Dara Adegoroye

Professor Maria Savasta-Kennedy

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The Future of Geoengineering and Earth's Atmosphere

Geoengineering, also known as climate engineering, refers to the large-scale manipulation of natural processes to counteract global climate change's effects. Currently, there are two main categories of geoengineering: carbon dioxide removal—a form of geoengineering that intends to remove carbon dioxide from Earth's atmosphere—and solar radiation modification—a form of geoengineering purposed to reflect sunlight into space before it can contribute to climate change. Within these categories, there are many methods of geoengineering such as reforestation and marine cloud brightening that all mitigate the effects of climate change while providing additional benefits. Geoengineering critics say that each of these methods comes with their drawbacks—such critiques are valid. However, the drawbacks of geoengineering are not as severe as climate change's drawbacks, such as habitat loss and an increase in storm severity—in fact, geoengineering can offset these drawbacks as well as other negative anthropogenic impacts on the environment such as deforestation and poor air quality from the use of fossil fuels. Thus, despite the challenges that it may bring, geoengineering provides too many benefits to Earth's sustainability for it to be eschewed.

Carbon engineering directly removes carbon dioxide from Earth's atmosphere, reducing the amount of greenhouse gases that trap infrared light and mitigating global warming. For example, reforestation—a carbon geoengineering method—allows more carbon dioxide to be sequestered in tree tissue. Carbon sequestration is a major contributor to climate change mitigation; Renée Cho states in her article, “Can Removing Carbon From the Atmosphere Save Us From Climate Catastrophe?”, that US’s forests already store 13% of the United States’s carbon emissions and forests globally sequester carbon from a third of the world’s carbon emissions. If nations start reforesting, the amount of carbon that trees around the world sequester will only increase. Reforestation also provides other benefits, such as counteracting increasing temperatures by providing shade and cooling the atmosphere via evapotranspiration, as well as providing habitats to species that might have lost it from deforestation—this also increases biodiversity. However, suppose non-native species of trees are planted. In that case, the environment may not support them as long as native species, causing those trees to decompose faster than normal, which releases carbon dioxide that will contribute to the greenhouse effect. As adverse as this consequence is, it can easily be solved by the proper management of reforestation efforts.

Multiple methods of solar geoengineering modify the atmosphere so that more sunlight reflects into the atmosphere, offsetting anthropogenic causes of global warming. One of these methods is called marine cloud brightening (MCB). MCB modifies certain clouds to have more albedo, or the ability to reflect more of the sun’s UV rays into space. According to David Keith’s research group’s article titled “*Marine Cloud Brightening,*” the most common proposal to brighten marine clouds is to inject natural-occurring sea salt into cloud updrafts. However, MCB and other solar geoengineering tactics can be risky—arguably riskier than carbon geoengineering. For example, altering the composition of the clouds could potentially cause changes in precipitation or other weather patterns, especially if it's used on a large scale. Furthermore, the Keith Research group speculates that MCB can only be used on ten percent of the earth's surface because MCB only works with certain types of clouds (Keith). Research is currently being conducted on stratospheric aerosol injection (SAI)—SAI mimics volcanic eruptions' cooling effect by injecting sulfur dioxide into the atmosphere to form sulfate aerosols that reflect the sunlight. But although this increases the terrestrial carbon sink and it mimics natural processes, this could potentially cause less sunlight to be available for solar power. This effect could be detrimental to many areas as solar photovoltaic cells are used to generate electricity for four-and-a-half percent of the world—this number is expected to increase by twenty-six percent by 2030—leaving sunlight as the third most used renewable energy source behind water and wind (IEA). Additionally, models have predicted that if enough aerosols drift to polar stratospheric clouds, stratospheric aerosol injection could lead to an increase in ozone depletion (Pitari). Solar geoengineering possesses too many risks for it to be a promising geoengineering technology; for it to be used, it's side-effects must be researched more thoroughly.

One of the more recent geoengineering methods is the Bioenergy with Carbon Capture and Storage method (BECCS) currently seems to be the most promising method. The BECCS method is when plants are planted to capture carbon dioxide as they grow; once mature, they are used as biomass that is later converted into bioenergy. While the land converted to grow bioenergy crops can decrease biodiversity, they don't decrease biodiversity as much as when other forms of biomass are used, such as trees. There will be an increase in fertilizer use, which could lead to nutrient runoff and eutrophication, but the nutrient runoff can be mitigated with sustainable farming practices such as contour farming or farming on terraces. There are also geologic storage concerns due to aquifer pollution or carbon dioxide leakage from pipelines—these issues can be stemmed with proper management of the storage, which should be a given. BECCS is essentially a negative emission technology—rather than a natural climate solution like reforestation—in which the plants emit less carbon dioxide than they use like a carbon sink.

Between carbon geoengineering and solar geoengineering, carbon geoengineering is the most beneficial to efforts on reducing the effects of climate change. Solar geoengineering should continue to be researched so that methods under it can be used in addition to carbon geoengineering—but currently, there are too many risks. However, geoengineering is not the sole solution to climate change; it does not change the fact that too many humans are living lives that are not environmentally sustainable. Geoengineering should be used as a complement to climate change mitigation methods, not a replacement.

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