Regenerative Organic Agriculture Can Reverse Climate Change

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By changing agriculture to one that regenerates soil organic carbon, we can not only reverse climate change, but we can also improve farm yields, increase water-holding capacity and drought resilience, and reduce the use of toxic agrochemicals.

Increased atmospheric temperatures accelerate the rate of ice melt in Iceland and impact farming production around the globe. Photo by James Studarus.

Introduction

When a boat is sinking, two things need to be done to reverse the situation: plug the leak and then bail out the water. Only bailing out water without plugging the leak, or only plugging the leak without bailing out the water, leaves the boat in a perilous condition. At best, either just buys time before the boat sinks.

Unfortunately, this seems to be situation with many governments and activist groups when dealing with climate change. They are concentrating on plugging the leak and forgetting that we need to bail out the water. We need a combination of renewable energy and energy efficiency to lower the emissions (to plug the leak) and mitigation (to bail out the water) to strip carbon dioxide (CO_2), the main greenhouse gas, out of the atmosphere.

The Problem:

Greenhouse gas emissions have reached a new record

Greenhouse gas (GHG) emissions are still rising due to many countries making inadequate pledges and/or not meeting their pledges to reduce emissions. The level of CO_2 reached a new record of 400 parts per million (ppm) in May 2016, which will result in temperatures rising between 5.4° to 9°F (3.5° to 5°C).

According to *Scientific American*, scientists regard 450 ppm as the point of no-return for catastrophic climate change. CO_2 accounts for over 80 percent of anthropogenic (human-influenced) GHGs in our atmosphere.

Assuming that the commitments made by countries at the COP21 (Conference of the Parties) in Paris in December of 2015, will stop GHG emissions from increasing the estimates are that this would not occur until between 2030 and 2050. GHG emissions will only start to fall *after* then.

Given that currently CO_2 levels are rising at around 2 ppm every year—the best-case scenario based on the Paris negotiations is that levels will stabilize at 430 ppm if the 2030 target is met. A 2050 target will mean 470 ppm of CO_2—20 ppm past the 450 ppm point of catastrophic climate change.

A 2030 target will still mean that the world will continue to warm and will go into severe climate change due to cumulative impact of past, present, and future emissions. The current reality is that it could take more than a hundred years before temperatures will stabilize.

The Secretary-General of the World Meteorological Organization, Michel Jarraud, stated *"*Carbon dioxide remains in the atmosphere for hundreds of years, and in the ocean for even longer. Past, present, and future emissions will have a cumulative impact on both global warming and ocean acidification.*"*

The Paris Agreement of keeping warming to just below 2°C (3.6°F) will require CO_2 levels being kept below 350 ppm. This goal has already been missed. Even if it had been achieved it would result in increases in the severity and frequency of adverse weather events. These will have a major effect on food production and global food security. The combination of periodic food shortages and millions of displaced refugees from flooded lowland areas like Bangladesh, or coastal cities such as New Orleans, New York, London, Bangkok, Jakarta, Manila, and the atoll island countries will cause massive social upheavals, economic shocks, and political instability. This is unacceptable. These citizens should not be the sacrificial pawns of GHG polluting industries. The aim must be to stabilize the temperature to pre-industrial levels, not allowing for an increase up to 2°C.

Stopping the increase in GHGs—and then reducing them—must be our first priority, and this should be non-negotiable. However, moving to renewable energy and energy efficiency will not be enough to stop the planet from warming over the next hundred years and the ensuing damage from the temperature rise. We have to draw down the excess CO_2 from the atmosphere to stop damaging climate change. Assuming the world can achieve this, we will still need to reduce CO_2 levels from 400 ppm to 278 ppm, the pre-industrial level of 1750 AD. This means reducing current levels in the atmosphere by 122 ppm.

Soils are the greatest carbon sink after the oceans. We already have too much CO_2 in the oceans. According to Professor Rattan Lal of Ohio State University's School of Environment and Natural Resources, there are over 2,700 Gigatons (Gt) of carbon stored in soils and 575 Gt in biomass (trees and forests) worldwide. However, soil holds more carbon than the atmosphere (848 Gt) and biomass combined (575 Gt).

[A gigaton (Gt) is one billion tons. For the sake of simplicity in this article, a metric ton and a U.S. ton are almost the same.]

Using the accepted formula that 1 ppm CO_2 = 2.12 Gt carbon, removing 122 ppm means turning it into 258.64 Gt of stable carbon. Just planting trees to mitigate climate change means that we would have to stop all forest clearing and expand the current forest cover by 50 percent to strip the excess CO_2 out of the atmosphere. Then there will be the need to prevent forest fires; with just a few fires, the sequestered carbon would be back in the atmosphere as CO_2. Stopping deforestation, preventing forest fires, and planting more trees will definitely improve the environment—and must be done. However, it is not politically achievable as a means to stop climate change.

The most logical and realistic way to remove the 122 ppm from the atmosphere is to store it as 258.64 Gt of carbon in the soil throughout the world.

The French Government is actively supporting this with the *"4 per 1,000 Initiative: soils for food-security and climate,"* an initiative of using a range of agricultural systems to increase global soil carbon to reverse climate change. Thirty countries have now signed onto this initiative along with key United Nations organizations and many NGOs.

We at International Federation of Organic Agriculture Movements (IFOAM/Organics International), have signed on to this initiative as part of the suite of solutions needed to stop catastrophic climate change. There is a good body of scientific evidence showing that the scaling up of regenerative agricultural systems such as organic agriculture, permaculture, agroecology, holistic grazing, a system of rice intensification, and agroforestry can make a significant contribution to drawing down the 122 ppm of CO2 from the atmosphere into the soil as soil organic matter (SOM), and reverse climate change to pre-industrial levels. This is based on current good practices, is "shovel ready," and can easily be achieved. With more investment funding research and development in regenerative systems, we will be able to get even better results.

The worldwide adoption of Regenerative Organic Agriculture means that we could reduce temperatures to pre-industrial levels and avoid 2°C in warming.

How would this work? In short, by stripping out the excess CO2 from the air and storing it in the soil as organic matter.

Agriculture is directly and indirectly responsible for 30 to 50% of greenhouse gas emissions, depending on the boundaries and methodologies used to determine its emissions.

Furthermore, the majority of greenhouse gases in farming come from the use of nitrogen fertilizers, and the loss of soil organic matter rather than from farm machinery emissions. Synthetic chemical fertilizers create a significant impact to climate change in terms of the energy used to manufacture them, and their contribution to nitrous oxides (N2O) and methane (CH4), both major greenhouse gases.

Nitrous oxide (N2O) is one of the most significant of the greenhouse gases emitted by agriculture. One N2O molecule is equivalent to 310 carbon dioxide (CO2) molecules in its greenhouse effect within the atmosphere. It has a mean residence time in the atmosphere of 120-150 years and also contributes to the depletion of the ozone layer.

The biggest contributor to human-produced N2O pollution is the use of synthetic nitrogen fertilizers such as urea and ammonium nitrate. The contribution of nitrogen fertilizers is even higher when all the CO2 and N2O that is emitted in the production of these energy-intensive fertilizers are included in the totals.

Scientists at the University of Illinois analyzed the results of a 50-year agricultural trial and found that the application of synthetic nitrogen fertilizer had resulted in all the carbon residues from the crop disappearing, as well as an average loss of around 10,000 kg of soil carbon per hectare. This is around 36,700 kg of CO_2 per hectare over and above the many thousands of kilograms of crop residue that is converted into CO_2 every year. (A kilogram per hectare is almost the same as a pound per acre.)

The researchers found that the higher the application of synthetic nitrogen fertilizer, the greater the amount of soil carbon lost as CO_2. This is one of the major reasons why there is a decline in soil carbon in conventional agricultural systems compared to the increased soil carbon in organic agricultural systems.

The worldwide adoption of regenerative organic agriculture would see the complete elimination of the main source of anthropogenic N_2O pollution as synthetic nitrogen fertilizers are not used in these systems as well as the loss of soil carbon that is turned into CO_2.

The Solution:

Soil Carbon Sequestration

Cover crops are an important aspect to regenerative farming practices. Photo cred: Colette Kessler, USDA NRCS South Dakota

Farming systems that recycle organic matter and use crop rotations can increase the levels of soil organic carbon. This is achieved through techniques such as longer rotations, catch-crops, cover crops, green manures, legumes, compost, organic mulches, perennials, agroforestry, permaculture, agroecological biodiversity, and livestock on pasture through holistic grazing.

The Rodale Institute in Pennsylvania has been conducting long-running comparisons of organic and conventional cropping systems for over 30 years that confirm that organic methods are effective at removing CO_2 from the atmosphere and fixing it as organic matter in the soil.

The Farming Systems Trial (FST) manured organic plots showed that carbon was sequestered into the soil at the rate of 3,596.6 kg of CO_2/ha/yr, and if extrapolated globally across agricultural lands, would sequester 17.5 Gt of CO_2.

A meta-analysis by Aguilera et al. published in the peer reviewed journal, *Agriculture, Ecosystems & Environment*, of 24 comparison trials in Mediterranean climates between organic systems and nonorganic systems without organic supplements found that the organic systems sequestered 3559.9 kilograms of CO_2 per hectare per year. The data came from comparison trials from Mediterranean climates in Europe, the United States, and Australia—and if extrapolated globally would sequester 17.4 Gt of CO_2/yr.

The Louis Bolk Institute made a study to calculate soil carbon sequestration at Sekem, the oldest organic farm in Egypt. Their results show that on average Sekem’s management practices sequestered 3,303 kgs of CO_2 per hectare per year for 30 years. Based on these figures, the widespread adoption of Sekem’s practices globally has the potential to sequester 16 Gt of CO_2 into soils.

The Ability to Reverse Climate Change

Using the accepted formula that 1 ppm CO2 = 7.76 Gt CO2 or 2.12 Gt carbon means that 122 ppm equals taking 946.72 Gt of CO2 from the atmosphere and storing it as 258.64 Gt of carbon in the soil as soil organic matter.

These three studies show that at the point emissions are stabilized at 400 ppm, regenerative organic agricultural practices would take less than 60 years to remove the 946.72 gt of CO2 and reverse climate change to the pre-industrial levels of 278 ppm.

The Rodale Compost Utilization Trial showed that carbon was sequestered into the soil at the rate of 8,220.8 kg of CO2/ha/yr, and if extrapolated globally would sequester 40 Gt of CO2/yr, and would only take 24 years to remove the 946.72 Gt of CO2 and help reverse climate change.

At this time, there are a range of other regenerative agricultural systems that are getting even higher levels of carbon sequestration. These systems are currently in the process of being published in peer-reviewed scientific journals.

We Must Stabilize CO2 Now!

The immediate goal must be to stabilize the CO2 in the atmosphere to 400 ppm to prevent any further increases in climate change. Ideally, this should be done by capping current emissions and adopting a combination of renewable energy and energy efficiency. However, under the Paris Agreement this will not happen until 2030 at the earliest. If we wait until then, as stated before, we will reach 430 ppm—just below the tipping point of 450 ppm. What we do in the next 14 years is critical for the future of the planet.

Currently, CO2 levels are increasing by 2 ppm per year. Since 1 ppm CO2 = 7.76 Gt CO2, this means we need to remove 15.52 Gt of CO2 per year from the atmosphere to stabilize our current levels. The widespread scaling up of regenerative organic agriculture, such as the Rodale Compost Utilization Trial, could achieve this. Based on the levels of CO2 sequestration that it has achieved, converting a quarter of the world's agriculture to regenerative organic agriculture would stabilize CO2 levels.

The greater the scaling up of regenerative agricultural practices, the quicker we can reverse climate change.

The Urgent Need to Get Started to Scale Up

It is not the intention of this paper to use the above types of generic exercises of globally extrapolating data as scientific proof of what can be achieved by scaling up regenerative organic systems. These types of simple analyses are useful for providing a conceptual idea of the considerable potential of regenerative agricultural systems to reduce GHG emissions on a landscape scale. The critical issue is to apply the findings for scaling up on a global level in order to achieve a significant level of GHG mitigation.

The potential of these farming methods is enormous, considering that these data are based on current practices.

These examples are “shovel ready” solutions. While research can improve the rates of sequestration, the examples given are based existing practices. There’s no need to invest in expensive, potentially dangerous and unproven technologies such as carbon capture or geo-engineering. All that is needed is to scale up the existing good regenerative organic practices.

Greater Resilience in Adverse Conditions

According to numerous published studies, the world is seeing increases in the frequency of extreme weather events such as droughts and heavy rainfall. Even if the world stopped polluting the planet with greenhouse gases tomorrow, it would take many decades to reverse climate change. This means that farmers have to adapt to the increasing intensity and frequency of adverse and extreme weather events such as droughts and heavy, damaging rainfall.

Published studies show that organic farming systems are more resilient to the predicted weather extremes and can produce higher yields than conventional farming systems in such conditions.

Improved Efficiency of Water Use

Research shows that organic systems use water more efficiently due to better soil structure and higher levels of humus and other organic matter compounds. Lotter and colleagues collected data over 10 years during the Rodale Farm Systems Trial. Their research showed that the organic manure system and organic legume system (LEG) treatments improve the soil’s water-holding capacity, infiltration rate, and water capture efficiency. The LEG maize soils averaged 13 percent higher water content than conventional system (CNV) soils at the same crop stage, and 7 percent higher than CNV soils in soybean plots. The more porous structure of organically treated soil allows rainwater to quickly penetrate the soil, resulting in less water loss from runoff and higher levels of water capture. This was particularly evident during the two days of torrential downpours from Hurricane Floyd in September 1999, when the organic systems captured around double the water than the conventional systems captured.

This is consistent with many other comparison studies that show that organic systems have less soil loss due to the better soil structure and higher levels of organic matter. *“We compare the long-term effects (since 1948) of organic and conventional farming on selected properties of the same soil. The organically farmed soil had significantly higher organic matter content, thicker topsoil depth, higher polysaccharide content, lower modulus of rupture, and less soil erosion than the conventionally farmed soil. This study indicates that, in the long term, the organic farming system was more effective than the conventional farming system in reducing soil erosion and, therefore, in maintaining soil productivity”* (Reganold et al. 1987).

Humus, a key component of soil organic matter, is one of the main reasons for the ability of organic soils to be more stable and to hold more water. This is due to its ability to hold up to 30 times its own weight in water and being a “sticky” polymer, and glues the soil particles together, giving greater resistance to water and wind erosion.

The Importance of Organic Matter for Water Retention

There is a strong relationship between the levels of soil organic matter and the amount of water that can be stored in the root zone of a soil. The table below should be taken as a rule of thumb, rather than as a precise set of measurements. Different soil types will hold different volumes of water when they have the same levels of organic matter due to pore spaces, specific soil density, and a range of other variables. Sandy soils, as a rule, hold less water than clay soils.

The table gives an understanding of the potential amount of water that can be captured from rain and stored at the root zone in relation to the percentage of soil organic matter.

Volume of Water Retained per Acre (to 12 inches) in relation to Soil Organic Matter (SOM)

- 1% SOM = 16,640 Gallons (common level: Africa, Asia, Australia)
- 2% SOM = 33,280 Gallons
- 3% SOM = 49,920 Gallons
- 4% SOM = 66,560 Gallons (levels pre-farming)
- 5% SOM = 83,200 Gallons (levels pre-farming)
- 6% SOM = 99,840 Gallons (levels pre-farming)

Adapted from Morris, 2004.

There is a large difference in the amount of rainfall that can be captured and stored between the current SOM level in most traditional farms in Asia and Africa, and a good organic farm with reasonable levels of SOM. This is one of the reasons why organic farms do better in times of low rainfall and drought.

The Rodale Farming Systems Trials showed that the organic systems produced more corn than the conventional system in drought years. The average corn yields during the drought years were from 28 to 34% higher in the two organic systems. The yields were 6,938 and 7,235 kg per hectare in the organic animal and the organic legume systems, respectively, compared with 5,333 kg per hectare in the conventional system. The researchers attributed the higher yields in the dry years to the ability of the soils on organic farms to better absorb rainfall. This is due to the higher levels of organic carbon in those soils, which make them more friable and better able to store and capture rain water, which can then be used for crops.

A study by Machmuller et al. 2015, showed that three years of management-intensive grazing in the southeastern United States increased the soil carbon levels enough to increase the water holding capacity by 34%.

This is significant information as the majority of the world's farming systems are rain fed. The world does not have the resources to irrigate all of the agricultural lands, nor should such a project be started, as damming the world's watercourses—pumping from all the underground aquifers and building millions of kilometers of channels—would be an unprecedented environmental disaster. Improving the efficiency of rainfed agricultural systems through organic practices is the most efficient, cost effective, environmentally sustainable, and practical solution to ensure reliable food production in the increasing weather extremes being caused by climate change.

Conclusion

Regenerative agriculture, especially organic agriculture, can change agriculture from being a major contributor to climate change to becoming a major solution. We can reverse climate change, improve farm yields, increase water-holding capacity, build drought resilience, and reduce the use of toxic agrochemicals. Given the urgency of the current situation, the widespread adoption of these systems should be made the highest priority by governments, industry, and climate-change activists.

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