

**CONVERSATION: THE GREENING OF AGRICULTURE AND SUSTAINABLE SOLUTIONS FOR TOMORROW**

October 14, 2011 - 9:30 a.m.

Margaret Catley-Carlson- Chair, World Economic Forum Advisory Council on Water

Good morning. Thank you all for being here. I thought you might sort of feel, okay, that was the great moment of my life, I can walk out and go to lunch. So thank you, thank you for still being here.

What an amazing man – you can see why he won his two elections, but you can also see the fervor that he brought to both reanalyzing things and solving issues. So in a way, at probably less decibels and a little less excitement, we're going to do exactly the same thing in this panel, which is to recharacterize some of the issues that are being faced in food production, in agriculture, and to find the solution elements in them.

We're all going to open our own water bottles, though, and we think we can actually make this happen. So we're very glad to be here. Thank you for that nice introduction. I was the founding chair of the World Economic Forum Global Agenda Council, but I am no longer that, so just to correct the issues.

The title of this panel is the Greening of Agriculture, and we've got some very good people who have thought hard about these aspects – because we are absolutely in a paradox.

We're now feeding seven billion people from a level of about 2.5 billion at the midpoint of the last century. We're feeding them better; there's much higher protein use. But we're doing so with an agriculture which is contributing more than its fair share, more than a big share, of greenhouse gas emissions, major user of energy - 70 percent of the water that human beings extract.

And agriculture gives back water in a difficult situation. People assume that smokestacks and industries are the major polluters of water. It isn't. It's agriculture runoff around the world. And those same amazing substances that give our plants better life, give us better food, and also have helped restore the soil, are doing dreadful things to water in far too many parts of the world.

So there's a paradox there. Both of those are happening at the same time. In water, as I say, nitrogen, phosphorous, blue-green algae, all of those problems.

Soil is the base of the pyramid, the absolutely essential ingredient for everything else that goes on. But yet the words we hear in this group, in these sessions, are mining the soil, denitrifying the soil, deadening the soil. We hear about dead areas of both the oceans, but we also hear about dead areas of soil.

We need to know not just what can be done to bring it back but how far can this problem go. And how can zero-till and other factors start bringing this back?

A century ago there wasn't enough food to go around. Now we're talking about waste as much as 30 percent -30 percent in the global South, usually from the farmer's field to the point to the sale, 30 percent in the global North from the point of purchase to the point of being thrown out. Waste - if we had that same water that is represented by the waste, there would be no water shortage for agriculture; obviously, there'd be a distribution in geographic part.

But here are the paradoxes. We're doing awfully well, but we're not running quite as fast to clean up some of the problem areas that doing awfully well makes. Nowhere is this worse than in biodiversity, because modern farming has been the single largest problem area creating the loss of species, loss of systems.

Luckily, we have some marvelous people to talk about these things this morning.

You have all got in your kits biographies, and I hope you read them, because it tells you what splendid people the World Food Prize program folk are able to bring up to these tables. So I'm certainly not going to go over them, but I'm going to give you six words about each of these people so that you'll know where they stand, because where they sit now depends on where they stand on issues.

Kwesi Atta-Krah is the DDG of (you might just stick up your hand), of Bioversity, which is one of the CG consultative groups. He is a scientist, but he's applied that science to forest, livestock, agronomy, economy, so therefore a deep grounding in looking at biodiversity through the lenses of many forms of agricultural production.

Daniel Hillel is a hydrologist, author, an innovator, an inventor, a student, an advisor to many, and a renaissance man in his interests, also one of the early people to ring a bell, talking about environmental issues.

Rattan Lal is a soil scientist, a science organizer, somebody show's known for a long time about carbon sequestration and can answer some of the issues about what's actually involved here - if it's that easy, why can't we get on with it and really do it?

Sahr K Lebbie from Kenya is a development specialist. He is obviously working with an organization, Heifer International, that adds animals to the international development and poverty alleviation process. So he has familiarities with international development, education and the very complex interactions that go on between animal, animal owners and agriculture.

And Johannes Lehmann is a soil scientist, but he's worked with manured soils, dry soils, weathered soils, tropical soils, and irrigated soils. He's looked at carbon, phosphorous, sulfur, biochar, and he's particularly expert on Biochar.

So if we haven't got here the people that can begin to tell you some of the answers to these things, they won't be found. So I'm delighted to be with them. We're going to ask questions if we can. We obviously got a little bit squeezed by the eloquence of our marvelous former speaker. We'll have time for a couple of questions in the audience.

So, Daniel, let's start with water, and let's start with the fact that many, many years ago you started saying that we were really running into problem areas, that we were using our resources in a way that was not sustainable and not renewable, even though that wasn't the vocabulary that we were using at that time. What set this off, what started your realization that we had to do something about that?

**Daniel Hillel**- Senior Research Scientist, NASA Goddard Institute, Columbia Earth Institute

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Well, I, very early in my career moved to the Middle East, moved to Israel and in most of the other countries in the Middle East, and the problem there is very much a problem of hereditary, an unstable climate, and the insufficiency of water and the ill use of water. The tragedy is that we are using or abusing the most precious, the most vital resources of soil and water.

And by degrading soil, by applying too much water, we waste the water, we're also raising the water table, salinizing, waterlogging and salinizing the soil. This has been the demise of civilizations in the ancient past and even more so in the present.

So the challenge is to improve the efficiency and especially the sustainability of the use of soil and water.

**Margaret Catley-Carlson**

Why hasn't sustainability ever been a known concept? I mean, we know the cradle of civilization is in Mesopotamia. We know that there were great civilizations there; there were civilizations based on irrigation and based on complex agriculture. Are humans not capable of learning that if you don't do this right, pretty soon it disappears?

**Daniel Hillel**

Human beings have weaknesses. They do what seems expedient at the moment, but they seldom look beyond the moment and beyond this generation to the next generation and to the long-term sustainability of systems.

And that's been a failure, and we have to manage ourselves even before we manage the resources. We have to look to the future. We have to consider sustainability, the sustainability of what we do, the ability to bequeath to the following generations a world that is, if anything, improved but not degraded.

And there is no better example than irrigation. Ill irrigation waterlogs the soil, raises the water table, salinizes the soil by this additional evaporation, and renders the base of the land sterile. This is what happened in Southern Mesopotamia; you see the land of Samar and Akkad and the

ancient cities that flourished there where writing began, where mathematics was invented, where machinery, the wheels, were invented, and some wheeled vehicles.

**Margaret Catley-Carlson**

So lots of wisdom, lots of knowledge.

**Daniel Hillel**

All of that is now encrusted by salt. We have to do better.

**Margaret Catley-Carlson**

Okay. I'm going to come back to you on how we can do better. But soils, the whole example, is what happened, had such a bad impact on soils. So is the soils question one that's been here forever? Is it one that population has greatly accelerated?

You know, we see what's happening to soils as a major problem, major artifact to the last part of the 20<sup>th</sup> century and the 21<sup>st</sup> century. But has the soil degradation problem always been there and it's just lower rates of population that made the difference. Do you want to start off?

**Johannes Lehmann**

I think we have dealt with soil problems for a long time, and the demise of great civilizations, as Dan pointed out, in the past, are linked to the soil use and abuse.

I think we have now a luxury that we are sitting here in this room together and can share knowledge across boundaries very fast. And that will be a key ingredient to find ways out of our current dilemmas - because soil management, there's an inherent problem, or challenge, I should say, with soil management that it doesn't come in a box. It's not something like a seed or a pesticide that you can buy. There are also knowledge systems attached to it. It doesn't come in a box. It's a knowledge that needs to be transferred, that needs to be locally applied.

And since it doesn't come in a box, it has also been seen lately in the last couple of decades as a management intervention that doesn't scale very well. And I think we can overcome that. We know a lot about soils. Yes, there's a lot more to be known, but we're now at a stage where we can apply our knowledge and bring the knowledge to farmers.

And I think Howard Buffett and other speakers in the first two days have highlighted the challenge of bringing knowledge to farmers, and that is especially the case for soil management. But I think we have the technology and the wisdom now to do that.

**Margaret Catley-Carlson** Margaret

Well, why now? Isn't this something that would have got passed on from fathers to sons and mothers to daughters?

**Johannes Lehmann**

We're facing new challenges through migration, through new demands on crops. And if I might add, we know, for instance, in Paris, grain yield, wheat grain yield even around 1900 was one ton per hectare. In Iowa here grain yield of corn was 2 tons per hectare in the 1930s. We've come a

long ways only in the last 80 to 100 years, and we need to make these same jumps all over the world.

**Margaret Catley-Carlson**

Now ten tons, yes. Oh, even get 14 somewhere. I want to come back to you and ask about solutions. But, Rattan Lal, would you, would you agree with that analysis? Why is it assuming the really different dimensionality of importance?

**Rattan Lal- Professor of Soil Science, School of Environment and Natural Resources, Ohio State University**

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Soil degradation has been with us ever since the dawn of agriculture thousands of years ago. I think the problem now is greater because the demands of humanity on the soil resources have increased. So the good soil is limited in extent; they are finite in area.

And I think more importantly, they are very susceptible and prone to degradation by misuse and mismanagement. And the misuse and mismanagement, which is kind of exacerbated by increasing the human demands, that has really caused a problem.

The problem has existed with us right from the Mesopotamian days and Mayan culture and Indus Valley civilization. But now with seven billion people, at that time, I mean, the beginning of the Christian era few hundred million people, the problem could be managed. Now we have a serious problem because we've got seven billion people to feed on that same or lesser area, going to nine and a half billion very soon.

I think the question whether the population increase has caused more erosion, for example, is a debatable issue. There was a very good book that came out "*More People, Less Erosion*". And she was arguing that having more people does not necessarily mean more mouths to feed. They also have two extra hands and a brain to think about.

So it is possible that if the lands are managed properly and judiciously, they can be sustained and they can be restored and they have to be restored.

**Margaret Catley-Carlson**

This is Lula's message to us, wasn't it? He said, you know, a phenomenon is what you say it is – you call it an investment because it's going to a productive enterprise, but you call it an expenditure if it's going to poor people. And he said, "I'm going to call it an investment and see if I can get it to boost the economy."

**Rattan Lal**

Exactly.

**Margaret Catley-Carlson**

So that's exactly what you're saying – You've got to look at these things and call them by different names. But the problem when you get to biodiversity is really tough; because, first of all, you have to explain the concept, and then you realize you're talking about things that are almost invisible – small seeds, genes, etc. – and yet the impact on the biodiversity of our fields,

our forests, our trees, etc. have been probably much worse than either of the soils or the water in the last century.

Say something happy.

**Kwesi Atta-Krah**- Deputy Director General, Bioversity International

No. I think you definitely are right on that. Biodiversity really is the basis of agriculture. It is also the basis of ecosystem stability. However, the reality is that human decisions and human activities can impact positively or negatively on biodiversity.

Unfortunately, over the last 100 years, all the efforts we have made in terms of trying to increase food production have had negative consequences on biodiversity.

**Margaret Catley-Carlson**

All of it?

**Kwesi Atta-Krah**

I dare say, even the Green Revolution. This is because we have focused very much on a few selected varieties. If you take the example of the Green Revolution, out of about a hundred different types of land races and varieties of rice that was being used very productively by farmers, we ended up with three top varieties. And this is what became the dominant varieties in rice that really drove the system.

Now, I think on hindsight we see that in addition to the positive benefits that we all got through the Green Revolution, there were real downsides in relation to biodiversity, in relation to soil, in relation to water systems... And I think it would be irresponsible on our part not to take the advantage of hindsight in basically moving and shifting the way in which we work.

So coming onto the biodiversity element, you did say, Margaret, that they seem to be very difficult to view. Not so when you go to the level of the small farmers. Biodiversity is one of the key resources that smallholder farmers use.

They don't use it just because of the environment, but they use it because it provides for them a risk management strategy. They use it because it provides for them different uses from particular types of species. And they therefore see it as a way in which they can sustain themselves and also improve their livelihoods.

If you would allow me, Margaret, I just want to say one last thing in relation to the subject matter we are dealing with - this is this whole issue of greening. And the question is - What do we mean by greening?

Well, next year we have Rio+20, and one of the big themes in there is going to be "Greening the environment," or "Greening the economy through agriculture."

The idea of greening is that green implies life. Green implies health. Green implies environmental and ecological sustainability. Green implies resilience. Green implies moving on to agriculture from a do-no-harm perspective. Green implies realizing that we cannot destroy

the resources upon which agriculture is based, and risk a situation where the generation that comes after us is not able to do it. And biodiversity is a key element in that situation.

**Margaret Catley-Carlson**

I'm going to come back to you and say – How are we going to make that list happen? And by the way, UNEF adds inclusivity to that list, because they say that it isn't realistic without inclusivity in this, because you'll just turn around and destroy your gains.

**Kwesi Atta-Krah**

That's right.

**Margaret Catley-Carlson**

So I'm going to come back and say – Okay, how are we going to make this happen? Daniel, you had a two finger on that one.

**Daniel Hillel**

Margaret, I would like to give a positive example. We've complained a lot. We pointed out the problems, but there are solutions, and we can take a positive approach and an optimistic approach.

One example is the improvement of irrigation. Whereas past civilizations abused the soil, caused its degradation, waterlogging, salinization, we have ways now of using waters much more judiciously, using the soil much more carefully, sustainability.

One example is drip irrigation. Instead of flooding the land with excess water, raising the water table, inducing more evaporation and the concentration of salt, we're now able to grow crops and get ten times the yield per unit of land by applying the water one drop at a time and by injecting just the right formulation of fertilizer in to the water and the pesticides into the water so that they're not applied in excess and they do not distribute themselves into the environment.

We can target the application of water and nutrients and all other treatments in proportion of the daily needs, never saturating the soil, supplying water into the root zone of crops.

**Margaret Catley-Carlson**

Why isn't everybody in the world using it?

**Daniel Hillel**

It is spreading widely. The problem is that it takes a certain amount of investment and a certain amount of knowledge, and there are traditions that need to be overcome. And one must condition the application of water, the pressurization of water, the injection of fertilizers, and the technique. It is spreading widely now in many parts of the world. Over the last 20, 30 years I have myself witnessed and participated in the dissemination of these techniques.

And so we do have positive ways. We can improve the way we deal with land and water and vegetative resources and all the rest that goes into production and sustainability of the environment.

**Margaret Catley-Carlson**

How much of irrigation is now drip irrigation probably? What is the percentage?

**Daniel Hillel**

I think still less than 10 percent.

**Margaret Catley-Carlson**

Wow. Well, it gives us lots to do.

**Daniel Hillel**

Right.

**Margaret Catley-Carlson**

Sahr, you and I are the non-scientists on the group, and you've got the task of introducing productive assets out of Heifer International into development situations, which are often situations of fairly low resources. And I know one of the things that you're trying to do is make sure that you're not just increasing the incomes of the families to whom animals or live productive resources are made available; but you're trying to pass on some environmental messages and trying to pass on some good practices along with these. This must be a rather tough task.

**Sahr Lebbie- Africa Area Vice President, Heifer International**

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I was thinking about scaling up, which in Heifer we are trying to do with our smallholder farmers, and scaling up so that they can grow more for their families, and scaling up so that more families can benefit from the projects that we support. So we are looking at to scaling from, say, 200 families to 1,000 families when the communities actually present a proposal.

Now, crop/livestock integration is an approach we have embraced, because many projects that focus on agriculture tend to look at crops and leave out livestock, which is part of the household; it's part of their livelihood. It's not like we are introducing livestock for the first time - it's already there, whether it's the chickens, the goats, the cows, the pigs, etc.

So crop/livestock integration invariably is going to begin affecting environmental issues, so we work very closely with the farmers to be sure that soil fertility is taken care of and we use manure to do that. Someone talked about manure yesterday being spread over a large area. We certainly don't do that.

So it's done on a small scale, and it has been done rather successfully. In fact, we have come up with four M's in Heifer when it comes to livestock - milk, money (because the more of it they can produce, the more they are able to sell some surplus). The third M is manure, which they use to fertilizer their land. And the fourth is muscle, because many of these farmers use oxen to plow their lands.

And they use oxen, of course, because we are not talking about large-scale farms, number one, so using a tractor would not come into the equation. In some situations, too, soil is so fragile that you don't want to put a tractor on it.



And so scale is one. Doing this faster is another, because for me at the end of the day – why are we doing agriculture? We are in agriculture because we want to improve nutrition. And when I think of 195 million malnourished under five and I think about a third of the deaths that occur among children are nutrition-related, that really should be the focus of all this production.

If I could mention one more thing.

**Margaret Catley-Carlson**

Very, very quickly.

**Sahr Lebbie**

And it has to do with the partnership between the large-scale farms and the small-scale farms, because they both have something in common. It's the same land, same soil, same water aquifer. So to the extent that these two can collaborate and not be greedy about extracting these natural resources, I think we might be heading for better success.

**Margaret Catley-Carlson**

Okay, thank you. Well, you provoked desires to speak in both Rattan and Kwesi, so...

**Rattan Lal**

Crop/livestock interaction is an excellent idea, especially for a smallholder. That's a buffer there against many calamities. But here's the problem in practicality.

If the crop and livestock integration does not happen properly, and if the crop residues do not get back on the land, and if the manure, rather than putting back on the land is used as a dung, then the system breaks down.

**Margaret Catley-Carlson**

As dung?

**Rattan Lal**

As dung, as cooking, as a cooking household fuel, for example, as a fuel.

**Margaret Catley-Carlson**

Yeah, okay.

**Rattan Lal**

So then the system breaks down, and as the system breaks down, then the soil fertility is degraded. Here is a situation. One of the practice that we recommend is no-till farming for smallholders. If there is no crop residue and the cattles are grazed uncontrolled, you have excessive compaction, you cannot do no-till farming, crop residues are removed, soil is getting depleted. You really get into a vicious cycle which you can't get out of.

So the question is – how do you integrate the animals in such a way that the ground cover is always maintained, crop residue is always returned to the land, the dung manure as a fertilizer is put back on the land, and soil is least disturbed?

In practicality in Sub-Saharan Africa and South Asia and elsewhere, this concept of integration and recycling the nutrients and residue has not happened. Consequently, the excellent concept of integration has worked against us.

So really the policy intervention, which is absolutely essential – and I would have loved to ask that question to our policymakers in Africa yesterday – what are the policy interventions that we can do so that the benefits of what is said integration can be realized?

Right now, just the opposite – more fertilizer nutrients are burned in household fuel in dung in India than chemical fertilizers are used. More fertilizer nutrients are taken out of the land to take away the crop residue and not bring any manure back, degrading the cycle. Here is the policy intervention that's absolutely necessary.

I would like to ask that question to President Obasanjo, or President Lula or others – how do you intervene so that the farmers are incentivized so they are paid for ecosystem services?

We kept on asking about subsidies. It's not really the subsidy. You ask them to do something to sacrifice the immediate gains so that they are compensated properly and justly, and unless that happens, we cannot solve the problem.

**Margaret Catley-Carlson**

But what is the woman supposed to burn in the household? Because if you're suggesting that the dung has to go into the soil.

**Rattan Lal**

We need to find a clean cooking fuel source. That has to be found. If you keep you using the dung, then you can't solve the problem. Again, can you imagine the vicious cycle of burning the dung, and children and babies and mothers expecting child inhaling those fumes, how many immature deaths and damage happen? I think finding the clean cooking fuel is an important component in terms of breaking this vicious cycle.

**Margaret Catley-Carlson**

Okay, Kwesi, you're in now, and then Johannes.

**Kwesi Atta-Krah**

Yes, I wanted to comment also on this crop/livestock integration issue and to emphasize the fact that at the level of the farmer, the farmer is involved in a system, and that system has so many different dimensions. So whether you are looking at things from the point of view of biodiversity or from soil or from livestock, you've got to take that into account.

I have seen projects, for instance, where just the insertion of one daily cow into the farming system of a household, the kind of transformation that it brings. I've seen projects, for instance, in Embu and in Kenya where you go in there and you see the positive link between livestock systems where the manure is actually managed and used, where they plant trees such as lucina, which they use as fodder source and where they have a system which is very well integrated.

So agroforestry, for instance, is a key element, but with a livestock element in it. So policies that will direct us and support the ability for these systems to receive support both in terms of research but also support at the level of the communities and the farmers so that they can implement some of these strategies.

**Margaret Catley-Carlson**

I think you've got a recruit for Heifer International here. Johannes.

**Johannes Lehmann- Chairman of the Board, International Biochar Initiative**

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Yeah, I want to pick up on all three of these comments. And I'm glad, Kwesi, that you mentioned some of the complexities that come into play to make this work under this certain circumstance that you mentioned.

Rattan, you mentioned this undoubtedly complex conundrum that we know that we should put the crop residues on the soil, but we cannot because we need to feed the cow and so on.

Now, to push our boundaries further across sectors to increase incorporate other biomass uses – and you mentioned the household energy systems that come into play that compete with soil use of biomass; and that's where biochar that I'm researching intensely at the moment comes in.

If then a soil scientist becomes involuntarily a combustion engineer to find ways of integrating the household energy needs with the soil needs for carbon, then we have maybe an opportunity to find clever ways of using the scarce resource to offer the same amount of cooking energy but retain half of the carbon that can be returned to the soil.

**Margaret Catley-Carlson**

Just tell us what that means in the real world. I mean, how do you retain half of the value for the cooking energy but still have something left over for the soil? Are you telling somebody to put the fire out and put the char in the...

**Johannes Lehmann**

There are now clever ways of changing the way we cook instead of using freestone fires or open fires with dung in either gasification or pyrolysis cook stoves that operate much more efficiently. They basically cook on the gasses that come off during pyrolysis and are as efficient as an open fire but retain half of the carbon that can be returned to soil.

And carbon, as we probably all agree, organic carbon in soil is what makes soils tick. We can boost fertility with fertilizers, and nutrients are essential, but if we are not maintaining carbon soil, carbon levels at an adequate level, we will never reach yield maximum.

**Margaret Catley-Carlson**

When you talk about agricultural char, that's what you're talking about – you're talking about semi-burned organic materials that are then returned to the soil being dug in or composted?

**Johannes Lehmann**

Yes. I'm talking about agricultural carbon biochar or char that can be returned to soil that is actually a part of soils almost anywhere in the world. It's a knowledge system that was recently inspired by the black earths of the Amazon and the Cerrado in Brazil but is by no means solely found in Brazil. We have colleagues in Ghana by chance that are working with us on finding the exact same soils also in Ghana and Liberia.

So these are knowledge systems that have existed for a long period of time, but we haven't tapped into it; we haven't adapted it to our modern constraints and opportunities.

To enrich the soil, to improve the soil. And just one sentence - why char is interesting, because it is much more stable than other organic matter, especially in the tropics; that is a challenge, that organic matter decomposes very quickly, providing these soil structural benefits for a much shorter period of time than, for instance, char, and benefits of retaining nutrients much more efficiently.

So I think our toolbox becomes fuller and fuller if we think across sectors where this complexity that possibly at the first sight seems daunting to connect all these value streams. But farmers can do it if we provide them with the support to think this through, what this means, what this toolbox means and which tools they can take out of the toolbox in their particular situation - thinking across sectors.

**Margaret Catley-Carlson**

Would this make an appreciable difference to the contribution of agriculture to global warming or emissions?

**Johannes Lehmann**

Absolutely, that is a pathway not only to smart agriculture but also climate-smart agriculture. To find ways of not only withdrawing carbon from the atmosphere but also reducing other greenhouse gases such as methane and nitrous oxide. So there are win-win situations possible.

**Margaret Catley-Carlson**

Any percentage that people put on this? What would be a maximize percentage that we could reduce from agriculture's contribution to greenhouse gas?

**Johannes Lehmann**

There are technical potentials that have been calculated that I might not want to discuss in detail, but those are significant contributions where around 10 percent of emissions could be reduced globally, and reversed.

**Margaret Catley-Carlson**

And reversed, wow, okay. The gods are not being kind to us. Just as we really get into some interesting things, we're running up against the time thing, so I'm going to go down this way and ask you to comment on anything that anybody's raised you want to or make a point that you wanted to raise that you haven't had a chance to raise yet. Daniel.

**Daniel Hillel**

I want to re-raise and emphasize the issue of climate change and the carbon cycle, and focus on the soils that have been abused and impoverished so that the [effect of] organic matter (the source of fertility and stability in the soil) being spewed out into the atmosphere and contributing to the greenhouse effect and climate change can be reversed.

The soils can become net absorbers of carbon by proper management, and in the process the soils will be enriched and made more sustainable. That's an extremely important component of the carbon balance or imbalance that we are now experiencing, and we can reverse that.

**Margaret Catley-Carlson**

That's doable.

**Daniel Hillel**

Absolutely doable.

**Margaret Catley-Carlson**

Good message. Rattan.

**Rattan Lal**

I want to second what Dan just said. The soils of the world have lost somewhere between 80 to 100 gigaton of carbon since the beginning of agriculture. The total biosphere has lost about 450 gigaton of carbon through the atmosphere since the human began to use the biosphere. Now, 450 gigatons - if you translate it into carbon dioxide, comes from the atmosphere; 4 gigatons is 1 part per million of carbon dioxide, so 450 of that 140 parts per million of carbon dioxide.

If we can sequester that carbon that we have lost back, it will be approximately equal to 100 parts per million draw-down of CO<sub>2</sub> at negative cost. Why is it negative cost? Because you restore the degraded soil in ecosystems. And this is where I think we need policy intervention.

Right now the geologic sequestration costs \$100 to \$150 per ton of CO<sub>2</sub>. The Chicago climate exchange sells for almost 10 cents a ton of CO<sub>2</sub>. If farmers are given \$20 per acre, for example, per year for carbon sequestration, at a normal rate of 100 tons per hectare per year, that is an excellent strategy to promote good agriculture as a solution to improving food security, climate change, water quality and biodiversity.

**Margaret Catley-Carlson**

So it's possible and it's doable and it's affordable and it's arrangeable. Okay. We're on a roll here, okay.

**Daniel Hillel**

In the original preindustrial revolution, concentration of carbon dioxide in the atmosphere was about 270 to 280 parts per million. It is now approaching 400, and we're well on our way to doubling the carbon dioxide content of the air, and thereby causing global warming. This can be reabsorbed into the soil and in the process enriching the soil.

**Margaret Catley-Carlson**

Okay. I'm glad to hear it, yes.

**Kwesi Atta-Krah**

Yeah, I'll just make two quick points. The first is really to emphasize the importance of changing the way we do research in agriculture. The Consultative Group for International Agriculture Research that I represent over the last two years we have really reformed the system to be able to develop new research programs that takes this greening dimension into account and also enhances the focus on smallholder farmers and focuses specifically on how to deal with poverty dimensions of all this. Because a lot of natural resource management issues are driven by poverty also.

So that's a very important area for us is to have more investment that goes into research for breeding particular crops as well as research that focuses on understanding the system and the circumstances of farmers and how we can help them from the point where they are.

The second point is also for us [we need]to find a way in which we can compensate – I think every time you mention that – but the way in which we can appreciate and compensate farmers and communities for the investments they make for providing societal goods in terms of environmental control and biodiversity conservation, in terms of water catchment area conservation. They do a lot of these things.

And when we talk about payment for ecosystem services, it has to be translated in such a way that the farmers and the communities also benefit. We have to be able to talk about payment for conservation services, for farmers that are hoping to maintain a diversity on which agriculture is based.

So those are new dimensions where policy must be directed to improve and enhance.

**Margaret Catley-Carlson**

We're going to have to get Lula back here. You know, I mean, he got his wealthier people to pay for some just plain eating and food services. You want payment for compensation for environmental services. We're going to need Lula back here to make the case on that. Thank you, Kwesi. Johannes.

**Johannes Lehmann**

I want to emphasize and make a plug for soil science, which sounds a bit selfish. But I think we've lost a lot of capacity over the last decade or so in soil knowledge systems on the academic level. Also in Africa we need to restore that capacity and integrate it, as Kwesi said, into more a systems discipline so that we come out of the very narrow view and see, as I mentioned before, look across sectors. I think that is absolutely essential to bring us.

And that's where the policymakers can come in and make a real concrete contribution.

**Margaret Catley-Carlson**

Well, we have to tell them, make them, make it inevitable, so yes.

**Sahr Lebbie**

I would like to make a couple of comments, one of them on policy. I believe many governments have recognized that it's no longer effective to implement one project in isolation of another. An ag project is invariably going to have some issues that have to do with health, so the two ministries need to act together – the private/public sector collaboration, civil society as well.

So that I would see as a very good approach to dealing with the policy issues.

On the comment about livestock and all that affecting soil, I would just like to mention that we use zero grazing in situations where it's not feasible, advisable to do open range out there, so that we can do both small scale and large scale, depending on the particular environment.

On commitment, the smallholder, at least in the projects that Heifer implements, makes a very firm commitment through an approach we call "passing on the gift," where a farmer signs a contract when they come on board on that project, that not only are they going to pass on the offspring of their livestock, but they're also going to pass on the knowledge that they acquire to the next family. And this is a very firm commitment.

We have seen second generation, third generation, in some places fifth generation. In Rwanda it was particularly touching because we had people who were at war actually exchanging amongst themselves, and that was very powerful.

**Margaret Catley-Carlson**

Yeah, very powerful. I want to end with one of my own suggestions. I sit on the International Fertilizer Development Council, and something very exciting is happening, in the first place in Bangladesh and now in about eight countries of Africa. And that's something very simple called urea deep placement where you take nitrogen fertilizer (urea can be mixed) and put a capsule in very close to the stalk of the plant. You can use up to as little as 30 percent of what would have been used as fertilizer, and the yields go up by as much as 40 percent and the subsidy bills to the governments – because all African governments now are paying subsidies for fertilizers – go way down.

This is a win-win-win-win because it stops some of the runoff which is so greatly damaging the water; you get a higher plant growth; you get less expenditure for the farmer and less expenditure for the governments that are doing their best to try and increase fertilizer use.

I would recommend and ask each of you to look up that technique if you're at all involved in fertilizer applications, urea deep placement, and look it up under IFDC.

So there, that's what I wanted to say, is that this is a very practical thing that can be done to really look after soil and water remediation.

We could have talked to these guys for another hour and a half each, I'm sure, but instead you'll just have to join with me in thanking them.