ILSI 2021 Annual Symposium Session 7: Greenhouse Gases from the Food Supply Chain: Paths to Mitigation and Sustainability

Transcript of the presentation, The Potential of Regenerative Agriculture for Carbon Management and Sustainability, Rattan Lal, PhD, The Ohio State University, United States; 2020 World Food Prize

I would like to thank the international life sciences Institute. The chairman Dr. Mike Doyle, I got the invitation from Dr. Jeff Smith and Stephanie Ridley and all others who made this meeting possible. The topic that I'm going to discuss is the potential of regenerative agriculture for carbon management and sustainability. So, to begin with, I'd like to define regenerative agriculture and sustainability. Regenerative agriculture is inspired by eco innovation. It's powered by non-carbon energy, driven by a circular economy and green infrastructure, and supported by the re carbonization of the terrestrial biosphere, soil, and vegetation at the bedrock of sustainable development. Therefore, soil organic matter essential to soil health is the elixir of life. With that perspective, a system-based regenerative agriculture reconciled in need of producing adequate and nutritious food within the necessity of restoring the environment and making farming a solution to environmental issues. I emphasize the word solution rather, than a problem.

In this context, regenerative agriculture encompasses a wide range of farming and grazing practices aimed at restoration and sustainable management of soil health through sequestration of soil organic carbon. There is no one size fits all practice for diverse soils and biomass. And regenerative agriculture comprises conservation agriculture, as one example, and conservation agriculture itself includes for example, no-till farming residue mulching, cover cropping, integrating nutrient and pest management, complex rotations and integration of crops with trees and livestock. These components have to be fine-tuned under site specific conditions. Remember, there are 300,000 known soil series, many eco regions, many biophysical and socioeconomic condition. Even you have only five components to combine for site-specific condition, to say that there is a one practice would be [inaudible], but the principles are acceptable. Regenerative agriculture leads to carbon sequestration because of its maintain continuous soil cover.

Soil never to be left bare, no soil disturbance, no [inaudible], nutrient management to integrated soil fertility management options and complex rotations so that we can restore soil organic carbon, improve soil fertility can solve quality and functionality. And that is what regenerative agriculture is all about. And the goal is to produce more from less, less chemicals, less water, less energy. Now taking the second definition. Sustainability, stating which demands based on the environment can be met without reducing its capacity to allow all people live well now, and in the future. Four pillars of sustainability environmental, economic, social, institutional, and these are all important. Therefore 'sustainability' is the integration or balancing environmental, social, institutional and economic issues. And I personally focus on environmental. Soil is a component of environmental. Therefore, sustainable development implies making people better off in an ethically sound way. And that is what stewardship is all about.

Soil as a living entity is the basis of all life. In fact, Charles Kellogg of USDA has said that it can be no life without soil and no soil without life. They have evolved together. And I like to go a step further. The rhizosphere, the soil root interface at nanoscale, is the only place in the universe where the death is resurrected into the life. When the microbes transform the dead organism, into minerals that are absorbed by plant roots and life begins again. It has, the soil is rich in organic matter content. It has 25% of all terrestrial biodiversity in the surface layer of the soil. And for rich organic matter content, soil is a healthy soil. And what's a healthy soil? Soil's capacity as a dynamic and biologically active entity. Biologically active entity. Within natural and managed landscape. To do what? To sustain multiple ecosystem services, such as net primary productivity, food and nutritional security in where the nutritional is very important.

Biodiversity, water purification and renewability carbon sequestration, air quality, and atmospheric chemistry, elemental cycling. For what? For human and nature do not forget nature. We, humans, are part of nature. If nature doesn't benefit, we do not benefit either, look around you and you will understand what I mean. There's a strong nexus between human health and soil health. In fact, human health is a fingerprint of soil health. Therefore, human health can be improved, should be improved that restoration of soil health of degraded, polluted and contaminated soil? One third of all soil globally are degraded, polluted, contaminated, eroded. It must be taken care of and the substitute to bring new land rather than taking care of those, which we have degraded is not a good one. Therefore, restoration of soil organic matter content to above the threshold range, can improve soil health and the nutritional quality of the food produced.

I strongly believe that the health of soil, plants, animals, human, environment, and the planetary processes, is interconnected. Therefore, rather than focusing just on one or two issues, it's very important also to address the sustainable management of natural resources in the context of the environment quality. Soil organic matter content is the elixir of life. And this has several components, living organism constitutes about 5%, fresh plant residues about 10% decomposing organic matter about 33 to 50% already decomposed organic matter about 33 to 50%. It's a very dynamic entity in soil. And the management of this is what we call on the basis of law of return. And the law of returns says, whatever you have taken out of soil in harvesting the produce, grains, milk, animal products must be replaced. If it is not replaced, we've got a problem. And that is the case with extractive farming.

We must respond wisely to what has changed, and we must be able to predict what will happen from anthropogenic and natural perturbations. And we must restore degraded soil by carbon sequestration. The idea is to produce more from less. And what do we mean by more, from less? How do we achieve it? Organic matter content is one of the key factors. The critical danger of organic matter content is about three and a half to 4%, maybe two and a half to 4%, two and a half, maybe in the tropical soils, 4%, maybe the temperate region soil. Organic carbon contains about 50% of the organic matter content, about. Therefore, the optimum level is somewhere within two and a half to four most soils of the degraded ecosystems, especially of the tropics and subtropics. The soil organic matter content is less than 0.5%. I fully support the idea that the soils of Africa and Asia must have more fertilizer application.

The 17 kilogram per hectare in Sub-Saharan Africa is not adequate but putting fertilizer on degraded soil is a double jeopardy. That part we must understand. We must make sure that the soils anywhere we put fertilizer are responsive to, receiving the chemical fertilizers. That is a part of creating a positive soil carbon budget, which means what we put into the soil through. For example, biochar, compost, cover crops, root biomass, crop residue must always exceed what is being lost from the soil. By erosion, very

serious problem, leaching, decomposition, erosion and decomposition more. Unfortunately, in extractive farming practices adopted by most resourceful or small landholders. Most of the developing countries, we have the extractive system leading to more losses than gains. Therefore, soils are continuously being degraded. And if there is degraded soil, we try to improve restore organic matter content. For example, those which have a half a percent, and we add organic matter content in the root zone by one metric ton per hectare while everything else remaining the same, the nitrogen fertilizer, the other inputs, tillage system residue management varieties, the yield of different crops can be increased somewhere between a hundred to 300 kilograms per hectare for Maze. 20 to 50 for soybean, 20 to 70 for wheat, rice, sorghum, millet all crops, including the root crops.

So, adding carbon content to soil by 10 tons. And that 10 tons may take more than 10 years, perhaps more like a 15 to 20 years. You could multiply the crop here in developing countries tremendously. And at the same time improve the quality of the food, nutritional quality of the food. And the same resources, like fertilizer, irrigation, pesticide, because by this, you create disease suppressive soil. So, this slogan in developing countries should be C N P K. Yes, NPK are needed absolutely. But if C goes before them, then the need for NPK progressively decreases over time. The use efficiencies of nitrogen especially, which right now is maybe 25, 30% under ideal conditions, that scenario can go up and the rate of application of chemical can go, go down by having high soil biodiversity, cause carbon in the food of the microorganism and macro, and other organisms, soils become diseased suppressive.

And therefore, they do not also need as many pesticides. And this is the concept of C N P K to cover crop residue mulching, an integrated system of soil for [inaudible] management. Therefore, there's a time for a paradigm shift, the transformation of U.S. And UN and worlds and any country like food production system. The green revolution, seed centric, and based on fossil fuel inputs of fertilizers, pesticides, tillage, irrigation, is definitely feeding 90% of the world population of 7.7, 7.8 billion people. Without green revolution, about 50% of all population would probably have starved. However, dependence on fossil-fuel based inputs and their environment ramifications cannot be ignored, must be addressed. Fossil-fuel information from 1750 to 2019 about 445 gigaton combined those with soil and vegetation, total 575 gigaton since 10,000 BCE, when agriculture began, are the principal cause of anthropogenic climate change, air pollution, water contamination, biodiversity loss, ocean acidification and other environmental problems. We cannot ignore them. They have to be addressed. And yet one in 11 people is prone to hunger, and two to three in seven are prone to hidden hunger, and the pandemic has exacerbated that problem by perhaps another 130 million people who are affected by assumptions in food supply chain.

Therefore, the humanity is at a crossroads and faced with the challenge of "Reconciling the need for sustaining food production with the necessity of restoring degraded ecosystems and improving the environment through adoption of regenerative agriculture" which we have defined what it is. Therefore, the 21st century green revolution now, the second green devolution should be soil-based soil resilience so that the need for pesticides, herbicides, fertilizer can be decreased over time. Remember I'm not eliminated altogether. Some may be needed because we certainly have soil, which you do not have enough nutrients, but many of them judicially because of the soil health management through the soil health management, it must be ecosystem-based eco efficiency of the inputs improvement. And it has to be science driven, science driven, which is a very important part. And of course, soil and agriculture and forestry and landscape have to become a carbon sink.

We have lost quite a lot of carbon over the last 10,000 years since the agriculture began. We can restore the carbon back into terrestrial biosphere. Here's an example of an improved system. You've got a plant,

which obviously can be used with a deep root system, has a larger biomass compared to Duarte varieties, which we are talking about in the sixties and the less root biomass we want root biomass, more above ground biomass. And yet we should be able to communicate with the plant through molecular based signal emitted when the plant is under stress. And that way we can save quite a lot of problem, which may happen when we do not understand that the plant was going through some issues that need to be addressed. And this should be combined with no-till, with mulch farming, with cover cropping, and of course, integration of crops with trees and livestock so that the recycling of nutrients can happen.

And through additional biomass to the critical level that I was talking about three and a half to 4%, soil can become disease suppressive. They have very high activity of the microorganism. And if some additional nutrients are needed, this is a very important part. I'm not saying they are not needed, if they are needed and they will be, especially during the transition period, they must be applied in such a way directly to the plant roots, according to the four R's right time, right dose, right method of application, right formulation. So that most of these are absorbed by plants and do not leak out into the environment. That's the problem, which I'm concerned about indiscriminate use of inputs and the leak out into the environment. So, the technical potential of carbon sequestration this way, technical maximum possible is about two and a half Peta-gram, gigaton carbon on a global scale per year.

In the terrestrial biosphere soils have a potential between 2020 and 2100, sequestering 178 Peta-gram gigatons. Vegetation 155. That's 333 total, which is equivalent about 157 parts per million of CO2. This is not enough to mitigate global warming unless the fossil fuel emissions are stopped. Once they are stopped by finding known carbon fuel sources. And we can then implement also same time restoring the carbon stock in the trees and soils, both organic and inorganic carbon sequestration. Yes, the fate of climate change is still within our hand and manageable. But fossil fuel substitution non-carbon must be found.

Translating science into action required adopting innovations. It can require technologies, organization, processes, management, and of course governance. All of these are important parts of the environmental sustainability. And the reduced economic returns, chronic poverty, hunger, malnourishment desperateness certainly are as threat to global peace and stability as any weapons of mass destruction. Yet we ignore this very simple concept. Therefore, what we are looking for is a pyramid. The base of this pyramid is a healthy soil and natural resources and carbon stock in the trees and biomass. This pyramid has four sides, food security we can achieve with this technique. Climate change adaptation mitigation can be addressed with this strategy, land and soil restoration land degradation neutrality can be achieved by this technology. And of course, the biodiversity can be announced by this technology. However, this pyramid cannot be stable unless the four corners where it meets, has a strong cementing glue and the glue, the political stability and peace and the policy that translate science into action.

And that's what at the human food summit we are not talking about. And one of the policy interventions is payment to farmer for ecosystem services at a fair and right price undervaluing such a precious resource such as $2 or $10 per ton of CO2 is a mistake. Right price is about 30 to $35 per ton of CO2. If the carbon dioxide injection from the industrial output into the ground, one mile below takes $50 per ton of CO2, why are we trying to undermine the payment for the farmers, ranchers and foresters? I think this equity must be carefully understood if farmers sequestered half a ton per hectare of carbon. That is $65 per hectare, $26 per acre. If farmers sequester one third, that's $43 per hectare, 17 and a

half dollar per acre. Another policy intervention I suggest is in terms of agriculture, sustainability, and looking at the rights of soil would be EPA already has a clean air act, 1967.

It has a clean water act, 1972. How is it possible to have clean air and clean water when you do not have a healthy soil? Therefore, this is just the right time to have a healthy soil act through proper policy intervention and governance. [inaudible] the coming farm bill of 2023. Lastly, I know this section is going to also discuss the Edward. Deming's famous saying, if you can't measure it, you can't manage it. But I think that there is another side of the story, that there are several things that cannot be measured. And I can think about many from the agricultural point of view, but they must be managed. If they are not managed properly, we are in deep trouble, and how to manage what you cannot measure is a very key question that I hope you will discuss. Thank you for the opportunity to talk to you.