



Agriculture Extension and Advisory Services under the New Normal of Climate Change

Presentation Session

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Speakers:

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Sponsor

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Zachary Baquet:

Okay, good morning, everyone. My name is Zachary Baquet. I'm the Knowledge Management Specialist for the Bureau for Food Security welcoming you today to our February session of the Ag Sector Council Seminar Series sponsored by the Bureau for Food Security, USAID's Bureau for Food Security and implemented by the Knowledge Management – or Knowledge-Driven Microenterprise Development Project. And so welcome you today to our presentation on Agriculture Extension and Advisory Services under the New Normal of Climate Change.

Before we get started, a few points of logistics. Please hold questions until the end. We do Q&A at the end so that people have a chance to speak into the mic and those online can hear the questions as well. So if you ask questions during the presentation, people can't hear what you're saying. Additionally, please put phones on vibrate, silent or what have you so that we don't interrupt the presentations. That said, also when asking questions at the end, please state your name and organization before asking your question.

With that, I'm going to give a few announcements. So some of our upcoming Agrilinks events, we've got the next Ask Ag Twitter chats happening on March 8th. This is going to be around International Women's Day. It's going to be about women and ag. The next event is also going to be March 22nd. We're going to have another Ag Twitter chat, we're going to be doing this in collaboration with the Water Office within USAID around ag and water issues. And then our next Ag Sector Council will be March 27th, it'll be around postharvest losses. We're going to hopefully have a panel with USAID GrainPro and the ADM Institute for Prevention of Postharvest Loss at the University of Illinois. So please look forward to that.

Also, we'd like to highlight a symposium brought to you by our implementing partner MEAS, so Modernizing Extension and Advisory Services. It's on improving the provision of extension and advisory services, evidence from the field. It's going to be taking place June 5th through 7th in D.C. You can register by May 1st. We've got flyers for people who are in person, that you can pick up outside on the table. For those of you online, there's the link you can follow to register as well. So please check that out. They give very good workshops and symposiums.

So I'd like to highlight the fact that this is the fourth year of us bringing you Ag Section Councils. And on this map of the globe you can see this is for all the people who are represented via the online audience and for in person. We've got dots in every country from across the globe for people who participated. And this is only tracking for the past three years when we brought it to online. So it reaches across the globe, as well across the

United States. And we're very happy that you've all been a part of this and many of you have returned over and over again to participate. With that, I'd also highlight the increased participation over – we continue to have large audiences. The year three, that was our spike when we had the integration series for Climate Change and Natural Resource Management. I'd highlight that as a series that we've got that captured on Agrilinks. It's a nice piece to actually see and view in relation to today's talk as well.

So thank you again. Last year I think we averaged probably about 100 participants per Ag Sector Council. Many of you joining us online and probably about 20 percent of our online audience coming from participating from around the globe. So we appreciate all your feedback. We appreciate your attendance and thank you again.

I'd also like to highlight and thank the people that make this possible. Within USAID, the Ag Sector Council Seminar Series was the brainchild of Dawn Thomas who's currently serving as the Office Director in USAID Afghanistan for the Economic Growth and Ag Office there. I'd also like to highlight Belien Tadesse who I believe is serving at USAID Ghana currently who actually shepherded this Ag Sector Council for the first few months before convincing me to take over to manage it.

And then also, I'd like to thank Stacey Young who's currently in USAID's Policy, Planning and Learning Bureau in the Learning, Evaluation and Research Office. She was the creator of the KDMD Project and welcomed us as a buy-in that allowed us to actually bring you these events. And then within KDMD, all the people who helped on bringing you these presentations and bringing you the quality user experience that you've come to enjoy. Meaghan Murphy who is my counterpart at KDMD who started this off, who's currently over at FHI 360 and was here for the first three years. Dar Maxwell who's in the back of the room who brings such great audio quality to these presentations for those of you online, you have her to thank often.

Also working with her is Adrian Gaskin. He's also helping in doing that. Julie MacCartee who's my current counterpart working on the Ag Sector Councils and has been working with me for over a year on this. Maciej Chmielewski who does our great Greenroom interviews that you often see on the blog posts on Agrilinks. And Lindsay Levin for also working on the blog and also doing our Twitter handle. And Bethel Alemu who does a lot of the logistics, the coffee and everything like that that you're enjoying now, too.

So with that, I'll go on to introduce our speakers. Our speaker is Brent Simpson. He's Associate Professor of International Development in the Department of Agriculture, Food and Resource Economics at Michigan

State University. And over the past 30 years has worked in over 20 countries, primarily in African. Currently he serves as the Deputy of the USAID-funded Modernizing Extension and Advisory Services (MEAS) Project for the Feed the Future initiative, and manages MSU's involvement in several international agriculture development efforts.

Also joining us is Gaye – it's Burpee? Burpee. Yup. Is with Catholic Relief Services. Senior Advisor on Climate Change and Rural Livelihoods for Latin America and the Caribbean. She oversees the region's work at the nexus of climate change, rural livelihoods and natural resources. She also served as Senior Technical Advisor for Agriculture, Environment and Deputy Regional Director for Latin America programs. With that, I'll pass that over to Brent to speak. Pass this forward. Okay.

Brent Simpson:

All right, good afternoon, or morning, I guess. I don't know whether you realize it or not, but this seminar was reschedule from last fall. We were supposed to be giving this at the end of October when Hurricane Sandy slammed into the eastern seacoast of the United States and disrupted most of your lives and certainly mine as well. It's probably fitting that an event like that postponed this seminar.

Us cautious scientists like to say that no single weather event can be attributed to climate change, but by definition, global climate change affects every single weather event. For the past 37 years, the average temperature, global temperature, has exceeded the 20th century norm. The difference between climate and weather, climate is the accumulation of 30 years of weather data. So we've already changed the climate. It's happened; it's going to continue to happen. And we want to talk to you today about helping farmers and others working in different parts of the world to adapt and adjust to the changes that are going to be taking place.

Our presentation is divided into four sections. The first is understanding the context. It's not just climate change, but it's climate change in a particular context. We're going to review some of the new normal, what we're calling new normals of climate change, look at some important concepts and principles related to climate change research and adaptation, and finally come back to some best practices and best prospects.

I'm going to stand over here so I'm not interfering with people's vision. Sometime in the fall of 2011 world population passed 7 billion. We're on our way by mid-century to probably 9 or 10 billion people on the planet. World Bank has estimated that need to increase basic cereal production by about 100 percent by mid-century. The FAO has been a bit more cautious in their projections, coming in at about 70 percent increase by 2050. USAID in this building is looking at a 60 to 70 percent increase in basic cereal production. A 60 to 70 percent increase in cereal production is

roughly equivalent to what the globe produced in 1979, in 1985. So we have to add that in addition to what we're already producing in order to feed everyone within the next 37 years.

We've done that in terms of percentage change over that time period, but we've done that in terms of volume. This is going to be a huge and very significant challenge facing us as we go forward. If we look at where this growth is going to come from, the graph shows the red and blue lines are productivity and yield increases. They're all going up. The green line down there is the land base. We already have under production all the best lands suitable for cereal production in the world. There are no new lands out there yet to bring under production. So we have to find this additional productivity somewhere else. It's not just going to be expansion of the number of hectares under cultivation.

We're talking about closing the yield gap then on those lands under production. I'm sorry, this slide is very small, but I want you to focus on some of the colors. The top map is for maize, the middle is the wheat and bottom is rice. These are maps of the global areas of principal productivity for those crops. The red indicates those areas that are constrained by soil nutrients. The blue is those areas that are constrained by soil and water limitations. And the green are those areas that are already within 75 percent of their estimated maximum productivity. So these are the areas where we have to increase our production for the principal cereals.

If we look at soil productivity, at soil amendments, first, during the Green Revolution in the 1960s and '70s, we got great bang for buck, additional kilograms of cereals for each additional pound or kilogram of nitrogen added to the soil environment. Going forward, the addition of more inputs to those soil environments is not generating that many more kilograms of output. So we have some limitations there, particularly for those areas that are already approaching their productive maximum.

If we look at water, these three graphs here. Agriculture on the left, domestic use and industry on the right. We focus on agriculture. Over the last 50 years we've increased the amount of water used by agriculture by 100 percent. It's doubled since the 1950s. Agriculture already uses 70, 80 percent of available fresh water on the planet. The issue is: can we begin to double the water utilization to boost those yields to meet the demands of the future? That's a huge question.

This is the big picture. The top lines, the green line is consumption. It's pretty steady. It's going up in reflection of changing diets in addition to population. The orange line is productivity. When the orange line is below the green, we're in a deficit period; we're drawing down in their

stocks. When it's above the green line, we're in a period of surplus. We're adding to those stocks. We're just barely keeping rate with the population demands as it is. The bottom, those are the standing stock susterials. They're level at best, declining most likely, and certainly the gap between current consumption and future consumption levels of where we are in stocks is growing. That's putting at risk that in future generations or future time periods for shortfalls in ability to feed everyone.

Moving onto energy. Energy's hugely important for agriculture. Certainly over the last century we've seen a precipitous increase in energy consumption tied mostly with economic growth. Most of that energy is coming out of petroleum sources: crude oil, coal, natural gas. Agriculture uses approximately 12 percent of the global energy. Doesn't seem like a lot, but it's very important.

We look at historically, any economist will tell you, when you have a finite resource and you're increasing demands in that resources, prices are going to be going up. And that's exactly what we've been seeing with oil prices. They're going up and they're going to keep going up as we go farther into the future. It's really hard to see this graph, but there's some very faint bars in the background that shows the discovery of new sources of petroleum energy. We've basically discovered already all the major sources of petroleum energy on the planet. The thin line that's draped over the top of that shows the development of those resources. We're already past peak oil. We've already identified and extracted the easy to get to, the cheap oil, the cheap resources that are out there. There's about an equal amount out there that we can still pull down or pull up out of the ground, but it's going to be increasingly more expensive to get to.

Agriculture in terms of industrial productivity. The budget for industrial agriculture, about 28 percent goes into energy sources directly. And when you look at the food on the shelf or food in the markets, 40 to 50 percent of the cost of that food is tied up in transportation, typically run off liquid fuels. Agriculture, by itself, is 60 to 70 percent sensitive to oil prices predominantly. When we look at the food price spike of 2008, 2009, we see that the oil price, which is the blue line in the bottom, it was pushing up the food price. So this twining of energy prices and food prices is very important, particularly when you begin to think about climbing energy prices in the future and climbing demands.

Looking back over the past decade, we see our principal cereal prices trending upwards, obviously there's some real vicissitude in that line, but given all the drivers that are pushing this line up, we can imagine that it's probably going to trend in those directions going into the future.

So what happens when food prices go up? Well, again, I really apologize for the background. It's kind of hard to see this. This is a great graph here. It shows basically, again, the 2007, 2008 price spikes. The red lines below that are violent demonstrations, riots where there's been loss of life tied to principally food prices.

For the urban poor who spend 60 to 70 percent of their disposable incomes on food, when you get a doubling of basic grain prices, basic cereal prices, they end up to take to the streets. They pick up rocks and stones and flip over cars because they simply can't keep themselves fed, them and the families, and they begin to blame then the seats of power.

You can go back in history and see the same kind of relationship in England in the 1700, 1800s with the bread riots and climbing prices for grains. So this is something we need to keep in mind going forward. If prices are going to tend up, it's going to act as a destabilizing influence on those governments that are trying to create a calm and tranquil policy environment to allow their different agencies and ministry to begin to address some of the important challenges that we have before us.

Okay, so this is the context. This is what's happening in the world without climate change. Now we really want to then turn our attention to what additional forcing influence is climate changes going to bring to the fore. I'm really going to talk about two here today. One is trends and the other is disruption.

First we look at trends. Going back over the past 650,000 years, CO₂ levels have never been anywhere near as high as they have now. That's just a fact. This is a great graph. If we look at the last 300,000 years, we see the blue line is CO₂ concentrations, the red line is temperature. The important thing to take in here is that the temperature and CO₂ levels track each other very closely, until we get over to the right-hand side of the graph and the blue line is way above the red line. That's suggesting that these sort of relationships are going to hold true, but in the future the temperature's going to be rising going forward.

A lot of the scientists are proposing that we need to keep our emission levels below 350 parts per million in the atmosphere. Just before coming in here today, I checked with the _____ record, we're at about 395 parts per million, certainly way above the 350 that's suggested to keep us below a threshold where a lot of very unpleasant environmental consequences will be set in motion.

Just to put this in context, the two little arrows down at the bottom, the one to the left indicates when our species, our human species emerged in its current physical form, homo sapiens, about 200,000 years ago. The arrow

to the right is when we evolved in our modern social structures. We're very recent. It's good to look at the temperature regimes that were in place during those time periods.

If you'll look right over here, right there, that's where agriculture, modern agriculture, or agriculture in general emerged, the last 10,000 or 11,000 years. It emerged at a point where the temperatures were fairly constant, fairly favorable. Looking at that larger record, though, we can't assume that those favorable conditions are going to hold true going forward. And when you begin to look at the forcing efforts of CO₂ concentrations, it should be a cause for concern.

Looking at the last 1,000 years, the red line at the bottom is a temperature graph. It's going up as we move into present day. On the right-hand side are all the IPCC model projections for temperature increases given different scenarios for emissions and policy changes. World Bank came out in December with their estimation that we're looking probably at a four degree temperature change by the end of the century. Some of the more pessimistic scientists looking at current energy consumption levels and emission rates think we're probably looking at more of a six degree temperature change by the end of the century. That's huge. That's huge. That's chilling. That would change reality, change life on this planet almost forever.

What does the empirical data tell us? The red dots denote over the last 20, 25 years temperature increases. The size of the dots denote the magnitude of the increases. Temperatures have been going up virtually everywhere, more rapidly at the poles. As temperatures have gone up, on the left is Greenland and the right is Antarctic, the ice shields, beginning to melt. As the oceans have heated, the water has expanded, giving rise to sea level rise. With the addition of fresh water, sea level has begun to rise and rising more rapidly more recently.

Overall, when we look at glaciers, land and sea ice is going down worldwide. If you want to see a fantastic film about this, you want to look for James Balog's *Chasing Ice* film. It's absolutely stunning, a visual evidence of the retreat and death of some of our most important glacial systems on the planet from a human view. It's not looking down from satellites, but it's looking straight on. It's sort of like looking at the first Apollo pictures of the planet from space, that blue ball. This is looking at climate change in the real, and it's quite chilling.

As the sea levels have begun to change in terms of their temperature, they have influences on the global circulation patterns or global climatic patterns. This slide here is showing the East Asian Monsoon, showing a decline in the number and intensity of windy days. These East Asian

Monsoon is linked to the Asian Monsoon, which is responsible for the climatic patterns that feed about 3 billion people on the planet. So when you see disruptions on these important weather patterns, the implications to the people living on the ground, producing food in those areas, is quite significant.

Overall precipitation record is a bit different. As air warms, it's able to hold more moisture, so we would expect to have more rainfall. But it's not even uniform in its distribution. Essentially, what we're looking at, areas that are already moisture stressed, the projections are in the future they're going to become more stressed. Those areas that are already receiving reasonable or sufficient amounts of rainfall may be receiving more rainfall going forward. So you can pick out your zones of operations, your zones work. The blue dots represent rainfall increases. The yellow, orange and red are decreases in rainfall.

Again, another slide that's very difficult to see. This is basically a global map of the principal wheat, rice, maize and soy producing areas looking at the last 28 years. The top is showing differences in standard deviations for temperature in those principal regions. The bottom is looking at standard deviation changes in precipitation. So the temperature regimes are definitely going up all across the world. On the bottom, the record for precipitation change is about mixed. About half the areas are getting more, about half are getting less. The impact on temperature change in particular is very important for crop productivity. Cereals are not exempt from that.

And when we begin to drill this down, the impacts of that onto national economies, those economies that are based largely on agriculture and that agriculture is largely rain fed, when you have disruptions to the rainfall patterns, it can have an immediate and direct impact on the GDP. This is a graphic of the economies for Africa. The top is a rainfall pattern over about a 40 year period. The bottom is the GDP. So you see that the GDP for these countries tracks very closely to the rainfall record. So you look at a more disruptive rainfall regime in the future, you can look at less resources being available to many of those economies to invest in infrastructure, to invest in human capital development and a lot of the other necessary types of investments to address some of the climate change challenges.

All right, those are the trends. These are the kind of big trends that have been occurring that will be occurring. Another important feature of climate change started getting to in the end is this disruptive character, right? This is a great graphic. This is the ten-year running mean for rainfall distribution in Zimbabwe. And I like to use this just because it captures the idea, well, that the magnitude of the climate system, the

amount of disruption is going to be increasing as we go forward. This is much too cyclical in nature to really get the aspect of disruption down. But it helps you to visualize or think about what disruption might mean in terms of agriculture in those areas. This is all, again, looking at rainfall.

Oceans are warming. More energy in the system. We're generating more storms. This is the storm frequency for the North Atlantic over the last 75 years, definitely going up. No question about that. More moisture in the air leading for more significant rainfall events. Flooding is going up globally by continent. No question about that. This is a graph of heat waves, both real and then projected going in the future. This star right here is the 2003 heat wave in Europe that killed 70,000 people. It's estimated by the end of this century that areas such as West Africa, the average temperatures will exceed current highs. So if you've been out in the Sahel in May in 48, 49, 50 degrees, can you imagine that as an average temperature? And then the high period going up from there. What's going to happen to the people who used to live in those environments? Because they won't be able to live there any longer.

As things have heated up and dried out, we've had an explosion of wildfires in every continent of the globe. You begin to stack all these things up, this is what the disruptive character of our environment is looking like. And this is not an artifact of measurement systems. This is all during modern times. It's all very well substantiated, very solid data records. It's just getting more chaotic out there.

And so we're having to produce 60 to 70 percent more food moving into mid-century. We're having to do that with declining resources, more expensive energy, and in a more disruptive environment. For those of us who work in agriculture, you probably can't imagine a more scary scenario.

Okay, climate change. Very complex. It's non-linear in nature, there's lots of feedback loops and linkages, internal linkages. There's tipping points, which if we exceed or go past, we can't come back from. Things are set in motion that we can't recover from. There's huge amounts of inertia in this system, and it's very, very long lasting. A molecule of CO₂ in the atmosphere last between 30 and 94 years. Some of it's more or less permanent. So the emissions that are up there are going to be up there for a good long while, and we still don't have the means to begin to back off or limit those emissions globally.

But what does this look like for agriculture? Greenhouse gases are going up, the primary impact is the rising temperatures. Going from left to right, the impacts on agricultures are changes in seasonality, increase in daytime high, increase in nighttime high, changes to continental and sub-

continental monsoon patterns, increased atmospheric moisture, and a melting of land and sea ice. Those are the primary impacts.

Secondarily, again going from left to right, seasonality changes influence flowering of plants, behavior of pollinators, the relationship of pests and prey species, photo-sensitivity of different plant species, change in daytime highs impacts plant maturation, grain fill, sterilization. Nighttime high prevents – increases - prevents plants from shifting over into respiration, also declining their yield potential. Changes in the monsoonal pattern again have impact at the field level in terms of rainfall pattern changes, increased moisture in the atmosphere, increases the frequency, the intensity and the out of season character of the rainfall events. And lastly, the melting sea ice rises sea levels, leads to salinization of water systems and will also exert a loss of irrigation water in those inland areas.

All right, so how do we begin to wrap our heads around this in terms of concepts, perspectives or ways of approaching the problem? The first line up there is really important. We have to understand what the risks are, the nature of the risk, what the vulnerability are for both human and natural systems with regard to those risks. What are the relative resiliencies in those systems that are existing and can be enhanced?

It'll be very important moving down to help to locate spatially appropriate types of interventions, to temporally phase our innovations. When you're on a trend line, each technological or social innovation is going to have a window of opportunity. And it's going to be suboptimal before that and suboptimal after it. So we're going to have to look at putting in line a whole series of types of interventions, phasing them appropriately. And we're going to have to begin to pair both our technological innovations with the support of social capacities that are needed to make them really work.

Certainly we're going to have to readopt systems thinking, begin to anticipate some of the linkages between important components in the natural system and the human systems, and begin to apply broad principles in terms of their ability to achieve multiple objectives.

With regards to a very relevant topic for extension, we're going to be needing to look at evidence from the past experiences from the past and experiences in other places on the globe that are wetter, drier, hotter, more disruptive to try to extract those lessons so that we can move them, apply them into new locations. This will give our research systems some much needed time to begin to develop new technologies.

And lastly, we're going to have to, by default, begin to rely on farmer agency, their own creativity and abilities to respond to much more. The

'90s was the decade in the development era of indigenous knowledge. And we're going to have to come by and rely on those indigenous capacities a lot more because we're not going to have 10 and 20 year research cycles to really fine tune individual technologies. We're going to have to develop half-baked things to farmer and let them do the local adaption and develop institute.

Okay. When we look at the role of those of us who are in the extension field, these would be these challenges, in particular, the adaptation to climate change. There's three things that are very important: mitigation, adaptation and vulnerability and resiliency.

And we'll start with mitigation. Agriculture, by itself, the very act of feeding ourselves contributes about one-third of the greenhouse gases to the environment. We can't feed ourselves without being part of the problem. That's going to be very important for researchers and extensionists who are going to have to pick up and begin to deal with mitigation issues.

This is just a graphic from the UN EP 1 billion tree campaign. But the notion here is that there's about 1.8 billion small holder producers around the world. They manage about 22 million square kilometers of the earth's surface. That earth surface has a huge potential for sequestering carbon and woody biomass and then the transition of that biomass, leaf fall litter into more productive soils that have a higher carbon content. So we need to find ways of engaging this magnitude of small holders in this immense surface area in sequestration activities.

And by the way, the 1 billion tree campaign is approaching 13 billion trees planted thus far. We need to double that and probably double that again to begin to have appreciable impact on CO2 levels, but it's very important. In terms of adaptation, we really don't have much experience with that. We've lived in a pretty stable place, all things considered. This is a graph from the West African Sahel area showing rainfall over the last century. Beginning at about 1955 rainfall had hit a high and began to decline. And around 1970 in most places, it crossed the border of the mean rainfall levels and went down and stayed down for 30 years, one of the few examples that we have historically of significant environmental change.

So you have to ask yourself, those farmers living across the Sahel, what did they do? Well, they first began to change the location where they planted certain crops, moving into wetter, more water retentive soils. They began to acquire new varieties of their traditional crops, those were more heat tolerant, more moisture stress tolerant. They began to expand the cultivation of other crops, those crops that they didn't traditionally grow, but that were more adapted or suited to the new conditions. And

they made wholesale changes in land use. They abandoned certain areas and then began to invest more in irrigation and pumping technologies.

Overall, the extension and advisory services did not really respond because they thought things were going to return to normal. We had just to tighten belts for a couple years and we'll go back to the way things used to be. Well, for us here now, that's not an option. Things will never go back to the way they were. And we have to get used to that idea. It's not a 10 year problem, it's not a 30 year problem, it's going to be with us for as long as our species is on the planet. We've got to wake up to this essential point.

Okay, I'm going to pass over the microphone to Gaye and she's going to take about some research and experiences and vulnerability and adaptation.

Gaye Burpee: Okay, which is the –

Brent Simpson: This is the forward and that's backward.

Gaye Burpee: Okay, I'm going to focus on some of the implications of what Brent has said. And I've been focusing on Latin America and the Caribbean for the last six years, and so most of the examples will come from there. In 1998, Central America was hit by a 200 year hurricane with 180 mile per hour winds, 50 inches of rain, 22,000 deaths in Honduras where the hurricane centered. Economic losses of \$7 billion, agricultural losses of \$2 billion and a third of farmers in Honduras had total crop losses and 10,000 hectares of topsoil were stripped.

Afterwards, world neighbors and a consortium of agencies went in to analyze some of the impacts. And what they found was that on conservation agriculture plots, plots that had permanent vegetative cover, had rotations, soil and water conservation, depending on the country, there was 58 to 99 percent less damage on those plots than conventional plots, 28 to 38 percent more topsoil, 2 to 3 times less surface erosion.

But in areas where there were gullies or landslides above those conservation agriculture plots, there was the same damage inflicted on conservation and conventional tillage plots. When I went into Nicaragua right afterwards – well, actually it was about ten months afterwards, farmers said, "We ignored you when you were training us in soil and water conservation because we thought it was a waste of our time." And they pointed to a slope where the plot that had been there had completely washed into the ravine, and they said, "We beg you to come back and teach us again because now we understand." And they pointed to a plot

that had conservation agriculture and was still there and still had crops on it.

Extension and advisory services need to support and seek behavior change, not only at the household, farm household, level, but at the plot level and at the watershed management level. And crisis, when it happens, can be used as a catalyst for change. That is one of the windows of opportunity that Brent referred to.

At the same time, trends in agriculture, the investments have gone down from a high in the 1980s and then they dropped in the early 2000s. There have been changes in that. There have been increases, but globally the trend was that public investment went down. And in Latin America there was up to a 70 percent drop in funds to extension over the last 3 decades, yet agriculture is 15 to 30 percent of the national economies.

In addition, 70 percent of the soils in African and 80 percent of the soils in Central America are degraded. And the percentage of land affected by human-induced soil degradation is high in those regions. At the same time, soil research stopped or decreased significantly in the 1990s.

Okay, getting to the specifics: this is an example of the climate patterns we're seeing in Latin America. It's a hotspot in Honduras, El Paraiso, and the blue bars are precipitation. The solid lines are the current levels of precipitation, and the dotted lines are what are expected by the end of the 2020s. And what you see over in the months of May to about August/September is the growing season. Maize yields – this is based on research that CRS did with CIAT and CIMMYT, two of the CGIAR Institutes. And what you see is that during the early growth stages of maize and in important critical stages, the rainfall is decreasing. The lines are the minimum temperature, the mean temperature and the maximum temperatures.

And the one that I want to point out to you is the bottom yellow line of minimum temperature because what you see is the dotted line is creeping up above 18 degrees Celsius in the middle of the growing season. And that becomes very important for beans because if beans don't get see a temperature that goes below 18 degrees Celsius at night, they will not flower. And if they do not flower, they will not produce beans.

Okay, what we did in a study called Tortillas on the Roaster is we came up with a traffic light mapping system. And the red areas are hotspots where we expect to see 50 percent or more yield losses in maize and beans. Sorry. And in those areas, production of maize in beans will no longer be an option. And farmers are going to have to transition out of current livelihoods into other types of livelihoods.

In the yellow or orange areas, there's going to be up to 25 to 50 percent losses. And the focus there will have to be on adaptation of the production systems with conservation agriculture, wind breaks, better water use, et cetera, supplementary irrigation. The pressure spots is where maize and beans in this modeling could have greater than 25 percent yield increases. But the problem is that most of those areas right now are either forested or protected. And incursion, agricultural incursion, would put the country at greater risk in terms of vulnerability to climate change because of the impact on water resources.

Okay, this map helps take the uncertainty for national governments out of planning for climate change. The red areas are the hot spots where beans – the map is just for beans – where beans can no longer be grown. But guess where the major bean producing areas for Central America are right now? They're this dry corridor that goes from Nicaragua up through Honduras. The yellow areas are the adaptation spots, and it's a very significant area in terms of size. It's huge. That's the area where governments are going to have to focus intensive extension efforts to help farmers adapt. And the green areas are the pressure spots.

Just to look at it from a different angle, over in the Today map, these are areas that conceivably could be grown to beans today. And the change into the 2020s, the yellow and gray areas are where they can no longer be grown. And down in the 2050s you see that the area keeps decreasing. The estimated losses in terms of economic income is \$122 million for both maize and beans. And one of the things that the modeling raised was how important soil health is for maize resilience. The graph or the chart on the left shows that using proxy indicators in El Salvador, maize losses in the 2020s and 2050s are about 33 percent on poor soils, but if they're grown on good soils, it drops to 1 to 2 percent. And then the chart just shows the productivity and the economic losses. And down here, this is a typo, it should be \$102 million in economic losses just for maize.

Okay. Small holders in Central America, one of their cash crops in the uplands is coffee. And we also did a study on the impact on coffee in Nicaragua, and what we found was the optimum altitude for coffee growing today is 1,200 meters. By the end of the 2020s, by 2029, that is expected to be at 1,400 meters. And by 2050, 1,600 meters. Small holders don't have the funds to move up. And so that's going to be a real problem, and adaptation will have to include gradually transitioning out of coffee into things like citrus or other crops.

And just to give you one slide that's not Latin America, on the left is given today – it says today's temperature, but it's 1989 data. The dark areas, the dark brown, is where robusta coffee could be grown in Uganda. The

yellow are areas less suitable. And then with a temperature increase of two degrees Celsius, which is expected by 2050, it shows you the change in where coffee can be grown. Okay, I am going to turn it over to Brent.

Brent Simpson:

Okay, one of the important things in particularly appointed just on a great example some of the research in Central America is the fact that researchers researched this and extensionists have to really begin to work in much closer collaboration in order to identify risks, climate change risks, ___ in the profiles of those impacts locating and the geographic extent of some of those impacts out on the landscape and the nature of their threats and opportunity. The likely timing of those impacts. We're talking about 2030s, 2050s, they're not all going to happen tomorrow, so we have to start developing a temporal scenario timeline for these things and begin to get much better at beginning to assess the vulnerabilities and resiliencies of the human natural populations in those most impacted areas.

Again, as Gaye pointed out in some of her examples, being able to capitalize on multiple-win or no regret options. And by no regret, we mean you do them and climate doesn't change, you're better off. You do them and climate does change, you're much more prepared. So it's no regret. Either way, you're going to come out better. We need to look for those technologies that will improve our well-being in terms of productivity, profitability, security. And also, at the same time, begin to improve our mitigation changes, our adaptation and the resiliencies of those systems that are targeted.

As I said earlier, we need to begin to think in parallel passions of both technology and then the social backstopping that's required for most types of interventions in order to improve the resiliencies and reduce your vulnerabilities to keep populations. And identify potential market and non-market forces and incentives.

With regard to technology transfer, really begin to get much more aggressive about refining new technical and social options, look to forming national platforms for the exchange of networking and exchange of experiences. So we're not all in our stovepipe little programs, but we're actually helping to facilitate the lifting of all boats in the water, if you will. And really begin to get much more smart and skilled at prospecting for new solutions, globally and also in the historical records. And one other thing that's dear to my heart is streamlining the procedures for technology release, particularly new varieties. We can't get mired down in some of these 10 and 20 year timelines. We're going to have to get some of these solutions out to farmers much more quickly.

ICTs, the Information and Communication Technologies are going to provide a particularly important role in terms of – these are just some examples – the forecasting that's important for policymakers, the type of weather information that farmers are going to need to have access to to supplement their traditional ways of sensing what's happening with the weather. And also some warning systems that are going to be targeted specifically at at-risk populations, coastal areas, river, flood plains and others that may be repeatedly hit by severe and disruptive events.

We need to really look in, and not just reform, but completely overhaul some of the pre-service education, in-service training programs, so that those field agents do have a sense of climate change dynamics. So that they're beginning to utilize broader systems orientation in terms of scale, multiple benefits, biophysical relationships in those systems that they're working in. That they have some of the technical competencies required to take on adaptive programming to help farmers become part of mitigation solutions, and also to begin to strengthen those local resiliencies. And they need to be very skilled at beginning to communicate the essential characters of climate change to farmers. Again, getting back to this notion it's not just a matter of belt tightening for a couple of years, we'll get back to normal. The new normal is that change is going to be a continuous process. And that's a very important idea, a very difficult concept to get across.

We need to begin to really do things that we haven't ever done before, and that's really conducting some organizational reviews of our core roles and responsibilities, to identify and remove programmatic barriers where they exist, capitalize on potential synergisms between different extension programs, be they in the agricultural ministries, livestock, fisheries, forestries. We can't be running our separate programs; we have to look at the relationships across programs. Bring into coordination coherency public and donor funded extension efforts. To be honest, it's chaos out there in the landscape in most areas.

The Paris Declaration was trying to get us all in line behind government created plans, but it hasn't really taken effect. The ___ process in Africa particularly has been very helpful, but we need to start aligning all of our investment resources along the same implementation path. We need to help orientate the private sector interest in terms of responding to the challenges, but also beginning to be part of the solution. There's going to be a need for a lot of new technologies, a lot of new materials and support services out there. It's a huge growth area for the private sector. And we have to begin to mobilize some of those resources.

And finally, looking at the policy and issues. And I've got a great example of somebody wants to raise a question from Morocco about

working at scales that matter. The little 12 village pilot activities, it's not going to cut it. This is global in scope. We need to start thinking about landscape level, large scale sorts of investments that are going to be necessary for us to begin to meet some of these really important challenges. We need to harmonize a lot of the conflicting policies out there, conservation activities, price subsidies that often are at direct conflict with each other's, and begin to plan and put some real resources in this human capacity building effort.

I bring this up again and again, but the negligence that we have directed towards the education systems, the agricultural education in service training program is going to come back and clobber us over the head if we don't wake up and start getting serious about training people and getting them out in the field and supporting them in the field to help farmers make these adjustments. That's all we have. We've gone in a lot. It's a very complicated topic. There's a lot of other extraneous factors we could have brought in, but I think we captured the core, and I hope to be able to respond to your questions. Thank you.

[End of Audio]