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Solutions to Combat Anthropogenic Climate Change Impacts: A Review of "Drawdown"

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Abstract

The *Drawdown* book surfs through 100 possible solutions and technologies. Those solutions could help mitigate GHG emissions in order to constrain climate change. In this book review, we examine the estimated CO_2 reduction levels as well as the costs of each solution. Alternative cement, smart thermostats, and geothermal energy are the top cost-effective solutions. We, however, discuss our top five solutions, according to the combination of their potential drawdown, cost effectiveness, and future development. Those solutions target refrigerants, wind energy, food, cement, and female education. Overall, the book could inform people with little or no knowledge about well-known solutions to mitigating climate change footprints. Nevertheless, the numbers and costs are too speculative to ponder for policy making.

Highlights

- We review a book, titles "The Drawdown" edited by Paul Hawken.
- The book suggests 100 solutions to reduce climate change impacts of anthropogenic activities.
- Alternate cement, smart thermostats, and geothermal energy are the most cost-effective solutions.
- We explore our top 5 solutions as: refrigerants, wind turbines, reduced food waste, alternate cement, and educating girls.

Keywords: Sustainability; Global Warming; Climate Change; Greenhouse Gas Emissions.

1. Introduction

We review *Drawdown: The Most Comprehensive Plan Ever Proposed to Reverse Global Warming*, edited by Paul Hawken (Hawken, 2017), a New York Times best seller book. Prior to discuss book's limitations, we like to praise the author's courageous attempt to compile a comprehensive set of strategies for managing GHG emissions. As the author claims, this set of solutions could allow us to "overcome fear, confusion, and apathy surrounding climate change, and take action as individuals, neighborhoods, towns, cities, states, provinces, businesses, investment firms." Despite providing a few solutions, the book ultimately does not live up to the promise of this claim.

2. Existing and Forthcoming Solutions

A variety of local, national, international institutions search for strategies/policies to combat climate change (Rouhani, 2013). *Drawdown* recommends 80 solutions and 20 attractive future technologies called *coming to attractions*. Let us first examine the CO_2 reduction levels offered by each solution.

Figure 1 shows all solutions separated into seven categories: food, energy, land use, women, materials, buildings and cities, and transportation. The size of each pie shows the reduction that each solution could offer by 2050. As can be seen in the figure, food-related solutions provide the highest total "drawdowns," followed by energy and land use. The author estimates that food-related solutions reduce CO_2 emissions by 319 gigatons. Note that the book's potential total "drawdowns" (1,044 gigatons) are substantially higher than those estimated by other studies, see for instance Pachauri and Meyer et al. (2014).

The book's top 10 GHG-reducing solutions in terms of magnitude are: refrigeration (89.7 gigatons), wind onshore (84.6 gigatons), reduced food waste (70.5 gigatons), plant-rich diet (66.1 gigatons), tropical forests (61.2 gigatons), educating girls (59.7 gigatons), family planning (59.6 gigatons), solar farms (36.9 gigatons), silvopasture (31.2 gigatons), and solar rooftop (24.6 gigatons). In total, the top 10 solutions offer 56% of total reductions. Furthermore, 9% comes from more efficient refrigeration techniques.

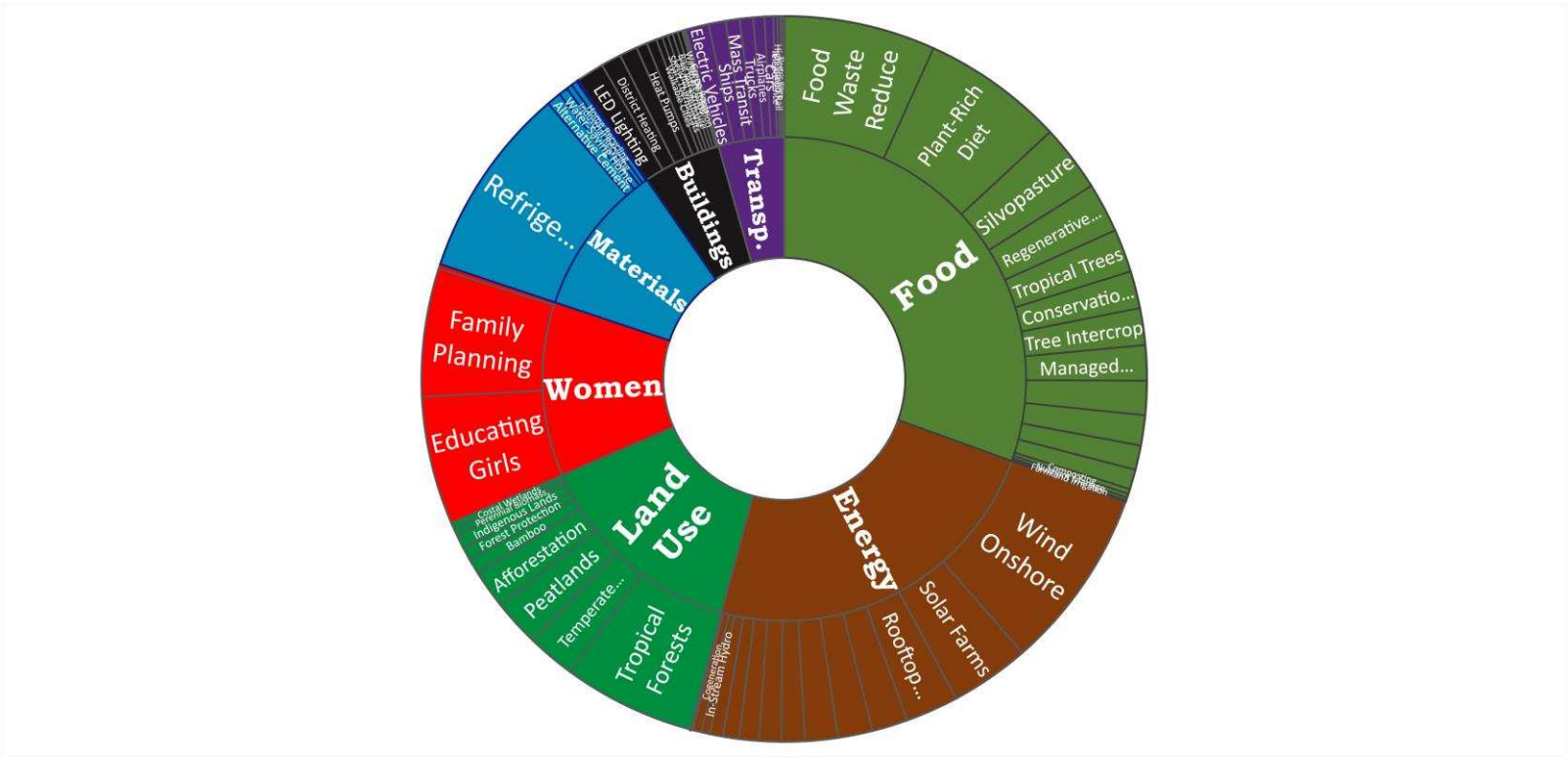

Figure 1: **CO_2 reductions by category/solution**

We also examine the estimated cost effectiveness of each solution (Rouhani et al., 2016; Rouhani and Beheshtian, 2016). Note that the cost values are not reliable, or at least are questionable. First, and perhaps most problematic, the estimated costs have no defined real values, i.e., no particular year of dollar. Furthermore, point estimates are becoming obsolete. Rather, a more robust methodology uses ranges with confidence intervals. For instance, see the Intergovernmental Panel on Climate Change's (IPCC) approach (Pachauri and Meyer et al., 2014). Despite these drawbacks, we study the cost-effectiveness of each solution. The top three cost-effective solutions (in terms of $/ton) are: (1) alternative cement using fly ash (-$150/ton); (2) smart thermostats (-$41/ton); and (3) geothermal (-$9/ton). Rather imposing costs, each of these options offer substantial monetary benefits by 2050.

3. Our Top Options

In the following, we provide a brief summary of our top five solutions. These solutions reduce GHGs significantly, require reasonable costs, and offer great futuristic potentials.

Our first choice is "Refrigerants". According to the book, refrigerants offer the highest GHG drawdowns out of all solutions. However, we could not rank this option

in terms of cost effectiveness because the book does not report its costs. Every refrigerator or air conditioner contains refrigerants, traditionally chlorofluorocarbons (CFCs) or hydrochlorofluorocarbons (HCFCs). These chemicals have been replaced by hydrofluorocarbons (HFCs) to decrease the Ozone depletion potentials. Released usually at the point of disposal, HCFCs have 1,000 to 9,000 times greater global warming potentials (GWP) than CO_2. The Kigali agreement in 2016 (Tollefson, J., 2016) mandates the phase out of HFCs. As cooling technologies proliferate, better refrigerants/management will become available. Although this solution offers the highest drawdowns, the process of phasing out HFCs will take many years. Before finding a replacement, policy makers should pursue strategies to purify, reuse, or transform HFCs into harmless chemicals. A large drawdown could be achieved by phasing out HFCs. John Kerry, the former U.S. Secretary of State, titles these chemicals as "the biggest thing we can do in one giant swoop" (New York Times, 2016).

Second, "Wind turbines" offer one of the cleanest energy sources while being relatively inexpensive. In terms of drawdowns, wind energy is ranked second (reducing 84.6 giga tons) using only onshore sites, and first (reducing 97.8 giga tons) using both onshore and offshore sites. It can reduce up to 98 giga tons if you add micro wind. However, in terms of cost effectiveness, it is ranked 26th using the most-cost-effective technology: onshore wind turbines ($15/ton). In 2019, wind turbines supplied around 5.9% of global electricity (REVE, 2020), with a 20% increase from 2018 to 2019 (IEA, 2020). The technology has been improved substantially after the oil crisis of 1970s (Hu, 2018). The ongoing cost reductions could make wind energy one of the least-expensive electricity sources, in regions where the wind potential is available (Wiser et al., 2016). However, its energy is intermittent (Kousksou et al., 2014). Nevertheless, wind energy is extremely environmentally friendly. Apart from its climate change and air pollution benefits, it uses substantially less water (98% less) than fossil-fueled electricity (Madani et al., 2011; Hawken, 2017). To secure future wind energy's growth, we should invest in its energy storage, transmission, and distribution.

Ranked third in terms of drawdowns, our next solution is "reduced food waste". According to the book, livestock emissions account for around 20% of global GHGs, a second source after fossil fuels. The food-related emissions could be reduced by 36%. The "reduced food waste" solution provide 71 gigatons of reduction (8% of all potentials) and can mount up to 137 gigatons (16% of total) if combined with a plant-rich diet. Despite the existence of hunger worldwide, "A third of the food prepared does not make it from farm or factory to fork" (Hawken, 2017). The key reason in low-income countries is poor infrastructure and in high-income countries is related to aesthetic/luxury objections, i.e., food is tossed out easily (Parfitt et al., 2010). In this regard, the UN sustainable development goals call for halving of "orphaned food" by

2030 (United Nations, 2020). The book points out to several initiatives. Italy and France have passed similar laws requiring supermarkets to send their food wastes to charities or animal feed (BBC, 2016; NPR, 2018). Most adults worldwide consume more meat than the healthy amount. As a result, "plant-rich diet" combined with "reduced food waste" could save lives, in addition to mitigating climate change impacts substantially.

We chose our fourth solution according to its cost-effective advantage. "Alternate cement" is the best solution, offering $41/ton in benefits. Concrete is one of the most-used materials in today's structures. It could become much less carbon-intensive by using fly ash in cement (Yu et al., 2017). Fly ash is a by-product of burning coal. For coal-dependent countries, it provides a clean substitute for conventional clinkers. Although very promising, the health implications of fly ash are still uncertain (PSR, 2018).

Our last solution is "Educating girls". It could offer 59.7 gigatons of CO_2 drawdowns. The reduction increases to 119.3 gigatons if combined with family planning. "Educating girls" also offers the highest positive spillovers to other sectors of economy. In fact, educated girls as potential future moms "have fewer healthier children and actively manage their productive health" (Hawken, 2017). Studies indicate that females' education is the single most important social and economic factor in reducing vulnerability to natural disasters (Otto et al., 2017). Moreover, "Educating girls" can control population growth as an important factor driving the global increase of GHG emissions (Allen et al., 2014). Finally, this solution could also offer important co-benefits to society, ensuring rebound economic effects (Duflo, 2012).

4. Conclusions

Despite its limitations, we recommend this book to uniformed readers about solutions to mitigating the climate change impacts. The author should be commended for his exemplary optimism and his conviction that humans can overcome climate change. The numbers, however, are too speculative to use for climate change policies. Furthermore, the book comes short of offering deep understanding regarding the approach to manage GHG emissions.

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