The Impact of Green Roofs on Climate Change

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Introduction

Climate change is an issue of increasing importance due to the growing population and urbanization of cities. Climate change is how the weather and temperature are changing around the world. One factor of climate change is stormwater runoff. Water drainage is a problem in cities with many human-caused buildings because materials like cement do not absorb water. These non-absorbent surfaces replace natural materials like soil, plants, and trees. When there is more rainfall than the drainage systems can account for, there can be dangers of flooding in the cities. Runoff is a problem because it leads to water pollution as rainwater collects pollutants through the city and leads into natural bodies of water (such as lakes, rivers, and oceans). Excess nutrients in these bodies of water (eutrophication) lead to incredibly low biodiversity for marine life. Another aspect of climate change is global warming. Global warming is the increase in temperatures globally caused by excess greenhouse gases in the atmosphere. Greenhouse gases are mostly carbon and come from fossil fuels from things like transportation and electricity. The urban heat island effect is the increase in temperature in cities caused by the buildings in these areas. According to the article, "Green roofs and facades: A comprehensive review," "In European countries, 36% of total greenhouse gas emissions is attributed to buildings" (Besir et al., 2018 pg. 917). With an increase in the global temperature, there is a risk to the life of humans and there can be a serious decline in the biodiversity of life on earth. This essay investigates how urban green roofs influence climate change. Urban green roofs are buildings in cities with plants growing on the roofs. By adding plants back onto the buildings, they can minimize the urban heat island effect, absorb a major greenhouse gas (carbon dioxide), control stormwater runoff, and insulate buildings. It is important to consider the materials and cost for urban green roofs and the best ways to utilize them.

Methods

The sources used to create this essay are all secondary sources. This means that the sources have done their own research and in-depth analysis of the topic. All the sources referenced in this essay come from the FSU (Florida State University) library and are peer reviewed. This gives them credibility because they have been read by multiple trusted people in the field before being published. The purpose of using secondary sources to create this essay is to gather data and perspectives from multiple aspects surrounding the topic of greenery in urban areas. The method for finding the specific sources within the FSU library is to search key terms that lead to answering the research question. Some of the key terms used to find the sources include urban green roofs, climate change, global warming, runoff, urban heat island effect, and sustainability. Each source has a different focus than the other sources which is helpful for contributing to the essay in a unique way. All the sources also relate to each other, which allows them to be easily tied together to create one cohesive investigation.

Results

The urban heat island effect occurs in cities due to the various heat-inducing conditions within cities. The materials that buildings are made of conduct heat which becomes trapped within the city because the air flow is limited by the buildings. This leads to the conclusion that "the temperatures in our cities are likely to increase up to 8 ^{o}C [46.4 ^{o}F] further due to the urban heat island effect" (Soltani et al., 2017, pg. 536). The rise in temperatures has a major impact on climate change. During urbanization, when buildings are constructed, trees and forests are cut down to make room for cities. Urban areas have less shade from trees, which increases urban temperature compared to rural areas. Besir et al claims, New York City is 2^{o}C (35.6^{o}F) warmer on average than the more rural parts of New York because of the difference in vegetation and the

urban heat island effect. Green roofs can be beneficial to cities because areas with more plants are cooler in temperature. When plants are grown on buildings in cities, the temperature decreases. To investigate how green roofs impact temperature, "research conducted in south Italy reveals that green roofs (without any insulation material) are cooler by about 12°C [53.6°F] in comparison with conventional roofs according to the average surface temperature measurements in summer" (Besir et al., 2018, pg. 920). This piece of evidence is valuable because it highlights how the green roofs that have been implemented have had success in terms of decreasing the temperature of buildings. This can help slow down climate change by reducing the speed that temperatures around the world are increasing. Besir et al and Soltani et al agree that green roofs can lessen the worsening of the urban heat island effect. Although this is true, Besir et al focuses more on structure and design and adds how vertical greenery on the walls of buildings in addition to the roofs is essential because walls have more surface area than roofs (Besir et al 2018, pg. 918). On the other hand, Soltani et al outlines a study about how temperature changes throughout the day, season, and location in various parts of Adalaide, Australia to determine what factors contribute to climate change and the urban heat island effect. They found that the urban heat effect is the highest at night in the winter. The city buildings block the wind, causing calmer weather and trapped heat within the city.

A well-known component of climate change is global warming, the rising temperature of the earth. Cities contribute to global warming largely because of the burning of gasoline from vehicles and the use of fossil fuels to power electricity in buildings. Surprisingly, buildings alone account "for roughly 40% of the total primary energy consumption and for about one-third of the overall CO2 emissions, causing the global warming and the energy cost rising" (Cascone et al., 2022, pg. 1). Because of buildings' massive carbon footprint, there is a need for more sustainable

methods such as green roofs. To make green roofs a reality, the proper materials need to be used for the most efficient outcome. In the article “Effects of Biochar and Sludge on Carbon Storage of Urban Green Roofs,” an experiment was performed in China at Nanjing Agricultural University to determine whether biochar or sludge is better to use in the soil of plants on roofs in urban areas in relation to the effectiveness of carbon (a major greenhouse gas) storage. Biochar is made from heating up and drying sludge in a process known as pyrolysis. Both sludge and biochar have useful nutrients for plants’ growth. Sludge has some potentially dangerous chemicals and the idea of creating biochar from sludge was to eliminate the dangers. The experiment found that sludge and biochar both increase carbon storage on green roofs, but biochar had better results than sludge as stated in the hypothesis (Chen et al., 2018). This means that using biochar as a substrate on green roofs can decrease global warming. By reusing the materials for the biochar from a local sewage treatment factory at Jinhua, Yongkang, in Zhenjiang Province, this resource does not have an unwanted negative impact on the environment. This experiment by Chen et al is like the study in the article by Cascone et al because they both focus on using materials sustainably. They are different because Chen et al reuses sewage to help with absorbing carbon dioxide and Cascone et al recycles plastic for maintaining stormwater runoff on green roofs. There is more about the study done using recycled plastic in the following paragraph.

Controlling stormwater runoff is an important aspect of climate change because there are more intense storms and rainfall from the changing climate. When the atmosphere is warmer, more evaporation occurs which results in more rainfall. Because cities have materials like concrete that do not absorb water, there is flooding. The materials used in green roofs are crucial to absorb water to avoid excess water from becoming runoff in the streets. The article written by

Cascone et al focuses on a laboratory test done to study the drainage of recycled polyethylene plastic granules in green roofs. Perlite, a common material used for the drainage of plants is perlite. Perlite has some disadvantages including producing fly ash-based aggregates and coal bottom ash, which negatively impact the environment. The article studied recycled plastics in five separate ways and measured permeability, particle size, weight, and density as plant drainage in a laboratory setting. Cascone et al concluded that recycled plastic is better than typical drainage products because they are lighter in weight, more sustainable, and are reused from agricultural waste and greenhouses so there is not a need to produce more resources. By reducing the amount of runoff in cities, it can reduce water pollution because pollutants in the city get picked up less by the runoff. A bolder statement is that "green roof implementation can fully counteract the impacts of climate change on stormwater runoff of urban catchment under 1-year storms compared to the base catchment scenario with no green roof implementation" (Liu et al 2023, pg. 9). This piece of evidence is supported by numerous other studies as stated by Liu et al. Even though Liu et al writes that green roofs are a great solution to stormwater runoff, there are limitations to where, by who, and how green roofs can be fabricated. Cascone et al studies the use of recycled plastic as a material on green roofs and Liu et al explores the costs and how to implement green roofs.

Green roofs can create better insulation inside buildings and energy efficiency. According to Soltani et al, Air conditioning inside buildings causes more heat to be released into the atmosphere. Air conditioning heats the atmosphere because of the electricity used to power the unit. People use air conditioning because it is hot outside, and more air conditioning is used for indoor comfort which creates an endless cycle. Greenery around the building naturally decreases

the temperature inside buildings which reduces the need for high energy air conditioning. Therefore, green roofs insulate buildings and save energy.

Many of the sources give mostly positive results regarding urban green roofs. However, both Barriuso et al and Liu et al acknowledge the high price that comes with building and implementing the structures for green roofs. Barriuso et al mentions that further analysis of the price is needed to make the smartest choices for how green roofs are put into place. The article written by Lui et al looks closely at the costs for green roofs. This relationship shows how these sources fit together in the conversation on green roofs and climate change. Because of the higher price than typical urban construction, poor countries might not be able to afford green roofs and will not be able to try implementing them even if they wanted to (Barriuso et al, 2021). This problem of unequal wealth around the world needs to be addressed because climate change is a global issue but not all countries have the resources for this complex solution. One solution to making green roofs affordable is "in Germany, where 83.5% of greening projects are extensive systems that offer a more cost-effective solution over intensive systems" (Barriuso et al 2021, pg. 9,10). Extensive systems have thinner layers of substrate and tend to cover larger areas while intensive systems have thicker layers of substrate and cover a smaller area. The article by Liu et al focuses on the cost of extensive green roofs in relation to managing stormwater in cities. This means that Barriuso et al provides a comparison between intensive and extensive systems while Lui et al does not investigate intensive systems. According to Lui et al, green roofs are expensive so it can be more economical to combine the green roofs with other, more common drainage systems in urban areas. This combined method can be a better way to reduce excess stormwater without paying a cost that is not able to be sustained. Policies cannot be put into place if they are not affordable.

Climate change is a global issue and various parts of the world struggle more in certain areas than others. Barriuso et al provides a distinctive perspective on this by explaining how each continent has certain aspects in the environment that contribute to worse climate change. The studies in this article show that green roofs and walls used in tropical and arid climates are more effective in holding stormwater. This is why America and Europe are better suited for focusing on the purposes of decreasing runoff and insulation. The slopes in Africa also suggest that they would be good for managing runoff (Barriuso et al 2021). Asia has the most use of urban green roofs and walls already and the study showed that they should attempt to bring down the temperature with the climate they have.

There are many researchers who agree green roofs can be beneficial for many reasons. At the same time, there are researchers who doubt the ability to make the plans a reality due to resource limitations. While there is overlap between the studies that each researcher conducts, the differences between the findings are valuable because climate change is a complex issue that takes many perspectives and approaches to thoroughly understand. The evidence shows that green roofs have a decent impact on climate change which means that to make this plan a reality, comparing results from research around the world is a key step to take in the development in this technology. Because climate change is a global issue that no part of the world is excepted from, evidence from each country is vital in understanding the scientific explanation for the problem and the solution.

Conclusion

Green roofs can minimize the urban heat island effect, absorb a major greenhouse gas (carbon dioxide), control stormwater runoff, and insulate buildings. It is important to consider the materials and cost for urban green roofs and the best ways to utilize them. Green roofs

mitigate the urban heat island effect by providing a more natural surface that is not a conductor of heat. When plants carry out cellular respiration, they absorb carbon dioxide from the atmosphere which slows global warming. Plants on buildings absorb water and reduce flooding in cities. Even though green roofs have been successful in many places including Germany, Canada, the United States, Singapore, Australia, Japan, and Portland, there are setbacks to expanding this solution including lack of availability to resources and poor economic state of certain communities. Climate change is a global concern because there are cities all over the world and "the population living in cities is expected to increase up to 67% by 2050" (Besir et al., 2018, pg. 915). This statistic originated from a report of the United Nations, and it helps illustrate how urbanization is a growing issue that needs to be addressed for the future. There is more research to be done on how to help poor countries implement green roofs and what the most sustainable methods and materials are.

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