open. And so I definitely see this becoming a little bit of a tipping point in terms of openness and transparency.

## SB: Do you feel that Defra and the FSA are leading on the importance of standards for interoperability, or are they waiting for industry to push a solution?

JPC: I am going to be completely honest. I'm not completely up to date. I'm not very familiar with industry and the inner workings, since some are coming from academia, which sometimes can have a bit of a narrow view. Obviously, we have had interactions with both sides. It's a bit of both. They do have really impressive machinery. And I'm sure that internally, I know it is massive. I know internally, they probably have some guidelines and from the few data we've been able to access, it's usually not terrible to work with.

But yeah, Defra is massive, it's super disconnected and disjointed, and we have experienced that in the conversations that we have with them, they have been very enthusiastic about what we're doing, and we have had many conversations with different groups, and apparently they do have a few initiatives internally to move towards a cohesive system on the distribution.

But I would be lying if I said they actually do care deeply about that. But this is just out of my ignorance, on how these things work internally. But yeah, we have had some good and bad experiences with them on that topic.

SB: I can say a bit more from having, as you mentioned, Elta, spent a bit of time inside Defra on that. And obviously Defra has access to a whole load of data that can't be made public. It's got all the data on all the farm boundaries and all the yields and so on for each farm. And that is collected. It's not a secret that that data is collected. But you can't just go putting that data public, because that's got economic implications for the farmers who have to provide that data. So, that's just one example. The government has to work with the really detailed datasets that they can't put public. So there are real limitations on what can be done in terms of open access.

At the same time, I would add that, certainly from experience in astrophysics, for example, putting data open costs money. And you said this already, Paul about that, and I didn't realise the FAO was sometimes struggling to get the money to put their fantastic datasets out there. It does take time, and it takes money, and it takes people, and if you're constantly, for example, being asked questions by ministers, like we need this thing on water quality tomorrow or something.

You can't be doing those long term much more thorough pieces of work, which you know are of that standard that you could necessarily have everybody scrutinising and sending in questions about all the time. That's a huge overhead. So I think that there are challenges.

PB: Yeah, could I just add one more thing, which is maybe slightly more on the nose. And I think that Defra has amazing data, much higher resolution than they say they can share. But I would ask, why not? There are countries around the world that share the income of every single person in the country. There are countries around the world that share all sorts of data that is deemed important. And if we think about the land in our country and how it's used, for the good and for the worse, is that something we should know? And so I would question whether maybe they should give more higher resolution data. So yeah, maybe a little bit of a controversial one there, but maybe it's just the desire to have that data.

SB: We have to declare our massive bias here as data geeks, that we just love data and we want more of it, so we're always going to want more data. But just to throw out some thoughts, for example, in our Roadmap for the AFN, we wanted to recreate the CCC's CB7, Carbon Budget Seven Scenario. And it was quite a lot of work to try to work out the assumptions that were made in there. And it would be amazing if for CB8 and future carbon budgets, then if all that data, all the spreadsheets, all the assumptions were made open access, and really reproducible, which is the gold standard for scientific research.

And with government money coming into the funding agencies, we have to do that in terms of science. So just a bit of a plug for that there.

## SB: Transparency is often suggested as a solution. But what would that actually look like in practice?

JPC: It's a double edged sword. I think the answer is that both effects are going to be observed. You are going to have a much more integrated system, but that can contribute to this lack of trust that I was mentioning. Since you will have this influx of opinions and assumptions and who should you trust? Who's right? Who nailed it with his particular set of assumptions?

I think one solves the other in the sense that this massive influx of assumptions will be scrutinised by everyone that has access to them. And the biggest win is that we are no longer doing policy based on guesses. We're doing something based on evidence, which is crucial, from a "who to blame" perspective to an actual results perspective.

PB: I would say that it would inevitably be difficult. It's a longer term goal for that and standardisation, interoperability, is essential. I think it's going to take quite a long time, and even when we get there, then we might have other models that come on board that then also need their own nuanced, standardised, approaches that we've been mentioning before. I saw AI was just discussed there, that adds in another I think fundamental point. We do have at its core, an issue with incentives, the financial incentives that are encouraging things to be closed, like we were mentioning earlier.

They've been paused to be open through public pressure, but also the incentives for academics and funding, the funding for pure data work, just bringing things together. That and standardising things, it's not as common as you think it would be. It's not the stuff that gets a lot of money. So that's tricky, but I think it's a long term goal. I think it's very important. Transparency, I think, is a good thing.

### SB: How have you turned stakeholder knowledge about the food system into numbers that can be used in a model?

SB: And I know this is something that we've been talking about in different groups, and just given the time, I'll just say briefly that this is one of our dreams. For example, we do this serious game on food system crises, and to take the expert opinions in those rooms and turn that into something we can put into the model, that can really model how different things would respond to food crises and different resilience measures. This would be a dream, but there's lots more we could do on that in future.

PB: So I think you keep a broad eye on everything. Don't just trust the models blindly, but also, do look at what they're telling you. Because as Juan Pablo said at the beginning there, it's better than guessing.

JPC: I would extend an invitation to be part of these efforts. The fact that it's open source means that we open the code and we open it for everyone to participate. So I'm pasting the link to our GitHub repository so you can have a look at it, look at the code, raise issues, participate and see exactly what we're doing.

SB: Well, thank you so much, Juan Pablo and Paul, and to all of you for coming and your excellent questions.

# About the AFN Network+

The AFN Network+ (UKRI Agri-food for Net Zero Network+) is a unique network of 2,000+ academics, researchers, third sector organisations, policy makers, and agri-food industry professionals
from farmers to retailers.

Together, we are working to identify key research gaps that may be holding the UK food system back from transitioning towards a net zero UK by 2050, while also enhancing biodiversity and healthy ecosystems, nurturing livelihoods, supporting healthy consumer habits, and minimising the environmental impacts of overseas trade. Our findings will inform the next decade of research
investments in this area by UKRI (our funder and the UK research councils umbrella organisation).

Alongside our core research, we run in-person and online events, produce topical resources, and give out hundreds of thousands of pounds of funding a year.

The AFN Network+ is coordinated by the University of East Anglia, University of the West of England, University of York, and University of Leeds, and is a £5m, 3-year project funded by four research councils; the Biotechnology and Biological Sciences Research Council, Economic and Social Research Council, Engineering and Physical Sciences Research Council, and the Natural Environment Research Council.

**Website: www.agrifood4netzero.net**

**Email: contact@agrifood4netzero.net**

**LinkedIn: www.linkedin.com/company/agrifood4netzero/**

**X/Twitter: @AFNnetwork**

**BlueSky: @afnnetwork.bsky.social**