THE BROOKINGS INSTITUTION

TACKLING THE "ZERO HUNGER CHALLENGE" BY 2030: A CONVERSATION WITH ROBERT ZEIGLER

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Featured Remarks:

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P R O C E E D I N G S

MR. McARTHUR: (in progress) in the Global Economy and Development Program at Brookings. Delighted to see you. And I'd like to start by asking a question. Many of you who've seen me or been with me at an event before know this is how I like to start is ask you for your thoughts. We have one of the world's true leaders on one of the world's most important issues, but he comes to an audience that speaks about and thinks about very different topics often every day. So I have one simple question for you. If you could just show us with your hands and vote with your fingers, how many days in the past week have you eaten rice? Is it zero, is it one day, is it five days, is it seven days? Just by a show of fingers how many days have you eaten rice? We have a zero, we have some ones, threes, any sevens? So two or three. I'd say the average is around two or three.

We are in this room exceptions to much of the world. The estimate we were just talking about, the estimate is that half the word at least has rice as its staple crop if not the primary staple crop. For much of the world, especially in Asia, rice is probably the most commonly consumed food every day. Nearly 60 percent of the world of course lives in Asia, but rice is a huge and growing part of the rest of the world's diet too. And as an economist I can say that I did not learn about how important growing food was to economic development until I started to spend a lot of time with in fact one of Bob Zeigler's colleagues named Pedro Sanchez who is the Director General of the analogous International Agricultural Research Center based out of Nairobi. And Bob is the leader of perhaps the most famous International Agricultural Research Center, IRRI, the International Rice Research Institute. But this is one of more than a dozen of these institutes around the world, including just down the road IFPRI, the International Food

Policy Research Institute. I say this because we are in wonderful buildings like this and in very policy focused communities like this very focused on thinking about growing economies and building markets while for much of the world growing your economy and building your market literally means growing more food. And many of the world's foremost entrepreneurs are farmers who are figuring out better ways to get more crop out of their hectare, more crop per drop of water, better ways to connect to markets, both for their inputs and their outputs. And one of the things that's very unique about agriculture compared to any other aspect of the economy is that the technologies are very place specific. So you can use a cell phone pretty much anywhere in the world. You cannot grow the same plant anywhere in the world. And there's a lot of location specificity to where plants grow and why. And IRRI I realized today is coming up -- I think it's had the 50th anniversary of the discovery but it's about to have the 50th anniversary in 2016 of the release of IR8 which is probably the most famous plant in the world in terms of food which in 1966 was released as this so-called high yield dwarf variety seed which was the anchor of much of Asia's green revolution. And it was so famous -- I love the term, it was -- when it was introduced in Viet Nam the local word used for it was rice of the farming god. This was how important it was. And it was the scientists who developed these often fertilizer responsive, high yield varieties that had better growing properties. These ones were shorter so they wouldn't fall over when the fertilizer was used. That was the secret to IR8. I'm simplifying dramatically.

MR. ZEIGLER: Great.

MR. MCARTHUR: Next to a plant.

MR. ZEIGLER: Keep going. That's great, yeah.

MR. MCARTHUR: But I think the economists have a responsible to

celebrate what the scientists are providing for us, quite sincerely. And there are many, many of these breakthroughs. There was right beforehand but really at the same time around Punjab and Hariyana in North India was the advent of the green revolution in India with wheat. And then the rice spread out throughout the country. We've had work which has been more difficult technically but slower to proceed, but making progress on maize in the maize growing regions. There is work on cassava, there's work on all sorts of plants to get the growing properties better, or to improve the growing properties.

Now the world in changing in terms of what you need to grow good food. The climate is changing, diets are changing, the stresses on the plants are changing. And so before, a generation ago, there was a challenge to get plants that could use fertilizer and grow quickly and double or triple yields literally in the matter of a growing season. Now with pressures like climate change, flooding, in much of Asia there's a challenge to get plants that can withstand the flood. And how to breed them in a way so that when the floods come as we've seen with increasing intensity and severity around Asia, the plants don't just die and lose a year because there's a flood. And I'm hoping we can talk a little bit about that today because it's one of the most exciting breakthroughs for potentially the global economies; some of the scientific breakthroughs around literally flood resistant rice. In Africa they're working on drought resistant crops. In IRRI and around the world they're working on flood resistant crops.

So let me just say a little bit about Bob. Bob is the Director General and Chief Executive Officer of IRRI. He's been in that role since 2005 so he's one of the most established leaders of the International Agricultural System. He's a plant pathologist by training. Like much of the world's agronomic mafia he comes out of Cornell University where he did his Ph.D. which is -- for those who don't know Cornell University really was

the pinnacle training ground for a generation or more of the world's leading experts on food security and this is one of its most distinguished alumni. He's been a professor at Kansas State University, he's worked in countries around the world, but he's a scientist who's worked on things like host plant resistance, how to understand the pathogens, vector population genetics, you know, technical things that I need to understand a lot better. But it's this science of food production that fuels our economies, and we need to understand how the science empowers the policies. And so I hope that's what we can talk a bit about today.

There are many great tensions, many great sources of excitement, and Bob Zeigler is here to share with us as a world leader on the issues of rice, but in general science for development policy, how we can think about the challenges of hunger and economic development. So please join me in welcoming Bob. (Applause)

MR. ZEIGLER: Okay. Well, thank you very much for that wonderful introduction. I was really gratified because a number of the points that I feel that I had to drop because of time limits you very kindly touched upon and, you know, I'll come back to some of the points you raised as well. But it is a pleasure for me to be here. You know, we have a lot of our colleagues up in New York looking at issues around Iraq and Syria, Ukraine, Ebola, so I thought I'd come and talk about some interesting good news stories about what we have to look forward to and what science can offer to address issues of global food security. Well, as was mentioned I am from the International Rice Research Institute. I've had the great pleasure of being its Director General for the last 10 years or so. And were founded in 1960 by the Ford and Rockefeller Foundations who were deeply concerned about issues of food security and how that could affect economic growth and development around the world. And if you remember back in the '60s and

the '50s -- most of you don't remember back in but a few of us remember -- that the story was then that Asia was a basket case. There was no hope to feed Asia. And the future of food security and development was going to be in Sub Saharan Africa. That was Paul Ehrlich's story. But some didn't buy that, created IRRI to basically address the primary food security issue of the world at the time which were rice supplies in Asia. And we started with a very straight forward mandate, and that is our mandate that continues today, addressing issues of poverty and hunger, health of our consumers, stability, sustainability of the rice production environment, and then working through partners around the world because of course one institute can't do anything on its own given the complexity of the issues.

Now I think it's good to start out -- particularly for an audience like this who eats rice one, two or three times a week, to really address the question, what is rice. It is first of all perhaps it is almost certainly the world's oldest domesticated crop. It's been cultivated at least for 10,000 years, it's been continually evolving and in fact I would argue that the domestication of rice continues today unlike wheat and maize in farmers' fields in Asia. It is tremendously diverse genetically. Its relatives are a small group of species that we can work with. So the gene pool if you would, the genetic diversity we can work with is enormous. Now it was mentioned that rice is a staple for over half the world's population. It's the most important food for most of the world's poor, but it's more than just a food. Those of you from Asia will know that the rice permeates all of the cultures in Asia. Every significant event, every creation myth, every ceremony around birth or marriage involves rice in some way or another for most Asians. I refer you to an article that came out in *Science* last May where they talked about the rice culture and that societies that are built on rice actually have social structures that differ from other

societies. And that's something for policy makers to keep in mind. When we question why people make what appear to be irrational decisions around rice keep in mind that the context, the cultural and social context within which they're making those decisions is in fact different from ours if you would.

Another very important point that I'll get into in more detail is that rice flourishes in a monsoonal environment of South and Southeast Asia and East Asia. No other staple crop can tolerate being in saturated, flooded soils for more than a day or two. Rice is quite happy growing up to its knees in water. If it goes under water it will drown, but if it's up to its knees, you know, 10, 15, 20 centimeters of water, it's as happy as can be. So it will be the primary staple over most of monsoonal Asia for the foreseeable future. And it's grown by small farmers. Typically a couple of hectares at most, very heavy reliance on human labor. And as we see global economies changing how long will that be the case? And I think we need to be looking at it. We are looking at ways to produce and meet the world's rice demand alternative production approaches.

Now if we look at rice consumption, here we have the dark green illustrating the more intense consumption, over 75 kilograms per person per day and it's obvious that most of the world's heavy consumption of rice is in Asia, but even across Sub Saharan Africa and Latin American rice consumption is significant. In fact rice consumption in Sub Saharan Africa is growing faster than any other food group. It is projected in the next 10 or 20 years that rice will surpass maize as the staple for Sub Saharan Africa. It's very suited to urban environments. When you look at an overlay of distribution of poverty and rice production each dot there represents a quarter of a million people living on a dollar and a quarter a day or less. You can see that there's a direct overlap. So if you're going to address issues of poverty rice is going to have to be a part

of that equation. And we're expecting global rice demand to continue to grow over the next couple of decades primarily driven by population growth as per capital consumption on the global basis is remaining stable. So just to stay where we are we need another 115 million tons of rice per year to stay where we are. And of course those figures of where we are, are not very acceptable.

Now to make matters worse we've got climate change, we've got expecting temperature increases, rain fall pattern distribution changes. Sea level rise is already of course a reality and weather hazards, storm surges, et cetera that hit delta areas particularly severely and delta areas are major areas where rice is grown. And deltas by definition are at sea level. So when you have sea level rise combined with storm surges, et cetera, you have a very serious threat to rice production.

So where is the world's rice going to come from? What are going to do? Ideally it will have to come from -- at least for the next couple of decades -- from increases on productivity of existing rice lands in Asia. We don't have any more suitable land for rice production that can be brought into agriculture in Asia, and frankly I think as global societies we would like to avoid converting natural systems to agricultural production systems as much as we can. But in Asia as we've got major demographic and economic shifts taking place. Land is moving away from rice, you've got urban spread going out, or urban sprawl moving out across some of the best productive land. Cities were founded in areas where agricultural productivity was the richest. And as city boundaries spread they take up the best land. Labor is moving out of rice. Rice is a tough crop to grow. If you have a choice between working all day knee deep in the mud or working in a semiconductor factor, it's a pretty easy choice to make. And water moving away from rice. In agriculture in general we have a lot of competition for urban

water, urban use, industrial use. Policy makers, governments will 100 percent of time if confronted with is water going to go to the city or is water going to go to the rural areas, they're going to pick the cities every time.

So we need major changes in our production practices just to stay where we are. And of course I argue that just where we are is not good enough. And I want to remind you that if Asia is food insecure the world is food insecure. So we're talking about global food security when we talk about rice production. So we need without a doubt a second green revolution. And I'll argue in fact the second green revolution is already underway. And that's got to be a science based revolution even more than it was in the past. And what do I mean by that? We have incredible revolutions taken place in molecular biology, genetics, communications, et cetera, plant physiology, that open the doors to developing more productive plants and rice in particular in ways that were unimagined in the past. We now have the capacity to start to understand what's happening in the soil, particularly the flooded rice soils. In the past that was simply a black box, you added some fertilizer, sometimes it worked great, and sometimes it didn't work so great; we didn't know why. Now we have the capacity to understand because what's happening in the soil universe is the soil universe is a living universe. And understanding the dynamics of what's happening beneath the soil will help us sustain our productivity. The explosion of computational capacity, communications, IT, infrastructure that has swept across the world is also transforming our ability to ask very complex scientific questions. And that's something that is really the glue that holds the other revolutions together. And most importantly, I think we need to make sure that our policy makers understand what science has to offer, how it could contribute to assuring our global food supply and global food security.

And I want to talk a little bit about rice genetic resources. I mentioned that rice is incredibly diverse. I think if I had asked the question how many rice varieties do you think there are in the world the top end estimate might have been about 100. And you would have been off by a factor of a thousand. In our gene bank we hold in our collection 117,000 different varieties of rice that have been collected throughout the world. Now a few of those have been used really effectively in breeding programs for good reason, but this revolution that I talked about we have just recently, working with our colleagues in China, sequenced the full genetic sequence of 3000 rice varieties from our gene bank. When I joined IRRI in 2005 the front page, cover page of *Science Magazine* had pictures of rice paddies to celebrate the sequencing of the first rice genome. Less than 10 year ago and now we've done 3000. And it is a staggering accomplishment that none of us frankly thought we'd be saying so soon.

So to ensure our food supply there's no question we have to make rice climate ready and there are issues of drought, there's salt, floods, heat, et cetera. And I'll give you a couple of examples of what we're going. And we talked earlier in the introduction about flood tolerant rice, and there are large areas of Asia that are subject to floods every year. At least 10 million hectares are lost to floods every year in Asia, and that's only going up. And even favorable rice growing areas might have short floods that we now know knock yields back. And rice as I mentioned while growing happily knee deep in water, if it is completely underwater for just a day or two it will die. It needs oxygen just like any other organism. And we did identify flood tolerant varieties back in the late '70s but the technology was not sufficient developed at the time to enable us to transfer that flood tolerance to our rice varieties a farmer would grow. I mean we developed some back in the '80s and '90 and when we tried them out with farmers one

guy looked at our breeder and said this rice is so bad our dog wouldn't eat it. So you can produce a yielding material, but if people won't eat it, you know, you've wasted your time.

Well, using some sophisticated tools around DNA sequencing, molecular marketing, et cetera, we were able to transfer the single gene for flood tolerance into rice varieties and the result was nothing short of spectacular. And here's an example of a field site at IRRI where we have varieties that were converted to flood tolerance and those that were not. Those varieties that are shown in white do not carry the flood tolerant gene, those in yellow. The same varieties did receive the flood tolerant gene. And this field was underwater, completely underwater for 17 days. A 17 day flood where your field is completely underwater is considered a catastrophic flood. That water receded and you can see what happened. Those with the SUB1 gene grew back nicely, those that did not have it barely survived. And this is a slide that reminds me once again why I didn't focus too much on statistics when I was at university because you don't need a pretty, powerful statistical analysis to tell you wish is flood tolerant. But the proof of the pudding is to take the material out to the farmer's field. And this was in July 31st. If you look up in the corner July 31, 2008 we took materials out to Eastern India which is a flood prone area. Mr. Paul was one of our first collaborators to agree to plant the rice in his field. This is what his field looked like after two floods. He had two successive floods that hit his field. This is flood tolerant rice. This is the way it looks. It dies back but then it recovers. His neighbors were laughing and telling him he should plow that up and they shouldn't bother with it. We convinced him just hang in there, just give it a little few days. And this is what the field looked like October 31st. Almost a complete recovery. And I did ask Mr. Paul -- actually my colleague asked Mr. Paul at my request how did the rice taste and he said he actually didn't know because he sold all of harvest as seed for his

neighbors. So, those who were laughing at him. This now is material moving rapidly with tremendous support from the government of India, Gates Foundation, government of Japan, the U.S.A., and et cetera, and it's gone to four million farmers by the end of last year. I predict that the adoption rates of these flood tolerant materials in these flood prone areas of South Asia and Southeast Asia will surpass those of the best green revolution varieties. And I said that the second green revolution has already begun. And I'll go out on a limb and I'll say not only has the second green revolution begun it began, it started at 1:17 in the afternoon on July 31st of 2008 when Mr. Paul decided not to plow in his crop. That's the marker and I'll stick by it.

I've been working on materials in stress prone environments for many, many year now, decades now, and always kind of talked about, you know, we're trying to develop materials that are beneficial for the least advantaged farmers, the most disadvantaged farmers in the most difficult environments. I knew we were doing it and I went out in the field and I could see what was happening. And we had Alain de Janvry who's quite a respected Ag economist out of Berkeley come -- we didn't have him, Gates Foundation had him come out and take a look at his team, have a look at what was happening in Eastern India with these flood tolerant rice. And they published this paper in one of *Nature's* journals; it's called such -- reports that come out, but very rigorous journal -- and when I was reading it I read the last paragraph and it literally gave me goose bumps. In the last paragraph it said that this study indicates that the scheduled casts are likely to be a major beneficiary from the spread of Swarna-Sub1 in India. The scheduled cast is the untouchables. They are the people who get the -- they are at the bottom of the heap in India. And they're the ones who are going to differentially benefit. And it gave me goose bumps to see that yes, we've actually finally done it. We've

developed a technology that will make a difference to those who've been excluded for the longest time. And I think to me that's just one of the greatest feelings I've ever felt and it dawned on me that we could actually do it.

We could also put drought combined with tolerance combined with flood tolerance. The tools that I talked about showed us that the biological mechanisms of drought tolerance and flood tolerance are completely independent. So you can have apparently paradoxical tolerances combined within the same crop. And this is important because in many parts of rain fed growing rice areas, which is half the rice area in the world, a farmer can experience a drought and a flood in the same season. It's the ultimate insult to injury. But now we have varieties coming out that will provide tolerance to that. But it's not only about varieties. We have to be able to manage our crops sufficiently. Rice is far and away the largest user of water in Asia. Almost half the fresh water used in Asia goes to rice. Of course when you talk about water use it's reused, et cetera, so it's a bit dicey. But the point is that with more and more competition for water resources there's going to be much more pressure on rice to be far more efficient. And we're looking at serious water scarcity in the future. And we are developing water saving options for rice, and I won't go into these in any detail, but the point to remember is that given that rice has evolved and been selected to grow in saturated or flooded soils over its entire history as a crop, as we change the water management fundamentally we are going to have to address how that crop interacts with its environment in an entirely new way. The nutrient supply and capacity, the microbial population of the soil, pathogen composition of the soil, the ecology of the rice paddy will all change. And there's a major research effort that will be required to be ahead of those changes.

Likewise the way the nutrients are managed. For the last 15 or close to

20 years now, we've been doing intensive analyses of farmer nutrient use around Southeast Asia and South Asia and East Asia in farmers' fields and found -- well, number one that really there are problems with nutrient use, way over use of nitrogen fertilizer for example. But we've also developed tools that allow us to predict what or how the farmers can rationalize nutrient use in their fields to maximize their yields under their particular circumstances. We've developed these tools. Took us a long time to figure out how to go about making the decision making tools available to farmers. At the end of the day, like many we've concluded that cell phones are the way forward, but what we are doing is rather than just have push messages advising farmers what to do we have an interactive set of programs developed where farmers answer a set of questions about their field, you know, what is their source of water, what did they grow last season, what did they do with their crop residue last season, what's the source of their water, is it rainfall, is it irrigated, et cetera. Any question that any farmer can answer and we can give very, very good fertilizer recommendations. And this is a fundamental change. And we look at this as just the beginning of putting together decades of research, crop modeling work, climate work, weather interaction work, to allow a full sweep of decision making tools for farmers that will be around not just nutrient management, but pest management, water management, post harvest management, sales, et cetera, all of which will be accessible to the farmer an relevant to their needs, relevant to their particular circumstances that season in their field. This is then a short step to providing background and a framework that will support credit and ultimately if you have reduced credit risk maybe a sustainable crop insurance model.

Now, those are just some of the technologies that we're looking at at the farm level, but we need to address what policy makers have to take into account when

they make decisions. And we need to have very good information about rice production statistics. Statistics today are terrible. To go to FAO you can get a pretty good estimate of what the bureaucrats said was happening in their fields to please their ministers two years ago, which is meaningless information to be blunt about it. USDA calls up their embassies around the world, their Ag USDA officer says well, we hear it's going to be a pretty good year but that's it. So we've been working to really put together technologies than can give us accurate statistics on what harvested area, when will it be harvested, what will the yield be. Pretty fundamental pieces of information we need to know. And we're looking at a combination of remote sensing technology, next generation remote sensing technology and crop growth models. And we're using some really neat technologies. The European Space Agency has just put up a couple of satellites, the Sentinel-1 and 2, one of which is microwave or radar satellite that uses radar imagery that penetrates clouds. The problem with previous remote sensing technology is it uses optics and over monsoonal Asia or anywhere during the wet season for rice the vast majority of your pictures from your satellites are pictures of clouds and that really doesn't help you very much. But the cloud penetrating radar, you can't get down, you can get a picture of your terrain day or night, sun doesn't have to be out. So we pictures every six days of what's happening in rice producing areas. The nature of radar, which I won't go into, allows us to very precisely estimate the area of rice being grown. We cannot only estimate the area of rice being grown we can get a very accurate estimate of the planting date. And if you have the area and the planting date, you have weather data, you have your crop models that you've spent 25 years developing, you can get a really good estimate of yield. And you can shift that yield estimate through the season. And this is just an example from the Mekong where this is a very -- you're down at the sub field level

measure of rice production and the yield estimate with the darker blue being the higher yield areas. And these are the kinds of data that we can generate and we can crank these things out in real time. So the whole question of rice supplies, availability, what's going to be on the market that used to be completely opaque is now going to be available. And we -- and there's many, many different questions you can ask about that but I don't want to go too far into it.

And what we're working to develop with our colleagues in IFPRI, the Food Policy Research Institute, are global information systems that will allow a publicly -- make publicly available information about production, about yield, about markets, et cetera, so that when policy makers are faced with difficult decisions, difficult questions about their food supplies or rice production, et cetera, they'll have the greatest amount of accurate information. Now whether they make an intelligent decision or not is something else, but at least they can't look at us and say you gave us bad information.

So I'll close with this, I just want to summarize that the green revolution I believe is already underway. It is science driven and science based, taking into account the need for policy. We've got tremendous surge of technologies coming our way. We know that the way rice is grown and market is probably consumed will be changing. We have a huge demand for these technologies. We aren't out there creating something that people don't need. We know that people want and need what we're developing and that's something that will transform the rice sector, and we're providing information for, we hope, intelligent policy development and execution. I do want to remind you that as our friends in East Asia say that the precious things in the world are not pearls and jade but the five grains of which rice is the finest. And with that I thank you very much and then we can continue to discuss this. (Applause)

MR. MCARTHUR: Thank you so much. Thank you. I think this speaks to the role of science in development, something we're not used to talking about in often policy circles in my view. But I just want to jump to the controversial side for a second, Bob.

MR. ZEIGLER: Sure. Controversy. What?

MR. MCARTHUR: And I think one of the great areas of public debate and misunderstanding or even partial understanding is probably the right way to describe it, is this question of genetically modified organisms, GMOs. This is very controversial, especially in Europe, some part of Africa. What you're describing, you know, is gene sequencing, breeding. How would you describe -- I always say to people I should say, you know, we have to remember, you know, Mendel was building GMOs in a certain respect but there is -- and we forget that because breeding is modifying the genetics intentionally but this notion of transgenics, where you're actually taking the specific gene, you know, and recoding in effect is different and is subject to different laws. How do you think that a policy community like this should think about those issues and the boundaries?

MR. ZEIGLER: Thanks for asking that question. I never talk about GMOs in my presentations because I know I'm always going to get a question. So I get a freebie so I can talk about it and not use up my presentation time. Your question is how should an institute like Brookings take a look at these which is a great --

MR. MCARTHUR: The public.

MR. ZEIGLER: It's a great question because, you know, we are fed an enormous amount of disinformation -- I would say misinformation, disinformation. It's woefully inaccurate about genetically modified organisms, GMOs if you would. I think

that highly respected institutions that don't have a dog in the fight as it were should critically evaluate the science, the information that's available, and report the results of those analyses and assessments with courage. Okay. I mean I'm just so sick and tired of hearing well, one says this and one side says that and one side says that the world is a spherical entity and the other says the world is flat, you know. I meant the science and the safety and utility around GMOs that have been marketed is irrefutable. There's no question about it for safety, et cetera. So I think that that message should be unequivocally communicated. I think that is the responsibility of organizations like the Brookings Institution. The responsibility of organizations like ours is to use the technology in ways that benefit the most, the poorest of the poor as it were. We're working on something called golden rice; some of you may have heard of. It's a transgenic, it's a GMO rice that creates Beta-carotene so it produces this beautiful gold and yellow colored rice that when people eat it they convert the Beta-carotene that gives it the yellow color into Vitamin A which is probably the most serious nutritional deficiency in the developing world. And so our responsibility as research institutions is to work on high priority problems that can only be addressed using transgenics. You know, we're lazy. All scientists are lazy. We like the easiest way to solve a problem.

MR. MCARTHUR: Economists are never like that. (Laughter)

MR. ZEIGLER: And so we look at if we have to use a transgenic technology we'll use it. And when I say we're lazy it is more difficult than using most conventional breeding approaches and because you have to go through regulatory hurdles, et cetera, it's more problematic and much more of a headache. So, you know, if we don't have to create problems for ourselves we'd rather not. So just to repeat, get the information about GMO's, et cetera, pull apart the argument about whether it's a Trojan

horse for the multinationals. I mean multinational control of our food supply and that sort of thing is an important question. And how we manage, you know, who controls what, but it's not the same question as whether GMOs should be used in our food supply. And that's a -- yeah.

MR. MCARTHUR: And I think that's an important distinction because the Monsanto kind of bug bear gets thrown around and part of this -- and just to underscore it it's about publicly funded research and open source technologies which is different from proprietary technology. So Monsanto is for example doing a lot of work on drought resistant varieties, some of your counterparts. And obviously IRRI is doing a lot of work on drought resistant varieties. So one of the different questions is who gains? But with that in mind I'm just curious, if you were to take the opposite end of the argument just to push you a teeny bit, are there scientific guardrails that should put up for this? We have a lot of these questions in other forms of biotechnology around human genome sequencing, there's law around even stem cell usage. There are ethical questions that come up around the science. Is that -- or should it be free form or should there be some form of protections to make sure we don't get into trouble down the road?

MR. ZEIGLER: Well, I think the guard rails should be there and whether something is GMO or transgenic or not is largely irrelevant, okay. I think we should be looking at safety, we should be looking at environmental impact. You know, whether a variety is herbicide tolerant from a GMO approach or from a non GMO approach is not relevant to the ecological issues around developing such a technology. So I would say food safety is number one and that's independent of GMO. I would say environmental impact would be number two. So you want to put two big guard rails on there. And I think we should evaluate all of our technologies using those criteria, including GMOs.

Whether something is ethical or not I'm very, very reluctant to get into that area because I've lived in enough countries, in different cultures, enough different religions to figure that's a personal choice, it's not something that really is something we should be thinking about.

MR. MCARTHUR: I want to open it up to questions so if you have anything raise your hand please. And I'll pepper some throughout; I'll go onto my own. But please go ahead. If we have a microphone. And just ask if you could please quickly introduce yourself and make sure your question ends with a question mark.

MR. BILLINGTON: Yes, thank. I don't think it's on. Is it on?

MR. MCARTHUR: Yes.

MR. BILLINGTON: Okay. Mike Billington. I work with the Executive Intelligence Review at Lyndon LaRouche and we've known Bob for many, many years.

MR. MCARTHUR: A little bit.

MR. BILLINGTON: Is it working? Okay. I want to ask a question about some things you've said in the past. In particular you've complained bitterly over the years that the funding for agricultural research, your institute and elsewhere, has been decimated from governments, and that you've been left more and more dependent on some of these private sources and the multis and so forth. I wonder if you can comment on that. And secondly with the recent development coming out of the BRICS conference in Brazil with the creation of a new development bank, with China's Asia infrastructure investment bank, there's a new game in town to the limited resources available for development generally and for agriculture. And I'm very interested in how you see the potential for this explosion of infrastructure technology and so forth coming out of that process in the BRICS nations and their related countries affecting your work in

agricultural research.

MR. ZEIGLER: First let me correct a misunderstanding. Yes, we have suffered funding shortfalls. If you compare what multinationals invest we operate on a shoe string. However we have not been dependent on multinationals for funding or anything. We get a tiny amount of our research support or any support from multinationals. Yeah, we don't -- we have a few hundred thousand dollars here and there but our rice budget for IRRI is $90 million so it's really miniscule.

MR. BILLINTON: And foundations and family foundations?

MR. ZEIGLER: Well, we get a significant amount from the Gates -- Bill and Linda Gates Foundation but that's a foundation. I think the interest that BRICS are showing in developing their rural infrastructure and putting resources together in a development bank, et cetera, is very, very interesting. The infrastructure revolution that's taking place across much of the developed world will transform our rural societies and agriculture, no question about it. It will be heterogeneous around the world of course. That will I believe make the agricultural sector in general, the rice sector in particular, much more receptive to new technologies. That in areas that were much more difficult to reach or farmers who didn't have market access and therefore if they produced a surplus they really couldn't sell it so it wasn't worth their effort will be connected to market. As that interconnectivity is enabled by this infrastructure development that will help transform the receptivity of the broader rural society to technological innovation.

Now how these -- I mean there's going to be, you know, a lot of give and take on how the investments take place and their environmental impact, et cetera, that, you know, we could talk about for hours but probably shouldn't go into that.

MR. MCARTHUR: Here in the back. Please.

MR. LOUDEN: Dave Louden, I'm a policy analyst.

MR.MCARTHUR: Speak up a little bit. The mic doesn't seem to be projecting well. So maybe just use your natural projection.

MR. LOUDEN: My name is Dave Louden. I'm a policy analyst now. My question ties into this gentleman's question. With the -- and this is probably (audio skips). Is there a way that this could be at least brought up for discussion is the current discussions on the Trans Pacific Partnership and all those countries that that entails, many out of Asia?

MR. ZEIGLER: The communities of Asia nations are becoming increasingly aware -- not increasingly aware -- they are recognizing they have to do something about the global rice trade, just to go straight to that question. We're working with ASEAN to get them to try to open up the rice trade. You know, it's so opaque now that --

SPEAKER: Here we go.

MR. ZEIGLER: Well, that's certainly amplified. It means I'll have to calm myself down one level here. So we're working with ASEAN for example to try to open up the rice trade, some kind of rice exchange. It's fraught with risks of course, but the current rice trade is such that it's very opaque and a few people make a lot of money and a lot of people lose a little money. And for the very poor having the price of rice be up 25 percent is actually losing a lot of money.

I think it's also imperative that along with the rice trade that there be a better flow of information and very specifically genetic resources, a lot of which seized up after the Cartagena Protocol was approved. So we were seeing the Asian nations beginning to understand that they're going to have to consider themselves more as a

community with respect to rice supplies which I think is a good step forward.

MR. MCARTHUR: I've just come -- I'll ask Homi. I've just come on this point of how it all fits together from UN the past few days. I'm going back up this afternoon. One of the big questions that everyone is talking about is how do you have these global standards and global processes with very practical local systems where everything. The CG systems -- for those who don't know the jargon, Consultative Group on International Agricultural Research of which IRRI is one member, the International Agricultural Research Entity works with and often its success is foundational upon the Natural Agricultural Research Centers. But Asia and like Trans Pacific Partnership and so much of the world is really about writing its own story rather than kind of falling into the international systems story. I'm just curious from a scientific vantage point does that come up in your life? Are the NARS kind of saying we're on our own now, thank you, or are they saying still no, we need your help, come in? How is that playing out?

MR. ZEIGLER: Yeah. We continue to have very close relationships with the national systems. They continue to value their partnership with us. When we began our work in 1960 the National Agricultural Research Systems were extraordinarily weak. We helped build many of those across Asia, at least the rice component of those. As they got stronger the relationship with them changed. Our relationship with China is very different now than it was 30 years ago. Our relationship with India, Viet Nam, et cetera, are still very, very, very strong but the nature of that relationship has evolved as skill and needs have changed. So we've been very careful to nurture those relationships. Very few have gone sour. Those who have gone sour have actually been reborn, so it's something that's critical. And it will be largely through the public sector in many of these countries, but also through the private sector because finally the private sector is paying

some attention rice. The big multinationals only want to talk about hybrids; I think they're missing the boats. But there are many small and medium sized enterprises that are poised to really take advantage of our scientific revolutions in rice. So the private sector, be it the provider of platforms for farmer decision making through seed sales, I think will be more and more engaged.

MR. KHARAS: Thank you. Homi Kharas from Brookings. I wanted to follow up on this issue of what is the nature of global cooperation when a few years ago the G20 sort of suddenly got food security religion, there was this great spurt of interest but frankly I'm not sure that much was actually done and I'd like your views on whether anything was actually accomplished by that.

MR. ZEIGLER: You noticed. (Laughter)

MR. KHARAS: And then again next year it's almost certain that there will be -- food security will be prominent amongst the new sustainable development goals, so there'll be another kind of surge of interest. So you've got these kinds of points where the global community says we have to do something. What is that something? What would be your ask for 2015 when the global community comes together to say what are the, you know, few things that you would really like to see that you think are necessary to be done in terms of global cooperation to, you know, take advantage of that political moment to put in place something new and different?

MR. ZEIGLER: Well, that's a great, great optimistic question. My experience has been that when you see the arm waving at various global fora it doesn't often translate into big, major changes. What happens is -- my experience anyway -- the bureaucrats back home just repackaged, already appropriated their allocated funds and say this is our contribution to this initiative and so you don't really see. Now there is a

chance and we've seen new players come on the field. Certainly the Bill and Melinda Gates Foundation has transformed from our, you know, small, you know, small ball perspective the resources available for agricultural research. But your question is to what would be what I think the world should be investing in, I honestly -- and I believe this to my core which is why I dedicated my life to it, that to transform agricultural systems I think we need to transform agricultural systems in developing countries you need a solid research base. And, you know, it's not very expensive relative to the return. So I think that the countries have to recognize the importance of long term investments in research. And this includes pretty significant reinvestment in the national systems. You need a building, a next generation of scientists, something I've been pushing for a long time, and you need for this to be an attractive career path. Now I'm arguing for a public sector investment and, you know, the current vogue is that well the private sector can do everything. But if you let the private sector make all the decisions about your investment priorities you're going to find yourself in serious trouble. I mean they will make very rational decisions on what will improve their bottom in line and particularly when the suits on Wall Street are looking at quarterly income statements. The rational decisions made by the private sector for return on investment are not necessarily the best decisions for society. Whole segments of society can be left out. I mean just look at the pharmaceutical trade, where investments are going, you know. I mean Rogaine and baldness and Viagra, et cetera, for old guys, or Malaria, TB, et cetera. Okay. Or Ebola, the current headline. And I think that all of our experience through all of our lives tells us that transformations in society to a large extent are driven by technology and technology is built on a research base. And, you know, I could be accused of feathering my own nest but I'm going to retire pretty soon anyway, at least from IRRI, but I think -- I mean it's

a relatively low investment but it has to be a long term investment. So that's what I would argue.

And the infrastructure investments, the communications investments, all of that, they're going to be made anyway, okay. So I'm reminding our policy makers that you have to prime the pump. If you want innovation you have to have a source of new information and knowledge.

MR. MCARTHUR: I would just underscore one of the big things that you see in health and it's this thing has got a 90-10 90-55, all the money goes to a small share of the disease burden, that is rich people, and Rogaine is the famous -- or balding, but most of the drugs that are breakthroughs that come to market have a very strong background in this country in the National Institutes of Health and the public funding of science and National Science Foundation. There's a huge backbone of publicly funded research that even funds the most entrepreneurial private sector innovation system in the health industry. We don't have that quite in the same way in agriculture.

MR. ZEIGLER: Right. Well, we used to, yeah.

MR. MCARTHUR: We used to.

MR. ZEIGLER: Yeah.

MR. MCARTHUR: And I have to say even just -- I didn't realize it until last night. You know, when you said the rice genome was sequenced first in 2005 that's after the human genome. I'd like to think rice is simpler, but I don't know.

MR. ZEIGLER: Well, plants are actually more complex but that's --

MR. MCARTHUR: But in any case it just shows that, you know, the food is trailing and so the need for the public science couldn't be greater even if we have to find better ways to get the connectivity between the public science and the kind of

entrepreneurial spin offs, the so called phase 2, phase 3 clinical trials for food as the analogy.

We only have a couple of more minutes. Did you have a follow up, Homi?

MR. KHARAS: I did.

MR. MCARTHUR: Okay. Let's take a quick pool. So, Homi, if you want to do yours and then the two in the back and then maybe we can synthesize. Homi is also, I should add, he's leading -- which I'm involved with this projects Investments to End Hunger on benchmarking these issues globally, so this is a live internal discussion for us here at Brookings.

MR. KHARAS: Sorry, so I was, you know, really intrigued to hear you talk about the need to transform agricultural systems, but most of what you talked about was on science and data and little about actual national policies. And, you know, stemming from policies all of the, you know, the waste, the storage, the other parts that go between actually producing safe, affordable, and nutritious food for people. Just give us a quick sense of the degree to which you think the first order problem is actually the science and the dissemination and the broader application of modern varieties and modern techniques and the degree to which it is public policy, whether it's procurement policies or other things that are operating on pricing mechanisms and market mechanisms that really need to change.

MR. ZEIGLER: Yeah, I tried to bring those together in my talk and I -- sorry for -- and thanks for bringing it up. I neglected it in my answer. I think it's again two sides of the same coin. You know, if you don't have an enabling policy environment the technology is not going to get anywhere, okay.

MR. KHARAS: And you think that that's getting --

MR. ZEIGLER: Well, no, I think actually -- if you look at our policy -- if you look at India, you look at Thailand, you continue to look at China, the policies are just hopeless. I mean we're actually working with the government of Viet Nam now. We're restructuring you probably know their whole agricultural sector and we're working with them specifically on rice and the idea is to get the right policies in place. But, you know, the fertilizer subsidies, the pesticide, the mismanagement of pesticides. There are incredible dysfunctional policies around, you know, irrigation water management, price support -- I mean it's just you name it. And then export and import controls that completely seize up the market. You know, we have to sort those out as well. So unless they are sorted out the technology will not be able to be anywhere near its potential impact. Unless there is some driver to stimulate policy makers to change their policies, like if you change these policies this is the return you'll get because of these new technologies, there's not much of a push to change the status quo. So I think they're both part -- they feed back and forth on one another.

MR. MCARTHUR: I'm afraid we only have three minutes left and it's a hard deadline because I have a plane to catch. So please if you could be very brief in the back. I want to get these voices.

MR. TUMUSIIME: Yeah, my name is ***Emmanuel*** Tumusiime with Oxfam. You mentioned a few minutes ago and followed up prior to the gentleman just asked about transforming the cultural systems and one of the things you mentioned was that water is being taken away from rice production, agricultural systems to other uses and I wanted you to comment what's being done to make rice production less water -- I mean production system that will necessitate less water use within the rice system. And

in particular I would also want you to comment about systems like the systems of rice intensification. I read a lot about it at Cornell University being promoted. I want you to comment briefly about that, about prospects about such a system. Thank you.

MR. ZEIGLER: We can talk for hours on this but there are a number of ways that we are working to reduce water consumption. Anything from shortening the actual crop cycle, to produce a rice crop in 105 days instead of 140 days, alternate wetting and drying, which is you can -- don't have to have your rice field flooded or saturated 100 percent of the time, certain periods of the crop you don't necessarily have to keep water on it are two big ways to do that and that is a part of your SRI that you mentioned. But that's --

MR. MCARTHUR: Thank you.

MR. ZEIGLER: Yeah.

MR. MCARTHUR: I apologize. One of the things I learned is if you want to learn more about what's really going on in economic development -- and this is absolutely true -- spend as much time as you can with farmers and the people who are helping the farmers. And it's an absolute truism. Every place I've gone in the world, having grown up in a city learning to think about the differences across farms, the challenges across farms, what a good farm looks like, what a bad farm looks like, all degradations in between, it's absolutely one of the most fundamental aspects of our societies around the world and how they're organized, but also there is a little factoid, unless you got lucky and discovered diamonds or oil there's no country in the world in the 20th century that didn't start long term economic growth without getting to two times per hectare of staple yield crops first. That first jump of the green revolution.

So I just want to, you know, very sincerely thank Bob for coming today. I

don't know if you have a few minutes afterwards in case people have some extra questions.

MR. ZEIGLER: Sure, happy to, yeah.

MR. MCARTHUR: I'm sure there are lots. But also I just want to personally thank you for what you do and please convey our thanks to everyone in the IRRI network for what they do because these scientists are the ones who are helping to lead this global revolution for sustainable development that we all want to see and they are unsung heroes in my view. So thank you, Bob, for joining us today.

MR. ZEIGLER: My pleasure. Thank you.

(Applause)

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