Approaching Afforestation in Unlikely Places

ENERGY INNOVATION REPORT

Planting Trees At Scale

Climate change is rapidly transforming our environment and wreaking havoc on the global ecosystem. At the current level of carbon emissions, global average temperatures may increase by five degrees Celsius by the end of the century.[1] The last time Earth experienced such rapid warming was more than three million years ago, when the temperature was about 3°C higher than during the pre-industrial era, and sea level was up to 25 meters (80 feet) higher than today.[2]

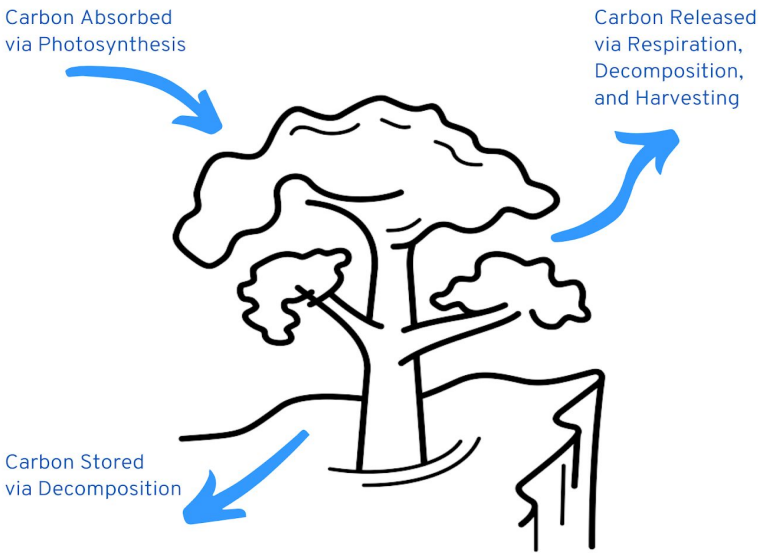
Without urgent and radical action on a large scale, climate change will impose widespread population displacement, rapid ecological degradation, and even death. Still, it's hard to visualize the implementation of large-scale climate mitigation initiatives. Individual activism, such as walking instead of driving or using reusable bags at the grocery store, are well intentioned acts that can alleviate further environmental damage. However, these actions cannot reach the scope of action necessary to curb global emissions.

Coordinated efforts to reforest desertified and degraded land are one such avenue of collectively addressing climate change. Programs such as the Trillion Tree Campaign attempt to achieve this by targeting regions for tree reforestation, but the international community must expand its scope beyond regional forest replacement solutions.[3]

What is Afforestation?

Afforestation is the establishment of a forest or stand of trees in an area where there was no previous tree cover.[4] This strategy can be integral toward implementing carbon capture at a large scale. Through photosynthesis, trees use energy from the sun to take carbon dioxide (CO_2) from the atmosphere, capture the carbon in their biomass, and then release oxygen back into the environment (Figure 1). This natural process can be leveraged to combat and reverse climate change — when implemented quickly and at massive scale.

Figure 1: How Trees Store Carbon Dioxide

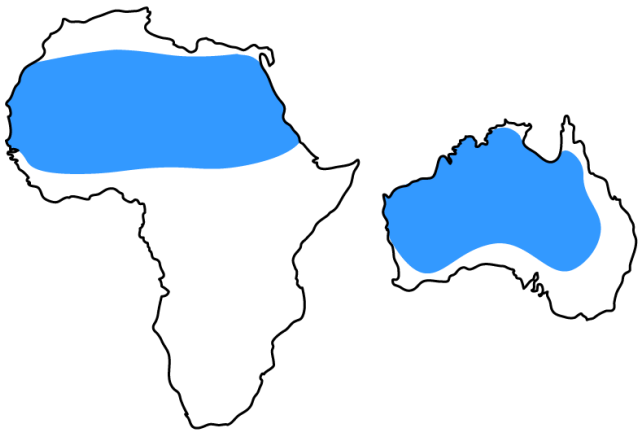


Where can Afforestation Happen?

Planting a few trees across small tracts of land in the spaces surrounding cities and suburbs is not enough to effectively tackle current emissions. Large-scale afforestation is best suited for underutilized and underpopulated regions where the potential disruption to local agriculture and economies is minimized. With this criteria, realistic options for target regions are limited.

To maximize the impact per square kilometer, desert biomes like the Sahara and the Australian Outback could be ideal. These regions are located in sub-tropical zones where a 12-month growth cycle is possible, which helps maximize carbon capture potential.[5] These areas also have the benefit of low population density, agricultural activity, and biodiversity. The Sahara spans 9.8 million square kilometers and the Australian Outback spans 5.4 million square kilometers (Figure 2). In the Sahara alone, if every square kilometer of land could hold about one thousand trees, this would yield nearly 9.8 billion trees planted.[6]

Figure 2: Comparing Targets for Afforestation



Growing A Forest

The harsh conditions of these desert biomes are not ideal for plant growth, as few tree species can survive in these hot, arid, and sandy environments. These parameters further restrict our options for afforestation.

For example, a silver maple tree can capture up to 11.33 metric tons in 55 years and is considered one of the best trees for carbon sequestration.[7] Unfortunately, silver maples thrive in moist, semi-soggy soil along ponds or creeksides — the opposite of the climate in the Sahara or the Australian Outback.[8]

The type of tree planted in these target regions must be evergreen, fast-growing, suited to the climate, and useful as a commercial resource. Unlike the Silver Maple, the Australian Eucalyptus Grandis fills all of these requirements. It is native to the east coast of Australia and prized for its commercial use. The Eucalyptus Grandis has been successfully tested for pulpwood and fuel; and its wood has potential for other products, such as poles, pallets, or veneer.[9]

Water Sources

Planting 9.9 billion trees in the Sahara would require about 4.9 trillion cubic meters of water. Unfortunately, water is a particularly scarce resource in a desert biome. Using the Nubian Sandstone Aquifer System may provide some support, but since the system is not renewable it will not be a sustainable solution in the long term.[10]

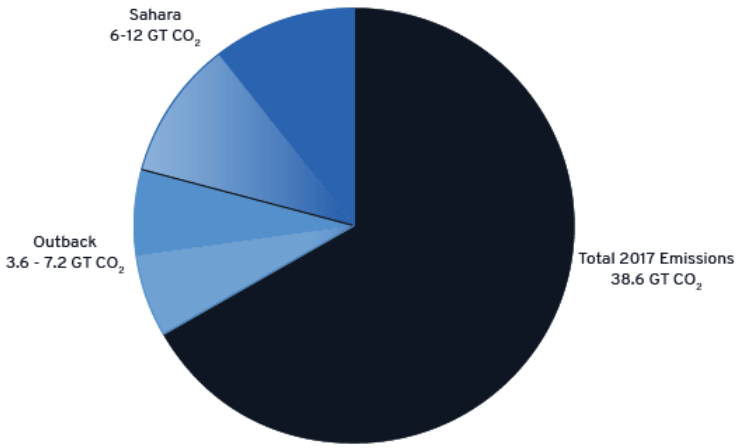
Recent developments in desalination technology, however, could help provide the water necessary for afforestation. Currently, one-third of irrigation water in Israel originates from saltwater treated at more than 150 plants. By 2025, the Israeli system aims to produce 1.1 billion cubic metres of desalinated water annually.[11]

Benefits and Costs

Afforestation of the Sahara would increase the world population of trees by about 33%. This new forest would capture from 6 to 12 gigatons of carbon, accounting for 16.3%–32.6% of emissions per year (humans produced 38.6 gigatons in 2017) once the trees are fully matured. Adding the Outback to these figures, which is 60% of the size of the Sahara, the best-case scenario would be capturing 50% of the world's emissions and bringing emission levels to those of the 1970s.

However, there are multi-order externalities to consider before implementation. The amount of water needed to cultivate this volume of trees would be extremely costly to produce. Although desalination is cheaper than it used to be, it would still be too expensive at the level of energy necessary: 4.5 kilowatt-hours per cubic meter of water.[12] While solar and biomass energy with carbon capture technology have the potential to address this energy constraint, the cost would still be in the trillions of dollars.[13]

Figure 3. Carbon Sequestration Potential of Afforestation of the Sahara Desert and Australian Outback compared with Global CO_2 Emissions



Beyond irrigation, this sudden and far-reaching ecological shift would have a significant impact on the ecosystems therein. Increased soil moisture levels would begin the process of evaporative cooling, affecting local temperatures drastically. As cloud cover increases so would local precipitation; this may benefit the irrigation effort but may also impose unpredictable ecological shifts. There is also the potential for the forest cover to prevent beneficial global Saharan dust dispersal, disrupting fertilization and the flow of nutrients typically carried to ocean ecosystems and the Amazon.

This level of afforestation would even modify the Earth's albedo (a measure of how reflective a planet's surface is). The higher the albedo is, the less absorptive the planet is, which causes higher temperatures.[14] Forests, as such, absorb solar radiation by decreasing the regional albedo. Due to the reflective quality of sand, this shift could be significant. However, clouds formed through evaporative cooling may also counteract this albedo change.

Afforestation in Practice

The Great Green Wall (GGW) in the Sahara is a first step toward a coordinated afforestation effort. On the *World Day to Combat Desertification and Drought* in 2002, members of the Community of Sahel-Saharan States discussed the need to combat increasing desertification in the region and approved a plan to plant an 8,000 km line of trees.[15]

Nearly 20 years since its modern conception, the GGW has stalled with only 15% of the targeted acreage having been planted by 2016, where most of the responsibility of planting falls on individual states.[16] As of 2021, the international community has provided nearly €7 million Euro directly to the UN Convention to Combat Desertification, and an additional $14 billion USD has been pledged toward the project.[17]

Conclusion

The literature on the potential impacts of afforestation is inconclusive. There is limited evidence in favor of the technique when considering the costs of labor and resources necessary for operation, while discounting the additional externalities which may result from the process. If policymakers are able to implement this strategy at scale, however, there is the potential to take a definitive step in combating global climate change by increasing the global population of trees by 33%. Translating to a 33% reduction of current global emissions, reaching levels comparable to the 1970s.

Endnotes

Further information, references, and hyperlinks

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