

Greening Cities from Above

Cities across the globe increasingly view green roofs as a practical step of sustainable urban development. Green roofs, also referred to as living roofs, are the practice of incorporating vegetation to the roofs of buildings, including layers for drainage, growing media or soil, and waterproofing [1]. From this, a number of benefits are derived, including stormwater retention, urban heat island mitigation, improved energy efficiency, and increased biodiversity [1]. Since the late 1990s, city and national governments have utilized a number of different policy tools to advance this nature-based climate solution, ranging from voluntary incentives to strict mandates [2]. In the United States, cities including Denver, Portland, New York, Chicago, and Seattle have implemented policy in a variety of forms. Internationally, cities including Toronto, Munich, and nationwide efforts in France further utilize a variety of policy tools to encourage implementing green roofs with their broader plans for sustainable development. These policies supports both climate mitigation, by lowering building energy use for example, and climate adaptation, through areas such as stormwater impact relief. Understanding the landscape of policy for green roofs is essential in order to identify gaps, as well as to design stronger and more equitable plans.

This analysis examines these diverse policy approaches through case studies, each of a different policy mechanism. The tools examined are general sustainability mandates, tax credits, zoning incentives, grants, stormwater fee reductions, and green roof mandates. Through analyzing these individually, as well as recognizing their overlap in some cities, it can be identified how different tools influence areas such as scalability, equity considerations, and durability of projects over time following implementation. With this, broader patterns emerge regarding failures in design of policy, vulnerabilities to opposing political stances, as well as ideas for more effective laws going forward. Using this analysis structure, it also highlights how different types of policy interacts with each other and how combining techniques can create more impactful and equitable results than any singular policy tool.

One example of the general sustainability mandate approach is Denver, Colorado's Green Building Ordinance, enacted in 2018 [3]. This ordinance applies to new buildings of 25,000 square feet or larger, permits for roofs of this size, or new additions to buildings [3]. Developers of buildings meeting this criteria must select from a number of sustainable development options, one of which is the installment of a green roof, the percentage of which increasing with building size [3]. As this targets large buildings at this municipal scale, within the City of Denver, it targets those who already have a higher ability to take on the extra costs often associated with sustainable development choices. As permits must be approved by the city, regulation to this ordinance can be well tracked, and the multiple choices which are available for the general sustainability mandate approach to green roof implementation allow success towards sustainable development [4]. The flexibility of this policy increases participation, but also introduces the unintended consequence that developers may choose the lowest cost alternative over green roofs [4]. Still, with this policy taking into effect at the point of construction, it reduces barriers associated with new implementation of sustainable design, such as with green roofs.

Philadelphia's Green Roof Tax Credit, established in 2007, represents a different policy tool [5]. Through this voluntary financial incentive, it initially offered a credit for 25% of installation costs up to \$100,000, this was expanded to 50% in 2016 in order to further encourage

adoption by reducing potential financial barriers [5]. In order to further support the implementation of green roofs, it has a five year maintenance requirement, supporting environmental impact, but still setting a relatively short timeline for the overall project to have a very limited impact [5]. The program ultimately had a very limited impact, emphasizing the constraints of voluntary incentives in a number of cases. Between 2011 and 2015, only four applicants used the credit, revealing a pattern true in many cities that financial incentives in their singularity still fail when initial costs are high [6]. This example shows how tax credits usually only benefit those who already favor sustainable design choices, and even then, results and response may remain minimal.

Moving on to incentives in terms of zoning, Chicago, Illinois' FAR (Floor Area Ratio) Bonus, enacted in 2015, provides another way in which green roofs can be encouraged [7]. By allowing developers to expand the floor coverage of buildings in downtown Chicago, but only if they incorporate green roofs or other sustainable design elements, this policy primarily impacts areas in the city's dense downtown [7]. With this, the economic benefits provided to the developers directly also provides a public quality-of-life benefit. While data on Chicago's program are limited, a similar incentive in Portland resulted in over eight acres of green roofs across 130 projects between 2008 and 2012 [8]. By offering developers significant economic value through additional leasable space, something not easily attainable through other avenues, zoning incentives provide a unique value for policy. However, because this type of policy tends to apply to areas where real estate is already of high-value, inequities on a geographic scale can be further reinforced. Lower-income neighborhoods, which often would benefit most from reduced heat and improved stormwater infrastructure, would see less development that would take advantage of the described zoning incentives. This approach can result in implementation in densely developed areas, but still from a spatial scale, impact is uneven unless policy complementing it targeting underseved communities is incorporated as well.

Included within Portland's border approach towards green infrastructure is their initiatives which emphasize the value of multiple layers of policy. On top of zoning incentives, the city implemented two grant programs the Green Investment Fund from 2005 through 2009, and the Grey to Green Initiative from 2008 through 2013 [2]. These programs both rewarded direct financial support for innovation, as well as \$5 per square foot for green roof installation [9]. These grants helped the city explore early implementation, as well as allowed local experts to begin to gain understanding of vegetative roof systems. However, like many grant programs, inherently limitations existed in budget constraints, competition for innovative projects, and the necessity for long-term monitoring [9]. This case of grants in Portland emphasizes how they can be used in order to encourage early adoption and understanding of new sustainable development, but reliance on grants as a sole incentive is risking failure and a fast retirement for green roofs.

Stormwater fee reduction programs are yet another approach, and Washington D.C.'s program as served as a leading example since 2013, housed within their RiverSmart Rewards and Clean Rivers Incentive Program [10]. In this, property owners can receive up to a 55% reduction on stormwater utility fees if they implement best management practices for reducing runoff, including green roofs [10]. As the discount is associated with the specific amount of runoff retained, individuals and developers are further incentivized to not just implement the bare minimum of stormwater infrastructure, but to use a variety of ways to retain water, including green roofs, particularly for larger buildings [10]. This policy allows for a continuous incentive, if participants continually maintain and implement stormwater management best-practices into their property [10]. As the program applies across all building types, including anywhere

between single-family homes to large commercial buildings, it has the potential to have a broad impact on a geographic scale [10]. Limitations of this type of policy still lie within its voluntary nature, as well as creating a barrier for lower-income property owners and neighborhoods. Similar to other policies for green roofs, including zoning incentives, it may lead to further inequities, reinforcing uneven distributions of innovative climate-smart infrastructure.

Much of the prior described policy incentivizes or funds the creation of general sustainable development, but still provides the creation of green roofs as an option for individuals or developers to take in order to receive their monetary benefits. One final area existing in many cities and one country globally does not provide these incentives, but rather directly mandates the installation of green roofs under appropriate circumstances. Often mandates address new construction or significant renovations of buildings, leaving smaller structures exempt. As previously addressed in general sustainability mandates, there also often are options for sustainable developments within this scope, which may decrease environmental benefits in some cases, but also increase in others where varied stormwater infrastructure may be valued, for example. Ultimately, green roof mandates allow a minimum level and ensure success of some form occurs for this climate solution.

The first city in North America to mandate vegetated roofs in some form was Toronto, Canada, with the Green Roof Bylaw being introduced in 2009 [11]. This mandate was in place for construction over 2,000 total square meters of floor area, had standards which always must be met, and the percentage associated with green roofs increased with size of buildings [11]. Even though it resulted in over 1,200 green roofs in the city, the bylaw was repealed as of November 5, 2025 as the city could no longer afford “costly boutique requirements,” moving this mandate back to voluntary [12]. Toronto exemplifies the successes and failures which often lie in green roof policy. On one hand, their mandate was a success, thousands of vegetation roofs were constructed, jobs and knowledge of construction and upkeep were formed, and direct benefits of the climate solution were seen in this city [12]. Yet, on the other side, it is a reminder that mandates are not always permanent, even if they do last over fifteen years. A local law, within the City of Toronto, was repealed by higher-level law in the province of Ontario, emphasizing the necessity of policy at a larger scale to create lasting impact in a time where local sustainability initiatives can be overridden if political climates change at a higher level.

As noted in various examples of incentives, grants, and funding for green roofs, a major gap in policy is rather low coverage, as the majority of policy is voluntary, or simply underfunded. Although a number of cities can be seen to have significant results in cooling, stormwater management, and beyond from the various positive climatic related impacts of green roofs, these are of the very small minority compared to the many failed, repealed, or low-success policies which exist globally. Another consistent gap throughout a number of different forms which policy for green roofs take is that of equity. In examples of Portland, Chicago, and Washington D.C., due to the nature of incentives discussed, inequities were likely furthered, and areas where there is a lack of stormwater infrastructure, or exacerbated effects of the urban heat island effect are denoted, are simply not impacted by this policy [7, 8, 10]. As noted in the low-success rates of some policies, such as in Philadelphia, credits can be seen to only benefit those who can afford it, and even if they can, they still may not in order to maximize profits, emphasizing the necessity for increased incentives for success [6]. One additional major gap is in regulation following construction. Throughout types of policy, further monitoring and accountability after a project is built is necessary to not just ensure proper environmental benefits, but as well as to ensure no negative externalities are suffered.

Moving forward, much action must be taken in order to create effective policy to increase the enactment of green roofs globally. Effective policy should be developed with considerations to local populations, considering and prioritizing areas which are identified as urban heat hot spots, as well as those especially prone to flooding. Mandates coupled with incentives to create green roofs in these areas specifically can result in broader, and more equitable, impact. This goes into the next step in order to improve existing green roof policy. Alone, mandates can be greatly influential and successful, but can be improved through diversifying the types of policy involved in this form of sustainable development. Through including policy in areas of stormwater charge reductions, zoning laws, and beyond such as incentivizing areas of the most need for this type of infrastructure, it becomes much more difficult for policy to be nearly entirely discarded, such as the case for Toronto.

Green roofs as a climate solution have already begun to improve the day-to-day lives of citizens in a number of cities globally. Yet, policy is not fully aligned in order to scale these potential impacts. By comparing diverse policy approaches, from zoning incentives to grants to mandates, it becomes clear that no single tool is sufficient on its own. The most effective and equitable strategies for policy which promotes green roofs must combine multiple tools, address existing and reinforced inequities, and ensure the long-term maintenance and stability of projects. As cities increasingly face climatic challenges, strengthening green roof policy can represent one area of climate policy which creates more resilient futures in urban areas.

Sources

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