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Why There Doesn't Need to be a Global Food Crisis
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Thanks for having me here and for letting me give this lecture and this talk. And I hope that we can make this as interactive as possible with an audience this large. But I wanted to talk to everyone about why there doesn't need to be a global food security crisis and walk you through some of the thinking and the logic that went behind that and the work that we're doing at my company to start tackling big, real-world problems essentially. Of which food is a massive one.

So, before I do, I'll just start by telling you just a little bit about who we are at Gro Intelligence and what we're doing, because it will help set context for the conversation that we'll then be having. Gro is AI (Artificial Intelligence) for agriculture. It allows users of our software to make better and faster decisions by quickly understanding and predicting factors that affect the availability and prices of agricultural products. So basically we've built a massive data product that serves as a search engine but also is a predictive engine for understanding our global agricultural systems. And thinking of agricultural systems goes well beyond food. Because as we know, food is a key part of it but it's actually not the only part of agriculture. And really, thinking of how food interplays within the agricultural system itself, is actually a key part of the work that we do.

Why do we do it? Agriculture is an $8 trillion market and there isn't a centralized repository that has normalized all of this information and allowed for information discovery to occur at a large scale. The fact that it is one of the oldest industries and one of the least-understood was not okay with me. It wasn't okay with me because I saw the revolution that happened in many other markets in my previous background looking at commodity markets and mostly energy and saw the revolution that happened there. And agriculture's so far behind. And that's largely the reason why capital allocation in agriculture doesn't happen on a long-term basis. It actually happens on a much shorter-term basis. The example that I always give is, if you take an energy producer and they discover some natural gas or some oil, they come out and they could say to me in my old job as a banker, "Hey, we have proven reserves. I want to come out and sell 20 years forward. Do you have a price for 20-year natural gas?" And I'd say, "Sure. I have a price for anything." And I could actually come up with a price, and go to a market, and hedge that risk, and manage that risk. And that risk was based off of my understanding of the fundamentals of the oil and gas markets.

You know, when an agricultural producer goes out and hedges two years forward, it's a miracle. And the fact that you were so far away – forget the 20-year hedge – but the fact that a two-year hedge in the U.S. is basically as advanced as it gets, means that the rest of the world is living day-to-day. And in a world where you live day-to-day, it's not sustainable. And information is what drives that ability to essentially manage and hedge that risk. And without that, we can't thrive and we can't build markets.

And so that's really what we strive to do. Help people who used to not find information about agriculture. Most of us have been here. Whether it's conducting and working through research, and trying to read through surveys, and transforming those surveys, or trying to poll some database from a different company that keeps crashing on a website – that's what it feels like. And that's what it feels like in a world where we live with iPhones and Android devices. And the fact that agriculture lives there is not okay. We actually have to bring it to the iPhone age. And that's really step one of working through this problem and understanding it.

Menker: Google, ask Gro 411.

Google: Sure, here's the test version of Gro 411.

GroBot: Greetings, this is GroBot.

Menker: Top five producers of soybeans.

GroBot: The top five producers of soybeans are Brazil, with 117 million tons; the United States, with 116 million tons; Argentina, with 39 million tons; China, with 14 million tons; and India, with 10 million tons.

So this is a form of AI in agriculture. And the difference between general AI, which is what Google Voice is or what Alexa is, and contextualized AI, which is what Gro is, is that you can build deep contextual knowledge to answer very specific questions. And the way in which you discover can change. So one way that we're all used to discovering information is charts and graphs. But that same back-end, that same AI that fuels that can essentially lead to interactive experiences that are different from charts, which is what we're used to. So we built a voice product as kind of a fun device, but everybody now has Alexa just running in the office because we like to ask Alexa all sorts of questions. And Alexa says, "I don't know". And then you say, "Alexa, ask Gro," and Gro knows. And that's the extension. And part of why we did this is to say, you know, some people don't need a lot of information, they just need something really specific and they need it fast. And we have to be able to start delivering that at scale about any crop anywhere in the world. And we need to be able to do that for predictions. We need to be able to do that for understanding the today.

The other thing that you see at the bottom is actually another version of GroBot, which is a chat bot. You can integrate it into any chat system. So this can be in any – this is in Slack – but any type of internal messaging tools, where GroBot is just another person - not really, but you know what I mean – that you talk to. And you can ask it questions. You don't have to go to Google and go find that answer, and find the right link, and click the link, and download the data, and try to get that answer. This is just a version of, "I have a simple question, let me just get a response. If I want to dig some more, then I can go and navigate from there." But it's really about enabling discovery.

How do we do this? We currently take over 30 million data series that come in multiple languages and formats. A data series is a unique indicator that is linked to agriculture. Again, this is not just looking at traditional supply-side data or traditional demand-side data, but really thinking of agriculture as a system. What are the components that drive it? Well, if you want to understand demand, you have to actually understand demographic trends. You have to understand socioeconomic trends. You have to understand infrastructure within countries. You have to understand foreign exchange trends and macroeconomic trends, because all of that actually feeds into the system.

If you want to understand supply, you have to understand the Earth, the environment, the climate. And so, what we did is we really thought of what does that universe look like and how do we develop a dictionary for it. That part was manual. There is no other way to build this dictionary other than to bring in people who know different parts of the agricultural ecosystem inside out and ask them to collaboratively build this dictionary. Once we built the dictionary, then the rest becomes a process of automation.

Now the data that we deal with comes in multiple languages and formats. It can be imagery, it can be PDF files, it can be PDF files with images slammed on top of it, and it can come in multiple languages. This is actually one of the biggest barriers to information discovery in agriculture. Beyond complexity of what it actually entails, you also have extreme diversity in the way that the data about it is reported. Because it's global. And so the best data from each country in the world for that country tends to come in some form of a native language or a national language. And English comes next. And so if you want the best data that's coming out of that country, most likely it's actually going to be in that language.

A perfect example is looking at data from China. You know, we take data from China. The difference – the timeline between what gets reported in English versus what gets reported in Mandarin – is about a year and a half. So, you can get data a year and a half earlier, if you only spoke Mandarin. Well you don't have to speak Mandarin with our system. We'll just do that translation. That translates to over 350 trillion data points that we're processing on a daily basis. That is essentially fueling that sort of engine and that continues to grow.

Every time we discover new data, the number of sources grow. The dictionary itself keeps growing. That's not to say it's – I mean, I was giving an example. The first part of building this company was building the infrastructure. And now it's really scaling the knowledge in the system. Six months ago, that 30 million was at 8 million, and maybe three months ago that was at 20 million. So the pace at which we're rapidly growing it is kind of testament to the work that's happened on the back end, which is just grunt work, but really deeply complex also technical work that needs to go into it.

So the process is essentially we take a wide range of sources, we clean and translate it, we normalize it through our ontology that is a key part of all of this is – this is the normalization layer. The definition of a year across countries is never the same. That's probably the simplest form of normalization that we do, which is some countries report in calendar years. Others report in market years. And if you're reporting in market years, it's tied to the crop cycles. And so how do you normalize all that? How do you clean it up so that if a person is searching for something and they're comparing five different sources, it's actually finding the right information that you need and it's given to you in a comparable format?

And then we basically built an API (Application Program Interface). The API powers all three products which I showed. We have a visual web app, we have a bot that's a chat bot, and we have a voice product. Now we're actually building another really fun one, which is not going to be useful to anybody, but it's one that releases coffee or chocolate scents every time coffee prices or cocoa prices go up. Again it is just to show that you can determine what alert you want. You can determine the signal you want and what matters to you. And you can also determine how you want that delivered to you. It doesn't matter. It's just a way of kind of keeping our minds and eyes open to also just thinking of how you creatively embed the technology that exists today and the way that we think about agriculture.

So what's our vision? Cheap and abundant food. It's simple and really difficult. I think it's simple because I believe we actually have answers for it. It's difficult because it involves a lot of behavioral change, and it involves a lot of people thinking collaboratively and together and acting together. And that part – the human aspect of this – is a lot more complicated than the scientific side of things. And that's really – but that's what drives us every day. That's why, you know, I left my job and started this company. It's why

we're able to recruit the talent that we have in the company. There are a lot of people who have done what I have, which is leave what your family views as a completely sane and normal career to go out and say you're solving big problems. I was telling someone I didn't tell my parents I quit my job for six months. Until I had to, basically. And then when I did, they asked if my old job would take me back.

And the problem we're really solving is this: how do we produce an extra 214 trillion calories per year to feed 8.3 billion people in 2027. Now as you can see, this is not the typical statement that you hear when people talk about the future of food security. You hear, "How do we feed 9 billion people by 2050?" And I always explain that first of all, the forecasted population for 2050 is actually closer to 10 billion, not 9. And two, I had no idea where 2050 came from, so we came up with a scientific way of saying what is actually the tipping point by which we should actually care, and how do we represent it? And for us, it became about coming up with a numerical representation that also represented food and reality. And that was not in saying how do we produce X million tons or X billion tons of food, but rather calories, because calories are actually what sustain us. And so I'll just contextualize this a little bit further – some people love this analogy, others hate it – but that translates to 379 billion Big Macs, which is more Big Macs than McDonald's has ever produced. So that's the gap that we have to fill every year, starting in 2027.

So how did we get here? The world 40 years ago looked like this. This is a map that we developed where we took each country's overall consumption of food and then we took each country's production of food. And we adjusted those numbers from tons to calories by putting in calorie weights. And the reason we did this is that we wanted to see what countries were basically running calorie surpluses and calorie deficits. Now if you looked at this map and you created this map actually using tons, what you would see is places like Sub-Saharan Africa would be bright blue – not red, which is a massive deficit – but blue. And the reason for that is that there's a lot of production of crops such as cassava, which are not so calorie-dense or rich. And so, when you actually take into account caloric content of what is being produced, you end up with a much more realistic picture of what the reality on the ground actually is.

And so this is what the world looked like. The United States was really the world's largest net exporter of calories. But what's interesting is that China was actually flat. Not a massive net exporter but it was always – it was self-sustaining, essentially. 40 years later, that's what happened. Now if you look at the flip here, if you go back, what you ended up with was North America gets even darker, South America becomes an emerging player, China just turns bright red. And essentially all of Sub-Saharan Africa except for Central Africa is light blue. And the reason Central Africa is light blue is actually just because the absolute numbers per capita are still very, very small. So it's not a success story. It's more kind of on a relative basis again. There are kind of other factors driving it. But China was a big flip. India went from a net importer in red right underneath to actually being self-sustaining. That was the green revolution, right? So we actually saw a lot of positive change occur, but we also saw immense demand coming from China that took all the excessive supply. It was there to take it all in.

So essentially, what happens when you look at this over time is, if you look at the green line chart here, that's China. Basically China was self-sustaining until it wasn't. And once it wasn't, it was off the charts and off to the races. What we are trying to understand is what's the scenario where you have multiple regions starting to do that? And at what scale and at what velocity? India as you can see is flat. Africa has been a net importer – it's a continent, not a country. But it's a way of looking at it. what you have

coming up is a demographic inflection point in these three regions. By 2023, they'll all have the same population. But after 2023, Africa will actually surpass the populations of India and China. You'll start to see a flattening out in China. India will continue to grow, albeit at a slower pace. This 2023 point of inflection starts to present really interesting challenges to that map that I showed.

So what does the world look like ten years from now essentially? That's what our models ran when we tried to figure out what the deficits looked like, and where progress was going to come from. And this is looking – again, we ran this for the whole year but it's kind of a messy chart to look at – so, highlighting the areas where we're focused in on. What you see here is a rapid rise in China continued. Africa continues to be a net importer. But India actually starts to flip. And that's where it starts to get dangerous, right? So if you go back two charts where China was normal, normal, and then it wasn't, there was no turning back. That's the point we want to avoid. You know, 2050 is so far into the future that by then we're in doomsday scenario versus any type of workable, livable scenario. And what we're trying to say is let's act on this today as opposed to worry about it 20 years from now. Which is what 2050 actually makes you think you have, which is a lot of time. And we don't have a lot of time.

Now this is essentially how we came up with the gap is – if you look at the growth in production in surplus regions – so what we essentially said is what are the yield gaps that exist around the world for all the major crops, and how much of that do we believe that different regions can actually potentially have, right? So there's potential massive upside for yields in Sub-Saharan Africa. But, if the system continues to function the way it is today, that future of tripling yields doesn't exist. There is a reality where we can make that happen. But not in the way that we have the system structured today. And so what this does is it just really says the onus still remains on all those blue surplus regions – which is the United States, South America, and Australia – to essentially continue feeding this growing population and this growing world. And they actually start to hit limitations. Now there is the option of essentially just chopping down the Amazon and converting it into farmland, but that is not really an option. And that's the option we're trying to stop. And so there are other sustainable options that we need to start considering that don't involve that.

So how do we avoid this, right? And what are the solutions that exist? Before I jump to global solutions, I want to actually present an example – a China example. And this is a real example from today, which is China's five-year plan. China operates on a series of five-year plans. In 2016, it introduced its thirteenth five-year plan. Now in the five-year plan they've always had food security in there. But the way that they worded it in the thirteenth plan was really interesting. "Self-sufficiency in cereal grains and absolute food security." That's how they actually thought of food security. "Self-sufficiency in cereal grains and absolute food security." What does that mean? For the first time, China stripped out the concept of food security meaning self-sufficiency, which is how we all think of food security today. When we think of making a country food-secure we think of making a country self-sufficient. What China said is, no we only need to be self-sufficient in cereal grains. So basic survival, you know? So, for basic survival needs, we need self-sufficiency. Everything else we need to create a new definition of food security called "absolute food security," which we will achieve through a series of steps.

These are the steps they outlined: first was consolidation of small farms, second is national R&D systems for seed varieties, irrigation and dry farming, precision farming, conservation actually made it onto their list for the first time, crop rotation, zero growth in use of fertilizers and pesticides – I'll walk you through

the math on that because that is still a little hairy, new clean energy such as biofuels. Now they throw biofuels in there but they don't actually explain what type of biofuel. And then this final line item: global agricultural diversification. Now this is an interpretation of that final line item because it was actually trade. But their version of and definition of trade is very different from our traditional forms of viewing trade.

So where's China today? Average farm size is about 0.3 percent of the U.S. So an average farm in China is 0.6 hectares versus 180 hectares in the United States. Most Chinese yields are behind the United States. Rice yield is at the U.S.'s 2000 level, corn is around 1977, and soybeans are about where the U.S. was in 1968. Protein demand in the form of soybean meal in China has grown by 956 percent since 1988, so by about 1000 percent. Grain demand has grown by about 80 percent since 1988. Now remember that fertilizer and pesticide use comment on zero growth? When zero growth in fertilizer and pesticide use is tied to zero growth from 7x per hectare what U.S. farms use, it's not a very good benchmark for what you can actually get it down to.

So that's probably the one area where – and this data on China actually is a perfect example of a data source that is really hard to work with because it only gets reported in Mandarin – but they actually provide pretty intricate datasets on pesticide and fertilizer use across China. So this has led to serious water contamination issues and public health issues that China is really starting to battle. Some of this is reversible and some of it is not.

Protein consumption, mostly in the form of pork, followed by seafood, followed by poultry, and then beef. Now if you actually look at growth rates, beef demand is growing at the fastest rate, but is still very far behind. If you're to look at what China thinks its beef demand is going to be, its attempted acquisition of the largest ranch in Australia a few years ago that was blocked by the Australian government is probably a good indicator of what they believe it's going to be. That was a 19 million acre ranch that they tried to buy. It was blocked by the government for basically national security reasons.

So if you look at their crop surplus-deficit – and this is just looking at tons here – but just to get a sense of how they define it and translating that back, this is looking at corn, bean, rice, and wheat – what you actually see is that they're kind of self-sufficient in their cereal grains already, right? The green is soybeans. That is a very different story, which is why that got stripped out from this concept of absolute food security. They don't believe that there is any version of the world where the bean demand that they have is going to be met by local production. What they really care about is sustenance and survival. Now where does it go? This is our forecast going out a couple of decades. What you see is that it's ability to remain self-sustaining in core cereal grains is actually okay. It's not swinging around much. But its bean deficit grows even further, right? It gets to about 160 million tons. It's running a deficit of about 97 million tons today. That deficit will grow to about 160 million tons.

Now remember that wildcard called biofuels that they didn't describe? Well in December of last year, they came out and expressed that the biofuel of choice was going to be corn-based ethanol and they introduced the E10 mandate to basically roll out E10 across China by 2020. That's 10 percent of their fuel mix being ethanol. This is what happens if you actually add ethanol to the mix. Self-sustenance, self-sufficiency in cereal grains is out the door and certainly not in beans. But you actually – they highly, highly disrupt the system by suggesting that one choice of biofuel right? So single choices that we make

in trying to avert one problem – so the biofuel solution came as kind of a reaction to, you know, obviously pollution problems that China has. But pollution in China is actually not caused by vehicles. Pollution in China is caused by coal-based power plants that are burning the lowest-grade coal one can find anywhere in the world. I mean it's like burning dirt, right? And so your solution there is probably renewable energy-based power plants, or even natural gas-based power plants before you jump into corn-based ethanol and really disrupting the world food system right? Because this is not even a – when I gave the talk last summer, the E10 mandate had not been introduced. If we'd added E10 to that, the calorie deficit number actually goes up drastically more. And so we're banking on the fact that they're just not going to actually roll out E10 the way that they think they're going to.

But the other thing – China's diversification plan – the plan that no one talks about. This is a map that looks at land deals that China has done around the world. This is land that is owned by the Chinese government and it is land that is owned by Chinese companies backed by the Chinese government. What you see is the land that's currently under production around the world and its in hectares, right? So the darker the blue the more land that's under production. So unsurprisingly, it's darkest in South America right now. What you see as red dots spread across Africa are what are called ATDC countries – they're Agricultural Technology Demo Centers. So these are ag-technology transfer centers that were built by the Chinese government in the form of essentially grants to 23 different African countries to encourage crop growth of very particular crops. Unsurprisingly, if you actually match where these ATDCs are to where China owns land, you start to see a correlation. You also start to see – if you dive in deeper and you say, what is each technology center built for – you will see that's it's optimized for the country and the crop. So for example, in a really small country like Rwanda, they're not doing maize research. They're doing mushroom research. Why? Because Rwanda will never be able to produce as much corn to meet whatever demand China would have, but mushrooms and specialty crops in a country like Rwanda that's actually built for discipline and structure, and actually being able to deliver is a perfect place for that. And so this is land under production.

Now if you look at areas where they've actually done deals, it's a lot darker, right? This is under production, this is where they own. So you see a lot more countries, but you see this getting significantly darker. It's about 17 million acres of land to date that has been purchased over the last 15 years. So China's diversification plan is very different – and China's trade plan is very different from the way we're thinking about trade. Everybody sitting here discussing and debating things like tariffs. They have another plan. And it's been put into motion in a very methodical, planned way, which is thinking of the next 50 and 100 years, and not the next two or three. Which is what we tend to manage the world to today. And what you don't see there is the failed deals. So if the Australia deal had gone through, the deal size globally would have doubled. But that would have solely just been for beef production that would have gone into China. So one thing it does tell us, though, is that the taste in beef preferences is more essentially Australian-style beef versus U.S.-style beef in terms of feed stock that's going to be required for beef that China buys. So unlike Japan and Korea, China is not buying marbled meat. It tends to basically buy meat mostly from Australia.

So what are the conclusions on China? And I'll kind of translate that to the rest of the world. The five-year plan is actually on the right track to this definition of self-sufficiency in grains and absolute food security, because they redefined food security. It is maximum diversification. So if one country that

you've diversified into turns against you, you have many, many more that you work with, right? It is literally a very different plan to how we think of the world trade order today. It is becoming friends with absolutely everybody so, in case something goes wrong, you have a backup plan and you have a backup plan on a backup plan. So, you know, my answer to how even the trade war today plays out is that if China really needed to, all that land it owns, it can start to become productive. Because all that land it owns is also in countries that it owns a lot of mining assets and energy assets in. And as a result, it's invested a lot in building roads, and a lot in building rail, and in building ports. So it can actually move anything out of these countries. So the backup plan essentially exists.

So, in China's case, there is that deficit. But they're addressing that deficit by coming up with a plan that says, what's our natural constraint locally? And then how do we diversify against that globally? Large-scale ethanol adoption completely derails this plan, and so it probably actually won't see the light of day or, if it does, it might be E1 instead of E10. And Chinese agriculture's global diversification will absolutely continue. These deals will continue to happen. Its footprint will continue to grow. And the world will actually continue to be more connected.

So what are the implications for the rest of the world, right? And this lecture was on how do we avoid a global food security crisis. You know, the first is understanding that the world is becoming more connected, not less. That means our understanding of agriculture as a system, as a connected set of crops, but the world as really a place. So, as I said, Africa's not a country, it's a continent – we're literally going to have to start looking at numbers where we just say the world. And it's going to be deeply uncomfortable but that's really how we have to think about it. Because we're starting to build linkages and connections that are so intertwined that unraveling that will actually get harder and harder over time. Economies of scale will be the key to driving down the cost of production. One of the biggest, biggest challenges to driving down the cost of production and increasing productivity in a lot of emerging economies is the fact that the cost of production is inherently too high. And that's because capital markets are not developed. Capital markets do not develop without the right data infrastructure to drive risk management, to understand risk, to be able to hedge it, and to understand your farmers better, etcetera. But, if you also look at that Chinese five-year plan, one of the things that's written there is consolidations of farms. They recognize that even in that scenario where you want to drive up productivity for just the self-sufficiency in your grains, some level of consolidation becomes necessary to be able to deploy technology the way that you want to deploy it, and the way that you should.

Technology transfer to regions such as Africa can actually start to help significantly. You know, people look at these maps and they start to freak out. And I think of it differently and I say, "Well, if African governments are really smart, they'll really leverage these technology demo centers and transfer that technology to the local ecosystem as well." And so how do you gain from that? You're not going to step away from it, so you can be a part of it and essentially start to say, "How do I build infrastructure on top of that, but how do I build my own independence from it as well?"

The tension between biofuels and food will continue. And this is probably one of the hardest decisions that I think we have to face as a global food system. Biofuels came as a solution to a lot of the struggles that we have with climate change and with our environment. But we have to start thinking beyond the struggle that we're going to have to cause between crops grown for food production and for

sustenance, and the crops we use to produce fuel. And what does that system actually look like? And how do we start to address these tensions? This is a conversation we need to actually start having now.

Policy-makers hold the keys to transformation. It's really hard because at the end of this – at the heart of all this – is about transforming food systems. And food is inherently politics. Part of the reason why 95 percent of the data that we work with is public is because it has to do with agriculture. And agriculture sits mostly in the public domain. And so policy-makers are going to be key to transformation. But local planning within a global context is the future. So planning for food security using the old definition of food security has got to get out the door. Anybody that thinks that they can grow the exact mix of crops for exactly their locale and get it all perfectly right will really struggle, right? So making that choice between what is essential and then what is a luxury – and some of these things that we don't view as a luxury here are a luxury elsewhere. But that balancing act is going to be key. Because it is local planning within a global context.

That means understanding the world more. It means understanding the world at a much deeper level. But it also means that to drive policy, we as civil society need to start getting a lot more educated about these issues. And we need to start making a lot more noise about these issues, in ways that are informed and are data-driven versus emotion. I think food is probably – and agriculture is – one of the most emotion-driven studies that I know of. I mean there's a lot of others, but food is deeply emotional because it's tied to our culture, it's tied to where we come from, it's family, it's everything.

And so the way in which we react to how we have these conversations tends to be emotional. I think we need to take emotion out of it and just bring practicality to the table and use facts to discuss. And having – you know for us being some type of neutral broker of information, or a facilitator of dialogue – it is not to say that every model and every prediction that we have is correct. But it's to say that it can be unbiased, it can be completely transparent. So that people can ask us really tough questions and we can keep calibrating. And by getting asked tough questions, hopefully, we help solve some of these problems. And so it's just about kind of, I guess, enabling the melding of minds that is just not happening in our food system.

And so where will our food come from? This is my hope – maybe because I'm Ethiopian but also because of the reality – which is if you actually look at Africa's arable land versus existing U.S. farmland in a true-to-scale map, you can see you're basically looking at about 400 million acres versus 1.7 billion acres of land. So it is not a shortage of land, it is not a shortage of productivity, it is simply our inability to change the way that the system has been functioning for a long time, and our inability to ask the really tough questions, make the tough decisions, plan accordingly, right?

I mean, planning on consolidating small-scale farms is not an easy thing to do because it actually involves some level of displacement. It involves people asking the question of, well, what happens to the children of the farmers? They're going to migrate to the cities. And if they migrate into the cities, then we won't have jobs and unemployment will go high. And if unemployment goes high, then there will riots in the street. And it just keeps cascading. Well you say, well then plan education differently. Plan for education to be different so that the education system is essentially training a future youth that is designed and ready for the world of the future and not the world of the past, right?

And so it's really just about kind of really thinking of the whole world as a connected system beyond it. but I really do believe that Africa can start to feed the rest of the world. But it's a really long ways away from doing that, because it requires a lot of committed, global change. Not local change. But just global change. And that's where my lecture will stop and I'll take any questions that people have and take it from there.

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