

Roz Naylor:

Thank you for joining us today. We are having another one of our food and nutrition security symposia with special guests who I'll introduce in a minute. This is our last one of this year and generously supported by Zachary Nelson and Elizabeth Horn. We welcome you to this symposia.

But today it is our special pleasure to introduce Professor Quentin Grafton from Australia National University. Quentin is one of the leading authorities on water resources area and particularly in the area of water resources and food security, which we consider to be one, maybe perhaps the most important topic of our time. So we're delighted to have you here.

Quentin is a professor of water economics and public policy within the Crawford School of Public Policy at Australia National University. He also runs the Center on Water, Economics, Environment and Public Policy there and he is the distinguished holder of the UNESCO Chair in Water Resources and Transboundary Water Governance.

This is a real honor to have him here at Stanford, not just for this talk, but for visiting this week and hopefully for weeks to come in the future.

I could go on and on about Quentin in terms of his publications, his past experiences, his current experiences and accomplishments. I'm not gonna do that, but I do wanna emphasize a few different things. He has just an incredible breadth of experience. He's been trained in three different nations. He's been trained at Massey University, Iowa State University, UBC in Canada.

He works on a wide variety of issues ranging from water market to water governance to indigenous rights. He's a specialist in irrigation and water rights and water markets in Australia and has worked in a variety of different systems around the world, including systems in South Asia which are particularly challenging in Vietnam, Haiti and a number of others.

So I think he's going to share some of his experiences in these various locations with us today.

His publications are vast as his awards. He publishes in *Science and Nature* frequently, as well as the top econ journals, the top water resource journals and the top agriculture journals. So as I look at his CD I think, 'Wow. How is somebody so prolific in so

many top journals in so many fields.’ That’s our real honor of having you here today.

When I asked Quentin and we asked him last night what were some of his most unusual experiences or his special experiences, he had to really think ‘cause he’s worked in so many different locations.

I think in the end he came up with one of his assignments which was in Haiti where he lived next door to a voodoo priest. I don’t know what the voodoo priests do to him, but he certainly is smart and he is entertaining. I will just turn it over to you, Quentin, for an interesting talk on insights from global food and water nexus. Thank you.

[Applause]

Quentin Grafton:

Well thanks so much, Roz, for a very generous introduction. IN terms of the voodoo priest, I was kept awake once a month. They had a ceremony and lots of drums, lots of noise. So one night a month I wasn’t able to sleep until the very wee hours of the morning.

Look, I’ve got I think 45-50 minutes to talk through a series of issues associated with the food and water nexus. I think you’re all familiar with the nexus. It has different ways of being defined, but the way I define it I think is pretty much the way most people would. It’s about connecting different systems. Once you start to understand how different systems connect, then you try to understand what are the contagion, what are the risks across those systems and systemic risks.

The nexus I think really took off, so to speak, as a concept when we had the last food crisis in terms of high food crisis and the end of the nineties, which was triggered by a number of factors including higher energy prices and, of course, biofuels policy. So that hasn’t all gone away and food security issues will continue to be a fundamental part of our future in the decades to come.

So what I am attempting to do today is to weave a story about food security and attach it to the issues of water security. It may come as a surprise to you. Perhaps not ‘cause of your expertise. Why you’re here today, but it’s surprising how little has been done to connect food and water.

It is already happening now, the last five or half a dozen years, that that modeling and in-depth analysis that puts food and water together has actually happened, but if you go back ten years or more, they're really in different siloes. It's remarkable. Some of the quite well-known results projections on food without even taking into account the limitation of water resources.

Anyway, a lot of good progress in the last years. I'll take you on a journey in terms of three issues. I'll briefly talk about global risks 'cause I think that's what the nexus is about. In my perspective it's risks. How you respond to those risks. What you do with those risks. Then I'm gonna talk through some food and water challenges. Then I'm gonna really end towards better decision making.

Now when we think about the nexus, it doesn't have to result in better decision making. You can describe, understand and comprehend the nexus issues without necessarily leading to better decision making, but I think for it to have meaning, at least from my perspective, it does and should lead to better decision making and because this is not about the – excuse anyone who works on the life cycle of butterflies, but this is about the lives of literally billions of people today and into the future.

So if we're gonna do this work, we presumably want to lead to better decision making and then ultimately better outcomes, whether it's in the food security or in the water security dimension and indeed in the environmental dimension. So that's the journey I wanna take us on.

So global risks. You can have a perspective that's half empty in terms of a glass or it can be half full, three-quarters full, whatever. I don't know what the future holds so I'm not one of those people who's going to make predictions out to 2050. I give you scenarios out to 2050, but they're not predictions. Quite different.

I think here's the glass half full. This comes out of the *Economist* in June of 2016. They did a special issue on food security. It's a very, very, very hopeful, very confident I would say projection of where the world is going in terms of food. The highlight here is on calories and the focus is on smart agriculture, precision agriculture and there's lots of opportunities out in the decades to come and the *Economist* focused on those opportunities and highlighted those opportunities.

In some sense, and you can read from that description there, that somehow all of these would just unfold in a wonderful miracle. We won't have any issues of food security by 2050. That's a particular view.

You'll get a different view from me today, but just to add to say that there are ways and we can look and point to evidence. For example, just yesterday in the journal *Nature Communications*, there was a piece that just came out that looked at the issues of how you can make some genetic changes, in this case, to a tobacco plant which would allow the plant to maintain crop yields with 25 percent less water. That's just come out.

It's not a generalization of all plants in the world, but it just gives you the sense that there are changes. There are opportunities out there to have the glass half full or, in this case, three-quarters full I suspect from the *Economist*.

But the issue about risk is not having confidence or not having confidence, it's about being aware of what those potential risks are and managing and hopefully mitigating those risks in an effective way. If the worst comes, then you're well-prepared for it. If the best comes, well, you've at least got your plan and contingencies in your back pocket.

So what are the risks? Well, I won't focus on the demographic and population increases. Not because I don't think they're important. I think they're very important, but that's the medium projections out to 2050; 9.7 billion, a little over 7.4 billion today. I think the highlight, and I'll come back to this, I think the highlight, of course, this is not some average across the world. Of course the most of that increase will take place in Africa.

If we're to start thinking through about security issues, we need to think particularly about Africa because that's where that substantial increase in population is going to take place and, indeed, in some places in the world, it's already happened, the population is then starting to decline. Japan is one country, for example. China's population is soon to peak within the next decade.

Clearly when we look underneath and start to unravel the pictures and stories, the regional perspective, where this is, the place is fundamentally important. That's the one thing I would object to. Maybe more than on in terms of the *Economist* quotation. The lumping together of Lusaka and Los Angeles, very different

places, very different income levels, very different set of institutions. Perhaps not the best way to think about it.

I'm highlighting in italics on current trends because these are the current trends. It doesn't mean that this is necessarily the future. I would highlight, of course, the demographic trend as that's essentially locked in barring some unforeseen major catastrophes, which hopefully we will not face. That's pretty much locked in.

But the other trends, the business as usual trends, they're not locked in. We can do something in the context of trenching these. Just like you take business as usual trends and greenhouse gas emissions, they're not locked into 2050 or 2100. Obviously we can change them and these things can be changed as well.

This is an OECD prediction. It's actually a prediction from 2010. It's saying that we're gonna use at least half the more water by 2050. There's some countries in the world that will actually use less water. A number of countries are actually reaching a point where they might be using less water. So to get that projection globally that means there are going to have to be some very substantial increases in some countries.

Then the issue of energy is there as well. I'm less concerned on the energy side. I do do work on energy. I'm less concerned on energy simply because I think there have been some major technological changes. Certainly reductions in levelized cost of energy. It's particularly on the solar side, but also in other forms of renewable energy. I think they are very positive developments in the context of issues on energy although that doesn't mean that there aren't a whole set of issues, energy and climate change.

This is an alternative, perhaps a glass half-empty situation that tries to think through what are those key drivers. Then let's take that story further and see where this leads us in terms of the sorts of things that we need to think through.

This will be familiar to the people here in this room. This is the 2015 global hunger map. Highlights the places in the world where global hunger is dominant. We know it's from those numbers anyway and it hasn't fundamentally changed, it's around 800 million people. That, by the way, that number hasn't fundamentally changed since the early 1990s. So that's worth highlighting.

Although the proportion of people who are hungry has declined and declined dramatically from I'd say 30 odd percent are now a little over 10 percent, the numbers are still there.

Of course in the last food crisis, that food price crisis, it spiked by about 150 million as food prices went up. So that indicated that there's a volatility behind that.

Of course it highlights in 2015 the issues associated with calorie intake. Africa predominates although there are places, particularly South Asia where there are particular sets of issues as well.

It's also worth highlighting that this just focuses on the calorie issues. There are micro-nutrient issues that are also very important. When we talk about 800 million or so in terms of insufficient calories, you at least a double add in terms of adequate micro-nutrients. So this is a big issue in 2015. Hopefully it won't be. Hopefully the *Economist* will be right. All of this will be solved by 2050, but I think there's a bunch of risks that we need to highlight and then think about how we can respond to those risks.

This comes out of a publication four years ago that was done for the Australian Center for International Agriculture Research. It's quite a substantial tone. It's well worth downloading. You can download it for free as a PDF. It goes through considerable detail looking at the historical performance in terms of yield increases over time. They're not just talking about Australia. It's a global perspective.

There are two vertical axis here. One is the grain yield in tons per hectare and then the right vertical axis looks at the relative rate of yield increases on an annual basis.

If you take the green line, which is referring to the left vertical axis, you can see the story is its variable, of course, but it is going up, which is good news and we can see that in the data going back to the early 1960s, per capital calorie consumption. So there are gain. It's not evenly distributed, but it's gone up somewhere between 25 and 30 percent over that period of time. A large part of that, but not the only reason, there are other factors as well, of course, has been the increase in food availability.

The perhaps not so good news and this is in some sense inherent in using linear percentage increases, but what you're seeing here is the change, the rate of change is declining. So still positive. Still a

good news story in that sense, but the rate of change is less than it was. It's basically leveling out.

Now the reason why I wanna highlight the leveling out, I don't know where it may or may not level out and I gave you this paper that came out of the *Nature Communications* yesterday so there's opportunities there, of course, but they haven't made any difference yet in the context of the rate of increase.

The thing that's worth highlighting that Fisher and his co-authors highlighted, is that if the rate of increase, yield increase, is less than 1.3 percent, so that's taking all the major serials in particular, then we don't have sufficient food after 2050.

The point about this is and I'm not being an alarmist, but the point about it is that we really don't have any room to maneuver anymore. If there are any to be further decreases in terms of the annual increase in yield we could be in serious trouble.

If climate change, for example, was to result in much bigger increases in, I should say in terms of reducing the increases in yields, that could be problematic in this context.

This is not about pressing any panic button. It's just simply highlighting that we are approaching points where without I believe actions, without better decision making, we may be in a better situation where we may regret.

I'm now connect the food story, which is just focused really on the food availability rather than the other aspects of food security and connect it to water. Of course the connection is obvious crops, grass, they require water. Of course the water comes in two principle ways. That's how it's described in some of the literature. The green water and so-called blue water, but what's relevant to ours in the context I think primarily in terms of water security is the blue water.

The blue water is the water that we extract out of streams and rivers, out of aquifers, out of storages. That's the thing that really matters. It matters in the context of irrigated agriculture.

This is the area equipped for irrigation. Sorry for all the curvy things. They represent different regions of the world. There are actually three different series that they put together to do this and basically we're a little over 300 million hectares, which is about 20 percent of the world's crop area is irrigated.

Now when I say irrigated, it doesn't mean they're irrigated in the same way or gets the same amount of water, but that means that they're certainly equipped for irrigation.

You may not be surprised to learn, of course, that as you get this huge increase in irrigated area, you're getting very substantial increases in water extractions associated with the delivery of water to the crops.

The question is where does this go. This is the idea of are we gonna have intensive agriculture or are we gonna increase the yields in the irrigated land that we have or the non-irrigated land or are we going to continue to increase the irrigated land area. That's one of the key questions going forward, which I don't have an answer to, but I think it's one of those key questions.

The issue that I'm gonna highlight here, again, I'm not pressing some panic button here. I'm just presenting. So these are not predictions. They're just simply scenarios. You can play with your own scenarios. This comes out of a global food and water system platform that I developed with my co-authors John Williams and Gung Jong and that's downloadable, free at the Food Environment Water Network, FE2W Network. If you get into the website you'll be able to find the platform and you can generate your own projections.

We developed the platform to be able to work with decision makers. It's freely available. I developed it just on the basis of my own funding.

So what's the point of this? Well, you've got four curves and you've got a time series beginning around 2010 and it takes us out to 2050. Remember the 2050 number I gave you, the 9.7 billion, that's the median projection. Keep in mind that the population projections will be getting higher and higher for 2050. So the expected demographic transition in Africa is not occurring the way some people thought it would occur. That's an issue I think of considerable importance.

So what do we have here. CYI is the yield increase. So that's the yield increase on an annual basis. So remember those numbers I gave you? The 1.3 percent is the minimum according to Fisher at Allen. It's also consistent with our work as well and others. Anything less than 1.3 you're getting into tricky situations.

So we're taking the one percent, which is below the current yield increases. So your current yield increases in the context of wheat is around one percent. I'm not picking some alarmist number here. For maize it's about 1.5 percent. So taking one percent is not some extreme current yield increases.

Then what we've also done is we've looked at different increases in the kilo calories required at a global level. So we've taken FAO projections and we've taken into account the angle basically as people get richer they're gonna spend a greater proportion on food and that will possibly, we think, lead to a higher increase in food demand than perhaps the FAO was suggesting.

But anyway, whether that is the case or not, we've got projections for the FAO in terms of food demand, we've got projections in terms of our current yield increases of .5 and 1 percent. So .5 is definitely on the extreme, but it's there to take that case. Well, what if it were to be much worse than we would project.

So where does this take us? Let's look at these curves. We've got one curve and, remember and I haven't said this yet, but the supply that I'm talking about is for 19 countries. For 19 countries in the world that are also the largest countries in the world, there are all the large countries in there, plus they're the world's largest producers of food.

But the demand that we have here is a global demand. So there's some things that come out of it. You're seeing a decline. Even on the best case scenario, you're seeing a decline in the relative surplus available from those 19 countries. Some dropping from about 16 percent down to 8 percent or something like that.

Then under some scenarios, certainly with the lower crop yield increases, you're even getting these negatives. Then, of course, these scenarios here that I have here with the higher demand increases, you get very substantial negatives. These are the percentage of the surplus deficit.

So again, it's not a panic button, but it simply highlights I think some of these are reasonable scenarios, that the food production that we currently experience in 2018 has to be pushed out of those 19 countries. Out of the United States. Out of Australia. Out of China. Out of India.

Where does it need to go? Well, it has to go to Africa. So Africa's gonna have to do a much better job than it's currently doing to be

able to make up the difference in these deficits. It's Africa that's the issue here in the context of what will happen to Africa.

In other words, we can't expect the 19 countries that currently provide the surplus for pretty much the world surplus of food to necessarily keep on delivering the way that we might like them to out to 2050.

That's a projection on food. Now let's start to think through the issues of water. So I've highlighted this idea of blue water, the extractions from streams, rivers, aquifers and storages. Of course, precipitation, rainfall, how much is available of course determines the nature of the stresses associated with how much we're extracting. It's not just simply determined by a socio-economic or institutional factions. It is also determined by geography.

You can see it with the nature of the mid-latitudes in the context with the Hadley cells. You can see that in the southern latitudes, and this is where I live, in the Mary Darling Basin of Australia. You can see that these are just naturally arid or semi-arid locations. We don't need to tell you about California. It certainly applies to the Sahara and good parts of South Asia and, of course, the Middle East then and up to Northern China.

What did this indicate? This is all about surface runoff and it indicates these high reds and an excessive one means that they're basically depleting the massively aquifers, but these are the sorts of colors that you want to avoid because once you're getting into using more than half, more than half of the surface runoff, you don't have that many degrees of freedom to deal with water. You're approaching your resource availability.

Despite some of the techno stuff out there about chipping the icebergs and all this sort of stuff, water's very expensive to transport so what you've got is what you have pretty much. There are some exceptions into basic transfers, but pretty much that's what you've got. That is problematic.

The other aspect to it, of course again, averages is the poor and vulnerable. So you don't have to travel very far in the places that are poor countries to be able to identify it's the poor and vulnerable are the ones who really get the challenges when it comes to water availability. Indeed right here in Capetown we've got a challenge right now in terms of about to go to D-Day so to speak in terms of not being able to provide water through their standard systems.

Yes, it's a drought, but much, much more than a drought. There's a set of issues there about agriculture use, et cetera.

So let's move on and say, well, that's the human dimension of the water stress and the poor and vulnerable. Very important, but there's the environmental side, too.

Again, there's a large literature out there that stresses that if the environment declines or the ecosystem services provided by the environment, it's typically the poor and vulnerable who get worse off in those contexts.

Everyone might be worse off, but it's the poor and vulnerable who get much worse off because they typically are dependent in a much more dependent way than the rich and wealthy in the context of ecosystem services. So this has implications for biodiversity. There's implications for the recreation, aesthetics, but it has certainly implications as well just as flora and fauna, but also for the poor and vulnerable.

So there again, not too surprising in terms of the locations, but highlighting in 2015 this is an issue already. This is not some issue for 2050. I'm pointing out that this already is a critical issue in these arid and semi-arid locations just right now in 2018.

So something is gonna have to change if we're not gonna get this situation to become even worse. So that's the bottom line really. Those are risks. They're not inevitable outcomes of what will happen, but they're clear and present danger in the context of these risks.

So what do you do? Well, you can walk away or ignore risks. You can imagine they don't exist. Some people like to do that or try to do that, but you can't do that. We can't do that because the consequences of some of these risky events are every dire indeed. The obvious one in the context of starvation. It's an extreme one, but it doesn't have to be starvation. There could be a whole series of other events that we need to most absolutely avoid.

Obviously lots of things. Mitigate. Try to avoid. All those sorts of things that we need to think through. So I'll come back to this, but I just wanna highlight it. I think when we put these things together, these different challenges, I think it's really important to go through it and think, 'Well, what do we do about it?'

It's one thing to raise the issue and I and others are doing that, but what do we do about it. It is simply good enough to publish in a journal and then put it in an envelope or send it as an email to the Minister of Agriculture and say, "Look, we found this. I've highlighted Page 2 for you. Go ahead and do it." Well obviously that's not the approach that we need to take. We need to work with decision makers, stakeholders.

This is just one approach. It's a causal risk approach or a causal systems approach really to think about what are the drivers. I talked through about population, but there's a whole series of drivers you might wanna think about. Then these controls are really the sorts of options that are available to decision makers. When I say decision maker, I don't mean necessarily a minister or president. Farmers are decision makers. They make decisions all the time. How can you influence them in terms of help them in the options available.

These triggers could be anything. Well, it could be a drought, for example. An El Niño event. Then the risk event is, well, you don't have enough water to grow your crops. The consequences, you've got very low income that year or maybe you actually have very low levels of calorie intake and maybe there's childhood stunting. Who knows what those consequences might be.

The mitigants could be well, you could have a food program. That's a mitigant, but you might wanna do something to prevent that actual risk event in the first place.

So the point about this is to simply say, well, let's think these through, let's think about the options and let decision makers go through that. This is a little bit more complicated, but it's the sort of thing that we've been working through and I'll go through more detail towards the end of the presentation.

To go through in a workshop type environment, this is the sorts of things that we would do. So we would start off with a blank causal risk. We would identify what the key issues are. They tell us. It's not like we're going to tell them. Then they work through what they think are the drivers and triggers.

The important part of this process is not just simply the understanding and it's a collective understanding because people will come in with different perspectives. The point about this is

these Cs. The Cs stand for control, which are actions. Do something. What are you going to do about it.

Then these Ms, which are also actions, but they're mitigants so they're after the fact, what are you gonna do about it. Then of course it's a prioritization exercise. What do you do, when do you do and how much do you allocate in terms of time and effort. That's obviously for the decisions makers to make and to do.

Now we've applied this at a mezzo scale. Now whether that would work at a national scale is a question mark or whether it would work effectively at a totally micro-scale, that's another question mark, but certainly we've applied it at a mezzo scale.

A mezzo scale. What are we talking about. We're talking about a province basically. A regional area of a country. So that's a mezzo basin type scale that we're talking about.

I'll come back to this and the sorts of the nature of what we're gonna think through, but it's a step forward I think to the standard approaches that are used in decision making. In fact, I have to say this that in many places in the world they don't even think about this. Water and agriculture, causal risk, they won't even think about it. So in those contexts it's definitely a step in the right direction if you haven't even thought about those risks. Of course you should and must think about them, especially in those arid and semi-arid areas.

I'm gonna go and do a pet peeve that I have about this water and agriculture/food security/water security. If you wanna push back you can push back at question time, but there's a view out there and it's not a view just in Australia in can tell you. It's a global phenomenon and it's a view at the United Nations as well that you can fix this problem of water and agriculture by increasing what they call water use efficiency or productivity.

It's the fix. It's already listened in sustainable development goals, 6. I think it's 6.4. It's in the UN high level panel of water. I'm not making it up. It's already there. There are genuinely people who wanna make a difference, but they think that that's the solution.

I'm gonna go through with you and I'm gonna suggest to you that yes, it might help, but there are a bunch of other things we're gonna have to think through. So I'm focusing on a particular action or series of actions. In this case it's about increasing water use efficiency. I'm gonna go through with you and explain why there

are real problems with this. I'm highlighting it simply because it is one of the policy directions that we're going in right now globally. Let's think about it very carefully.

We could spend a lot of time thinking about the various misallocations of water. Obviously the focus can be in the context of rural, but also urban and rural. All sorts of different sets of issues exist in terms of how water can be used and misused and how we can improve it, but I just wanna go and jump to this particular slide to give you a sense of what I'm talking about in terms of this policy action.

So what do I mean by water use efficiency. It's simply a ratio, which is the kilograms or tons or pounds or whatever you want, some weight measure associated with the production associated with irrigation over the volume of water that's delivered primarily. That's how it's defined. To the fields. So it's a kilograms per mega liters, for example.

The idea is you can get more crop per drop. That's the term that's frequency used. More crop per drop. Well, you can't get more crop per drop. You get more drop and more crop because there's essentially a linear relationship between how much water's being used in terms of transpiration by the crop, by plants and the yield.

In other words, you can't get something for nothing. Notwithstanding that paper that came out in *Nature Communications* yesterday, which if it comes through is a fundamental shift in the technology, but you can't get more crop per drop. You get more drop and you get more crop.

I estimate some 19 countries. So it's a bottom up estimate; not a top down estimate. You can see what you actually see in this global context for the 19 countries we have, you can see that there's a leveling off here in terms of the relationship. These curves represent a relationship between as you increase the amount of water that's being applied, you're going to increase the amount of kilo calories that are available, but at some point or other it's going to level off.

You're not getting more crop per drop. You're using more drop and you're getting more crop. At some point or other it levels off. Interestingly enough it levels off now globally at about this level.

What this is saying is that if we're gonna get more crop, the only way we're going to get more crop with water is if we actually

increase the area of land in irrigation. I'm not saying we should do that. I'm just saying that's pretty much the only way we're gonna get it. It's, therefore, yet another risk or headline that we need to be very cognizant about.

It also highlights, in this case, it's about 35, 38, 36 percent for the 19 countries we studied. Irrigated crops account for about 35 to 40 percent of the calories that are actually produced. So very important. You take away irrigation, we don't have enough ability to feed the world. There's no question about that. So irrigation is really important.

Then the other thing I wanna highlight and you'll be familiar with the statistic, but globally farming and it's irrigation that does this, takes about 70 percent of the world's freshwater extractions. So it extracts 70 percent of the world's freshwater is extracted for irrigated agriculture.

And the level of water consumption, which is different than the level of extractions, is considerably higher than 70 percent. Why? Because plants have transpiration and, of course, that uses up the water that's available and goes in as water vapor. In other words, we're not gonna get a solution or set of effective decisions to the risks that we face unless we can deal with irrigated agriculture in an effective way. That's what I'm highlighting.

Sorry for going through some water and I'll go through water balance in the context of a basin. I'll quickly go through it, but I just wanna highlight the thinking.

This is from a farmer's perspective the only thing that really matters. It's the beneficial transpiration, possibly a leach infraction to deal with salinity, for example, from the farm crops. That's what the farmer thinks about at a farm scale. That's what matters to the farmer. How much can I get out of the water that's delivered to my field, for example.

But there's a whole bunch of other stuff that really does matter. Not just to the farmer down the road, but to everybody. This is the issue of non-beneficial transpiration. That's by the weeds, the crops that we don't need. Then there's this non-consumed water. This is water that's consumed one and two, but the non-consumed water, that's water that doesn't end up as water vapor. It stays in that system, in that basin. It includes return flows to aquifers. It includes return flows to surface water systems. It may also include flows to non-recoverable sinks.

The reds here are the sorts of things that we probably don't really care about. Neither the farmer does or perhaps we don't care about because we can't make use of it in an environmental context or in other ways. Although I will highlight that evaporation does have impacts down the road and in other locations.

The things in green are what we should care about. The problem with the focus on water use efficiency is it typically ignores the green bits. That can be enormously important.

Let me give you a picture that tries to highlight and hopefully you can see it at the back, but it tries to put this all together. In a water balance context you'd have precipitation. So that's an inflow into the system. You can have inter basin transfer. If it's coming in, that's an inflow into the system. Then you're gonna have evaporation. You're gonna have crop transpiration. That's an outflow in the system.

Then you get the surface runoff, which I'm talking about, that goes back into the streams and rivers. You may get the non-recoverables, as well as the recoverable water that goes into groundwater. All of this matters. If we only consider what's going on on the farm, not considering the surface runoff or the recharge to aquifers, we're gonna miss a serious, important aspect of what happens in the context of water.

Typically, I have to say this typically the focus is very much on the farm level. They're not thinking about the bigger picture. If we don't think about the bigger picture, we're gonna have all those risks potentially come to fruition.

These are just definitions about water losses and water savings. The important thing to keep in mind is the water savings represent those things that I highlighted in red that are sorts of things that we don't really care so much about. The things that we do care about are the things I had in green. Those recoverable return flows.

If you think about it, when you make a change to irrigation efficiency, as you increase the amount of beneficial water consumption, other things change as well. The other things that change as well, the changes to water savings and the changes to these recoverable return flows. We ignore them at our peril.

So give you an understanding of why this is so important. Let me show you a curve that came up with just last week in fact. What

does this do. It has on the vertical access water availability. So that's this thing that we should care about if we're in arid and semi-arid areas. In areas where there's lots of water, maybe we don't wanna care too much about it, but we certainly have to care about it in semi and arid areas.

Then on the horizontal access we've got this ratio, water savings to water losses. Now remember, there's water savings or the stuff that we don't really care about. So the bigger that proportion is of our overall water losses as we increase irrigation efficiency, the less it's gonna be a problem for us.

But let's look where most of the world is. I've got three scenarios here, but most of the world, sadly, is in this world right here. What happens is that governments wanting to increase water use efficiency apply subsidies. There's multiples of billions of dollars spent every year to increase water use efficiency, but typically what happens is that the extractions either remain the same or increase.

If that's the case, it's just hydrology 101. Water availability must decline. You're getting less water that is available in that basin and in that catchment. Yet that very policy to increase water use efficiency, one of the claims is that it will increase water availability. Well, it doesn't. It doesn't do that.

The only way it can increase water availability is if you're in this world where you account for all those water losses in terms of the change in your extractions. So in other words, you reduce your extractions, your diversions and the same amount as what's happened to your water losses. If your water losses go down, you reduce your extractions by the same amount. Then you're in a happier state of world and you can even get increases in water availability, but that's not the world that we live in. That's not the real world.

The real world is right over here. The world that I live in in the Mary Darling Basin is this world here where a fraction of the water losses are accounted for and reduced extractions. Indeed in the Mary Darling Basin, based on the parameters that I have, indicates that the change associated with those subsidies, that \$4 billion to increase water use efficiency, have led to – we don't know the number 'cause we haven't measured the return flows and neither has the Australian government, between -140 gigaliters, that's minus 140 million cubic meters and zero.

So a policy that's claimed to increase water availability probably hasn't done so at all in Australia and for most parts of the world, it's quite the opposite. It actually reduces water availability.

So the bottom line is here is a policy that's out there, people are supporting and lots of money being spent on it, but it's actually sending us backwards in terms of dealing with water availability and the water scarcity issues that we're facing.

I won't go through these definitions. They'll be available on the slide. The key thing I think is what do you do about it. Do we just say well, let's forget about increasing irrigation efficiency? Well no, I don't think we can. I've highlighted those crop yield increases that they have been declining. I've highlighted the potential scenarios with the increase in food demand.

We've gotta do something. We can't just ignore this. We have to do it in a way that mitigates and controls for those risks. So just have a water balance. Do the water accounting as you go in and make those changes in the irrigation systems. Measure what's going on. Then you have offsets in the context of what are you ever doing in the context of changes in terms of those recoverable return flows. Look at the impact and change the diversions.

Think about the winners and losers. Not everybody's a winner in these situations. So who loses considered compensation. Then this is what happens in the United States. So it's net diversions. So US tends to beat up on itself, but it's one of the few places in the world which actually considers net diversions. It takes into account the return flows. We don't do that in Australia. WE don't do that at all.

Then here's this issue: transparent decision making. It may come as no surprise to you . Why do you get decisions that involve billions of dollars in subsidies for certain groups. Well, there's rent seeking. At least make the decision making transparent. We can't solve all rent seeking. It'll be with us forever I imagine, but at least make decision making transparent. To make it transparent, of course, we need to have measures and stuff.

Let me come to an end now in terms of the third and last part of the presentation. First part was to highlight these risks. They're very real risks as far as I'm concerned, but they don't necessarily mean they have to happen. I've highlighted that there are processes and I think that can help in terms of getting better decisions.

Then I've highlighted a policy action that's currently in play at a global scale. Not just in Australia. It's a global scale type intervention in fact built into the sustainable development goals. It's built in there. It's hardwired in there. That's a policy action, which some people claim will actually deal with the water security issue. I showed you. I showed you those three curves, doesn't actually do that unless they're offsetting actions.

That already tells you, I think, that we're in trouble. I think we're in serious trouble because in 2018 we're doing a bunch of policy and spending a bunch of money and a lot of resources that's actually taking us in the wrong direction. It's all fixable, but we better get our act together because the OECD has some horrendous numbers by 2035, starting in 2010 from its projections in terms of what the implications are in terms of number of people who are living in insecure water stressed locations by 2035. It's close to 4 billion people.

There's a whole series of things that have to be done. It's all doable. It's all fixable, but we've gotta put our lenses on and start seeing the way the world is and actually doing something about it.

One place that I think it has its own limitations, but one think that I think has been a positive development, at least in the context of thinking about the issues of water security, is now this definition that comes from the United Nations from 2013.

It builds on the work that was done on the Dublin Principles and the Integrated Resource Management and it does incorporate the issues of risk. It really does have risk and resilience incorporated. This is the definition. It's the key aspects of it. It incorporates the economic development side to it, the well-being and it does, I'm glad to say, incorporate the ecosystem side, which is really important.

So if we don't have water security and it's quite a long definition, that's why I haven't got it here, it's basically an entire paragraph definition, but it means that there is a base, there's a foundation to work from in terms of understanding what's important. We can use that I think to take us forward.

I've done some work with a couple colleagues and it just came out. It was done for the World Bank. What we highlighted was the issues of water misallocation and not just in the context of agriculture, but generally. We suggested a three-step approach. I'm not trying to sell you a three-step approach or whatever. I'm just

simply saying that the current approach, the current decision making I believe is grossly inadequate in the water dimensions and that would connect to food as well.

So we're suggesting that things that can be done, they probably should be done, but it doesn't have to be this. It can be something different or some modification, but the obvious place to start, of course, is the sorts of ways we think about better decision making. You need to scope what's going on. You need to understand what's going on.

Then this is the key part to it I believe. It's the risk assessment and options. Go through those risks. Think about the options with the stakeholders, with the decision makers. Have them come up with what they think is the appropriate series of actions based on information, of course, and evidence and then go into the issue of implementation and of course adaptation 'cause many things we don't know, we won't know and we'll learn it as we go along.

It's a fairly obvious type of approach. The scoping has a whole bunch of aspects to it. We highlighted the issue of what we call JADE or Just an Allocative and Dynamically Efficient Water Allocation, highlighting the issues of both equity and efficiency in the water allocation and the temporal dimension as well.

Then the sorts of things in scoping. Risks and options. I just wanna go through a schematic with you for the risks and options because the network that I'm part of, the Food Energy Environment Network, FE2W network, which I told you about has the global food and water system platform that's freely usable and you can use it on your phone in fact. You can just go in there and get some results just on your phone. You don't have to download the program. You can use it directly.

This is a process that we actually applied at a mezzo scale, a Risk and Options Assessment for Decision Making, in the Central Highlands of Vietnam. We did that in 2016 and 2017. The work is now complete. They faced a whole series of issues with the last El Niño events.

When you think of Vietnam you think of a country that has lots of water. That's a very big river, the Mekong, of course, but there are a series of water security issues associated in Vietnam, particularly in that period of time. So we went in there to assist a particular province about how to think that through. We didn't go in there.

I had particular views about the sorts of things that could perhaps should be done. I'd worked a lot on water pricing, but I didn't go in there and say, "Well, you need to do this or you need to do that." We went through it with them in a process that they worked through. This just highlights the things that you would do; the scoping, the causal risk models.

Those causal risk models that we worked with is butcher paper sort of stuff on a board. You've got the drivers, the threats, the risks and the consequences and they work out what they think are the big threats and risks. Then you think through the controls, the options, the actions and you work that through and then they make a prioritization in terms of what they think's most important.

It's an exercise. You then do the evidence to back up well, what do these options actually mean as we start to study it in more detail. You take that back to them and give them the evidence. Then they go through and then hopefully make a better decision. There's no guarantee they'll make better decisions. The process doesn't guarantee a better decision, but it allows the decision makers the opportunity to make better decisions.

Then, of course, there's an evaluation process that's gonna have to be built into any of these sorts of things. So whatever the policy actions that we do in the context of the food and water nexus, we've gotta build in the evaluation. Is it working or it isn't working. What's the evidence. How can we change it. How can we make it better.

I'm gonna conclude my last slide is that just think through the next steps. As I said, I don't have all the answers. I have some suggestions.

First one, of course, is that the risks are real. They are absolutely real and that we need to manage those risks much more effectively than we are. I totally believe that. I'm totally convinced of that.

How we manage those risks. Well, we can pick different approaches in different places, of course, but I've suggested one approach.

What I wanna highlight is that there is no necessarily one pathway here. In the context of Australia we developed water markets and I think we've done a good job at developing water markets in Australia and they've been very effective for us dealing with water scarcity in our droughts. Actually very effective. The savings

associated with water markets, we're in the billions of dollars. There are very substantial benefits from the water markets.

Allowing water to trade from lower to higher value use has been very, very beneficial. So the person selling the water right benefits, they get a return for the sale and the person buying the water right gets to produce the crop and also gets a payoff. As long as the market's competitive and has all the other good, natural things that you'd want, it can deliver.

That's one pathway we've applied in Australia. I would not in any way suggest that because it's worked in Australia, water markets, that we go to – I'm not gonna mention any particular country 'cause it might be viewed that I'm being derogatory to that country, but think of a country that you might wanna think of where it doesn't have the institutional frameworks that we have in Australia, doesn't have the levels of income and all that stuff, think of that country and then think, well, could you drop in water markets right there. You'll probably get the answer you have in mind.

You have to take different pathways. I wasn't referring to Vietnam, but Vietnam is not gonna be doing water markets anytime soon, but they may do other things.

So the point about it is it's trivial in some sense. Different countries, different locations will have different levels of capacity. That's the bull. The clove represents the capacity. Of course, there are multiple pathways that lead to better, improved or better outcomes in terms of water here, but that's food and water.

It's really up to us as researchers. It's up to us as people who care about where the world is going to work with the people, stakeholders and all the people who actually are gonna be affected in the world. Not just here in the United States, but in other places in the world and help them to make those decisions that they need to make so that they can face those risks in a way that will deliver much better outcomes than if they didn't.

I will close at that point and look forward to some questions. Thank you.

[Applause]

Roz Naylor:

Thanks very much. As moderator I get to ask a question.

Quentin Grafton: Of course.

Roz Naylor: This was a really interesting talk. As I'm looking at this, I think water is power is money, right. Especially with the scenario that you just set out. There's nothing really more valuable to us than water in some sense.

In California certainly we've had a lot of water politics here. Your story of Australia I think is very interesting because the public sees water use efficiency and things, but there's no real transparency on water recovery and what's actually happening with water availability.

Are there ways using technology that we can get better transparency, either through remote sensing imagery of what's happening to the landscape or different sorts of social media? Have you explored in Australia and should we be thinking globally of ways we can make this more transparent?

In California I think about the California Water Authority as being the most powerful people. Can we call them on things?

Quentin Grafton: I think it's a very good question. I would highlight that I spoke to David Lobell this morning. David's not here I don't think, but he was telling me work he did a dozen years ago looking at spatial imagery and working with a student to look at some estimates of what's happening to water.

Shockingly the Australian government has spent \$4 billion in subsidies on infrastructure to increase water use efficiency, but has not measured the impact on these recoverable returns.

So what would have been the cost to do that? Well, trivial compared to the \$4 billion, but all is not lost because there is satellite imagery. We can go back many years, in fact. We can get some estimates. I don't have the qualifications to do that, but there are people who do that.

So we could. At a basic scale we could be able to get some rough and ready estimates. In fact, I'm contemplating spending my own money to get some rough and ready numbers. Not at a basin scale in a particular locations would cost a few thousand dollars, but the Mary Darling Basin Authority charged for doing this hasn't done it. Maybe someone should do it and then show that this can be done. I wouldn't do it. Then feed it into the transparency that we need.

I think one thing I would highlight, again, I feel like I'm stating things that are really obvious, but in the context of the Mary Darling Basin, I've been working on it for a long time now. First thing you do as a researcher is you do research and you publish it and you can get evidence that's useful.

Then the next step is then you go and engage and say, "Well, I found something useful." You don't just send them the – I was being facetious. You don't send them the PDF and highlight it for the minister. You go and meet the minister or minister's advisors, and I've done that. Then you explain the issues for them.

Most ministers are smart. They get it. You explain it to them. Then you hope you get some outcome. Not always. In fact, in this case, no. Then you engage in other ways. We have senate inquiries. We have parliamentary inquiries. We have commissions. These sorts of things have happened. You make submissions to these things and it's publicly available what you've submitted. It feeds in, you would hope, into the processes to get good outcomes.

Well, you can reports that come out by Parliament, parliamentary inquiries. No one pays attention to them. So things are said in these reports from the senate and from the parliament and as far as I can see, no attention has been paid.

Then you engage with public service. You spend a lot of time, many, many endless hours with public servants to make sure that they get it. Then they help hopefully bring about – and I've done all of that and none of it has really made a scrap of difference.

What I and 11 others did 5th of February, so it was just last month, we said, "That's it. We're gonna make a declaration." Tell the people of Australia what we think is going on. We have a website, media and all that stuff so people know what's going on.

Ya' know what? It's already having an impact because already there's discussions now about the sorts of things that we talked about. There's nothing controversial about what we're saying. We're simply saying audit. Audit what's going on, but you can see why some people don't want an audit. If you spent \$4 billion and it looks like you've got nothing for it, the people who made those decisions don't wanna have an audit.

That's problematic, but the fact is you've gotta get the people involved. The people have to be engaged and say, "Well hang on.

That was my money. That's taxpayers' dollars. Why can't we get an audit?"

So that's the longwinded way of responding to you that yes, it's the evidence, yes, it's possible to do a bunch of stuff, but I think you gotta do the next step. If no one's listening to you who make these decisions, then where else do you go. You try and let the people know about it. So far we've seemed to have had an impact. Whether it ultimately makes a difference, we don't know.

Roz Naylor:

I'm gonna ask you one more really obvious question and then turn it over. The decisions makers include the farmers and they can do on efficiency is grow crops themselves that are less water intensive. So they're lowering the extraction. Then you would have greater recovery but they also have the water rights and they don't wanna lose their rights to this water.

So is there any way for farmers themselves to go towards a more water efficient crop approach without having water markets? Without them being able to actually receive an economic benefit with their rights? So do you have to have water markets to actually have that go on?

Quentin Grafton:

No, I don't think you have to have water markets to have farmers respond to incentives. It doesn't have to be markets. It can have prices, but there are other ways to engage with farmers as well in terms of a range of things about different practices, for example, but you can build in incentive mechanisms where – there's hundreds of water trusts in the world where you go in and people are compensated in terms of reducing their water diversions or whatever so others downstream can have that water. Obviously there's monitoring. Otherwise you're not gonna pay something for nothing, but those things exist in all sorts of places now.

I think there's a lot of different things that can be done. In the context of the Mary Darling Basin, because we have water markets, what it means is that when we have a drought, water prices go – well, they go sky high. So prices can go from low of \$5.00 to \$10.00 per million liters non-drought upwards of \$2,000.00, \$1,5000.00 high, dollars. This is a huge increase.

So when you get to those high prices there's a whole bunch of farming that just shuts down. So cotton farming is not very economic at \$1,000.00 or even \$500.00 a million liters. It's just not economic. It uses a lot of water. You can only basically grow

cotton and make a profit in Australia when there's substantial amounts of water and water prices are relatively low.

So it's a built-in mechanism. Drought, higher prices, they don't grow cotton. It just doesn't make – what do they do? Well, they've got water rights so they sell their water rights to culturists, horticulturists or whatever. They're not making as much as they would in a good year with cotton, but they're still making money because their operation's essentially shut down and they get the payoff from the selling of the water right. It's a built-in mechanism of the water markets.

Question:

Thank you very much, Quentin. I buy all your analysis on the macro level. I think the data are strong. My question is we just have a huge problem when we try to go to impact, as you discussed some frustration. It seems to be a core problem. You gave a case in saying I got everybody in Vietnam who was in this water shed to sit together and we worked on it, but water sheds do not map well on political borders.

I lived for five years in Pakistan. I'm really worried that everything is coming down from the Indus River out of India where there is enormous let's just say political tension.

So the idea of resolving this, you said this huge transboundary shifts in water, it's just hard for me to see how these kind of collaborative, let's get together and talk it through approaches, and solve these.

Quentin Grafton:

Well, I share your concerns. Some people have held up the Nile in terms of the Nile Treaty as a good example and it has been talked about taking that to the Indus.

Look, I'm not a lawyer. I care about governance, but I'm not on the legal side. Look, I think it's a big issue, but I don't know what else you can do than go through and do let's say in the context of a national scale, you're talking at a ministerial level 'cause that's the level that we're talking about here.

I would say the way I would do that is I would do a foresighting exercise with them. You would go through and foresight in the sense that, "Well, if you choose to do X, then here's what potentially might happen and you're a loser as well."

You try and I think craft some way of them engaging with the risks and the consequences and get them to think through what they may

do. It may be impossible in that the political constraints may be so much, so tight and so difficult that nothing will happen, but you still need to try and the foresighting I think would be one approach. Otherwise you just give up, which you're not suggesting that. I think that's what I would say.

The other thing I would say, it takes time. Good policy, which is constrained by a whole bunch of different things, takes time. It's not something that just happens overnight. Typically good policy takes years. It starts as the genesis of someone's bright idea and then well actually, then it goes to this and then this and that and boom, boom, boom. That pathway will take you at some point or other to better policy decision making and some good outcomes.

I think you can't give up. Particularly on the Indus or even on the other side of South Asia with Gangha. The risks are too big. The consequences of not managing that effectively are just enormous so you've gotta get involved.

The US has been involved in this. I know Australia has been involved in terms of supporting regional dialogues in South Asia. A long way to go, but at least it's happening. At least it's started and at least there's engagement. From Australia and the US, not just Australia and the US, but Australia and US perspective, we collectively think it's important, even though we're not Indians and we're not Pakistani's and we're not Bangladeshi.

I'm hopeful, but no surety of success.

Question:

So has there been any impact on the water market and prices of Australia? If there has are there any government interventions in the states that could happen and what are some of the actions that the Australian government is taking on?

Quentin Grafton:

So just to be clear. What the water markets are doing are transferring water from lower to higher value uses. So that changes the nature of the crops that are produced and that will have price impacts. No question about it.

But the question really is something about water markets that's deleterious to the working of the price mechanisms. Not at all. I think it makes it transparent what the value of the water is in the context of in use and I think that's been very helpful.

So I gave the case of cotton. If we didn't have water markets, so most of the cotton produced in the Mary Darling Basin is in the

northern part of the basin. That's also the most severely affected part of the basin in terms of environmental issues.

So if we didn't have water markets, these people would have a license to water. They'd grab whatever water they could in a drought. Whatever was allowed to be grabbed, they would grab it and guess what they would do? They'd grow cotton.

So because we've had water markets they haven't grown cotton during the drought. We've grown other things. So to what extent that has on the price of cotton, well, we're a very tiny producer of cotton globally so really no impact.

In the context of food prices, wheat. Australia is a significant exporter of wheat. Australia can influence the wheat price. There's not many other things that we can influence in the world price. So then you'd have to ask the question to what extent water markets have influenced the world wheat price. I haven't done that work.

But to me I think the issue is our water markets supporting the better outcomes. It's certainly generating better outcomes for farmers. On the long term, that's good I think in terms of food supply. Although there may well be anomalies along the way.

Question: I came from UCLA, Claire.

Quentin Grafton: Thank you.

Question: I'd like you to comment more specifically about Africa if you don't mind. We started with Africa really being the crisis in terms of the coming food shortages.

At the same time we're seeing all this investment, agricultural investment in Africa, China, India and Brazil. There's a real effort to empower the small farmer in Africa and provide irrigation and fertilizer and feed, but how is this being discussed and negotiated with these large agricultural enterprises that are funded by other countries? What's happening in Africa around water?

Quentin Grafton: I'm not trying to cop out on that. I can answer that, but I think there's probably people in this audience who are better able and qualified to answer that. So if anyone wants to stick their hand up who feels –

Question: Well, you kind of implied that Africa would not become self-sustaining by 2050, but I think a lot of people are very hopeful that it will. So there are a lot of scenarios obviously.

Ertharin Cousin: Hi. I'm Ertharin Cousin and this is part of the work that I'm doing here in Stanford right now.

Question: I've heard your talk.

Ertharin Cousin: Oh, okay. The reality of it is that one of those things that's missing from the Africa experience right now is a database of all the different parts. There are lots of activity going on right now, both on the traditional large cement projects related to water usage, as well as more work around small farmer irrigation, which many of us believe is going to be a big part of increasing agriculture outputs by 2050.

I don't wanna take your show at all –

Quentin Grafton: Not at all –

Ertharin Cousin: But I'm happy to talk to you about this at any time.

Quentin Grafton: That is say pretty much what I would say is there are good things are happening. There are real opportunities, but where they will take us by 2050, I don't know. We just don't know.

I think the fact that the foundation Bill and Melinda Gates and others have made substantial investments in is a good thing. They recognize there is an issue and that's really positive.

The issue about land that's leased essentially by state corporations in certain countries, that's relatively small amounts of land area, but not insignificant in some countries. The question I would raise there is who's getting the money 'cause they're not doing it for free. Someone's getting paid.

If you're a land rich country and someone comes to you and says, "Look, I wanna use some of your land and I'm gonna pay you a bunch of money to do that." And you take the money and then you use that money to invest in your people, well, that doesn't seem to me like necessarily bad transaction, but if you get the money or you get the money and you don't give it to anyone else and you just look after yourself, then that's a bad transaction because then you've removed out of the land area. There are clearly gonna be

losers. Pretty much go to anywhere in Africa, you find people cultivating some or pasture.

The only exceptions would be the national parks or possibly a few places in the Congo. They're everywhere. It's not like there's great swaths of land that no one's in. It's not true. So there's clearly people who are losers when that happens. Have they been compensated. What are the gains to the economy. That I think is the more fundamental question. I'm not opposed to it per se, but to what extent are the people benefitting and the people who've lost out, have they been compensated properly. I haven't done research on that so I can't answer that, but you'd have to be concerned.

Roz Naylor: _____ and then Wally and then we will . . .

Question: How much worse does the picture get when you put in the non-farm uses of water that increase in 2.3 billion people? Most of them are gonna go to cities where they're gonna engage in productivity and they're gonna have activities that require water. Where the economic return on the water's gonna be higher. How do the water markets picture get complicated and will food production win or lose?

Quentin Grafton: Look, that's a really good question. We did some scenario modeling in the context of India. Once you put in industrial demand, the situation gets very serious. A country like that is in serious trouble when it comes to water.

It uses now, in terms of the total resources available, it's about 55, maybe 60 percent. With the projections that you've got in terms of population increase and made in India and industrialization, which is great, increasing per capita income worldwide. So it's got huge increases in water use. It doesn't basically add up. It's a major problem that the Indians are gonna have to deal with and deal with it sooner rather than later.

So yeah, I think it's a real problem, but that is the outlier. I think India is an outlier. I think in other countries with the use to resource ratio at much, much less. You take China, it's around 30 percent, which is still easily high. I think the US is around 15 percent or something.

In China, I have options I think in China that perhaps India doesn't have. Of course they've done a lot of massive engineering to transfer a whole bunch of water to different places in China.

In terms of water markets, yeah, this is a critical issue. It's fundamental to what I've been talking about. If there's a higher value use, let's say it's industrial use or let's say household use in an urban center and it always is gonna be pretty much more variable than agriculture pretty much. There may be some exceptions.

Then you've got a potential win-win in the context that if you do the appropriate compensation, you can still make the people who have the water now no worse off and that could make them better off and still make the people who are in the urban centers better off in the sense that they've got an increased supply.

The critical factor as you've highlighted is the issue of food. There again, I get back to the key countries. So if you're a small country and you reduce your food production, you specialize in industry and whatever services, and you have higher income, you just important the food. That's a Singapore model. Great for the people in Singapore; have no issues pretty much in food security. As long as the supply trade routes are there, they're doing just fine. Thank you very much.

They don't affect the world either, but for a large country, a country like India. Is it 1.25 billion now or China. When they start to have changes in terms of their food production it really, really matters. It really, really does matter because who is going to make the difference up. If you start talking about the population of Singapore with its residence is maybe 5 or 6 million, but if you start talking about this in India's context, you'll have – I don't know – maybe hundreds of millions. Where is this gonna come from.

I showed you one of those scenarios. I know that's a projection, but they were all serious issues. Where's this gonna come from. Is it intensive agriculture. So if that means more inputs and one of the key inputs is water. That means water's gonna have to be used more someplace else in the world to feed more Indians if India's not gonna produce its food.

Or it's gonna be expensive agriculture. Not either or. There could be both. That means more land and crop production and, in particular, more irrigated land in crop production. That has a whole series of potential consequences. Not saying that we shouldn't do it, but I'm just saying there are a whole series of consequences that come from that.

Yeah, I think you've highlighted these big tradeoffs and how to manage them at a global scale. We don't typically think about them at a global scale. Hardly at all.

Roz Naylor: _____ and then _____.

Question: You have a shortage of microphones as well as water.

Quentin Grafton: I'm gonna get some water right now actually.

Question: Given the importance of water, which brings us all together, do you have an explanation why so many of the key institutions of the world, like the World Bank, like the Regional Development Banks, like many governments, like an awfully lot of universities, at least in this country, have gone away from more global looks at that? It's really quite shocking I think as you look around at these institutions now versus 25 years ago. We're losing ground. We're not making ground in our thinking and our analytical capacity in the water area.

Quentin Grafton: Well, John, I'm probably more optimistic or probably more optimistic than you are in the sense that if I look at the modeling and the research that's being done that's on a global perspective, I see a lot of good work that's come out certainly in the last five years, the last five to ten years at a global scale. So I think that's a really good thing.

In terms of the particular organizations and the World Bank, they've got this new global practice. Water is one of them. I know some of the people there. They've got really good people there. A lot of good people there, but I won't mention some other organizations where you really do have a lack of capacity. If I think of my own country, Australia, it has got worse. There are fewer hydrogeologists and hydrologists working on the basin issues than there were 20 years ago. That doesn't make a lot of sense to me, but that's the nature of what's happening. Fewer people have been trained. That's a problem.

It's not just an Australian problem. South Africa's got a massive problem in the context of expertise. Quite a lot of people have left South Africa and some of them actually come to Australia, but a lot of that capacity's been eroded over time. So yeah, in key places, quite a number of places have gone backwards. Some places, some foundations I can think of, water's no longer a priority. It's whatever it is.

I'm not saying that it should be the only priority, but I can't see how we can deliver on the sustainable development goals unless we deliver on water in a meaningful way. To me it's impossible to think of it. So someone or other, somebody's gotta be thinking about it and investing in it.

So yeah, much, much more should be done, but I suppose if you go to any – whatever the theme is, everyone will say, "Well, we need more money. We need more money for research and we need capacity." Everyone says that. So it's trying to separate how do you prioritize where water fits visa vie a range of other things that people have to think through and prioritize and invest in.

But from my perspective and what we talked about today, I think it's a pretty convincing case that if you don't think about water and at least incorporate it into what you're doing, then we're gonna be in very, very serious trouble. We're certainly not gonna end poverty and no hunger without dealing with the water issues. That ain't gonna happen.

Roz Naylor: I don't wanna hold you from the reception, but do you have a quick question, Michelle, or would you like to talk to him at the reception?

Michelle: We can go to the reception.

Roz Naylor: Okay. Because we have a really nice reception here. This has been great conversation so I suspect a lot of people will wanna ask you more questions. Quentin, I just wanted to thank you for a great presentation –

Quentin Grafton: Aw, thank you. Thank.

Roz Naylor: And really good discussion and thanks to all of you as well.

[Applause]

Quentin Grafton: Thank you \so much. Thanks for the opportunity.

[End of Audio]