

Rooftops for Whom? Some Environmental Justice Issues in Urban Green Roof Policies of Three North American Cities

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Abstract. Green roofs provide multiple benefits to households and urban neighbourhoods by lowering temperatures, reducing energy costs, and reducing stormwater runoff. However, green roofs are expensive and may not be available to all residents, which raises questions about who benefits from green roofs and urban policies that support this technology. Policies to support different social groups' access to this green infrastructure is important for achieving equity. This study aims to identify and analyze to what extent existing different rooftop greening incentives and mandatory policies in three American cities, including New York, Chicago, and Philadelphia, address environmental justice. Nine policies were analyzed from three cities based on three dimensions of environmental justice. The results show that all policies have neglected a degree of distributional, recognitional, and procedural environmental justice in their policies. Although incentives try to advance distributional justice by implementing green roofs in different parts of the city, these policies do not pay enough attention to support themes such as zoning, size, rental status, land value, and affordability in all urban areas.

Keywords: Green roof, environmental justice, green infrastructure, urban policy

1. Introduction

Urban green infrastructure (UGI) is increasingly recognized as an essential part of urban and public policies among policymakers and governments worldwide. Over the last two decades, developing new types of UGI including but not limited to green roofs, green walls, and community gardens in cities by providing financial incentives and policies has been widely expanded in North America, Europe, East Asia, and some other countries.¹ To mitigate climate change impacts and enhance health benefits, cities are rapidly exploring new UGI such as green roofs (GR). GRs provide multiple ecosystem services to mitigate climate change and urban heat islands by lowering local air and surface temperatures, preserving biodiversity, promoting food security, supporting energy

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1 P.J., Irga, J.T., Braun, A.N.J., Douglas, T., Pettit, S., Fujiwara, M.D., Burchett, F.R. Torpy (2017) "The distribution of green walls and green roofs throughout Australia: Do policy instruments influence the frequency of projects?" *Urban Forestry and Urban Greening* <http://dx.doi.org/10.1016/j.ufug.2017.03.026>

savings, and reducing stormwater runoff.^{2,3,4,5,6,7,8,9} Sustainable rooftop systems have gained in popularity in the United States over the last decade.¹⁰

A green roof is a vegetated roofing system which is functionally integrated onto a roof area. Green roofs can support city sustainability goals by reducing stormwater runoff and lowering local temperatures.¹¹ Additionally, multiple studies show that green roofs provide multiple benefits for people who reside under these roofs in terms of psychological health¹², quality of life and well-being¹³, thermal comfort in indoor environments¹⁴, and improving creativity and emotional respite of residents and employees.^{15,16} According to a study, green roofs can provide a variety of multifunctional spaces for a variety of important experiences and activities in urban residents' daily lives, such as social interaction, contact with and learning from nature, rest, and renewal, growing, and harvesting local food, and experiencing landscapes, scenes, and seasons with all five senses.¹⁷ From commercial buildings to residential dwellings, green roofs can be added to a variety of structures. Green roofs come in two flavors: extensive and intensive.

Yet, the distribution of these systems is often uneven with poor people lacking access to green roofs.^{18,19} This inequitable access creates an environmental justice concern.²⁰ Environmental justice is defined as 'the right of the entire population to be protected against environmental pollution and to live in a clean and healthful environment'.²¹ Urban and public policies to tackle environmental justice must ensure the accessibility of a wide range of people regardless of color, income, gender, and race to heat mitigation and stormwater management

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- 3 Masson, V. et al. 2014. Adapting cities to climate change: A systemic modelling approach. *Urban Climate* 10: 407-429.
- 4 T. Carter, C.R. Jackson. "Vegetated roofs for stormwater management at multiple spatial scales". *Landscape and Urban Planning* 80 (2007): 84-94.
- 5 Hiu H, Clark C, Zhou J, Adriaens P. "Scaling of economic benefits from green roof implementation in Washington DC". *Environ Sci Technol* 44(2010):4302-8.
- 6 Heckert, M., D. Rosan, C. 2015. Developing a green infrastructure equity index to promote equity planning. *Urban Forestry and Urban Greening*, <http://dx.doi.org/10.1016/j.ufug.2015.12.011>
- 7 Versini, P., Gires, A., Tchiguirinskaia, I., Schertzer, D. 2020. Fractal analysis of green roof spatial implementation in European cities. *Urban Forestry and Urban Greening* 49: 126629.
- 8 Cristiano, E., Deidda, R., Viola, F. 2021. The role of green roofs in urban Water-Energy-Food-Ecosystem nexus: A review. *Science of the Total Environment*, 756: 143876.
- 9 Calheiros, C.S.C., & Alexandros I. 2021. Stefanakis Green Roofs Towards Circular and Resilient Cities. *Circular Economy and Sustainability* 1: 395-411.
- 10 Kellett, J. 2010. More than a roof over our head: Can planning safeguard rooftop resources? *Urban Policy and Research* 29(1): 23-36.
- 11 Bliss, D., Neufeld, R., J. Ries, R. 2009. Storm Water Runoff Mitigation Using a Green Roof. *Environmental Engineering Science* 26(2): 407-417.
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- 13 Rezaei, M., Nyirumuringa, E., Kim, J., and Kim, D.H. 2021. Analyzing the Impact of Green Roof Functions on the Citizens' Mental Health in Metropolitan Cities. *Iran J Public Health*. 50(5): 900-907.
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- 15 Cinderby,S., Bagwell, S. 2017. Exploring the co-benefits of urban green infrastructure improvements for businesses and workers' wellbeing. *Area* 50: 126-135.
- 16 Lee, K., Williams, K., Sargent, L., Williams, N., Johnson, K. 2015. 40-second green roof views sustain attention: The role of micro-breaks in attention restoration. *Journal of Environmental Psychology* 42: 182-189.
- 17 Mesimäki, M., Haurub, K., Kotze, D., Lehvävirtaa, S. 2017. Neo-spaces for urban livability? Urbanites' versatile mental images of green roofs in the Helsinki metropolitan area, Finland. *Land Use Policy* 61: 587-600.
- 18 Van Herzele, A., De Clercq, E. M., & Wiedemann, T. 2005. Strategic planning for new woodlands in the urban periphery: Through the lens of social inclusiveness. *Urban Forestry and Urban Greening*, 3(3-4), 177-188. doi: 10.1016/j.ufug.2005.01.002
- 19 Pham T-T-H, Apparicio P, Séguin A M, Landry S and Gagnon M. 2012. Spatial distribution of vegetation in Montreal: an uneven distribution or environmental inequity? *Landscape Urban Plan*. 107 214-24.
- 20 Sharma, A., Woodruff, S., Budhathoki, M., Hamlet, A.F., Chen, F., Fernando, H.J.S. 2018. Role of green roofs in reducing heat stress in vulnerable urban communities—a multidisciplinary approach. *Environmental Research Letters*, 13: 094011.
- 21 Gould, K.A., Lewis, T.L. 2017. *Green Gentrification: Urban sustainability and the struggle for environmental justice*. Routledge.

facilities at the rooftop. To this end, any policy should alleviate the disparities between different social groups and communities with a particular focus on accessibility and spatial distribution to nature and UGI.^{22,23}

I realized two gaps in this field of study. First, despite a wide variety of urban greening and green infrastructure implementations in U.S. cities, there are few studies about policy effectiveness at promoting environmental justice.²⁴ Second, although there are some investigations regarding spatial equity of green infrastructure,^{25,26,27} little consideration has been given to rooftop policy justice. This study examines how green roof policies incorporate principles of environmental justice and identifies opportunities to create more environmentally just rooftop greening mandates. The additional objectives of this study are answering the following research questions: To what extent do the current urban policies and plans of rooftop technologies address environmental justice? Who benefits from the implementation of green roofs in cities? Do residents who are real users of green roofs enjoy the same benefits due to their geographical locations or color?

To answer these questions, it proceeds by 1) reviewing the literature on environmental justice and its application in green infrastructure and rooftops implementation, 2) conducting a qualitative analysis of green roof policies in Chicago, New York, and Philadelphia to identify how environmental justice principles are incorporated into each policy, and 3) identifying implications and recommendations for advancing equitable rooftop technologies in other cities, in the US and other cities around the world.

2. Overview of the State of knowledge

2.1. Environmental Justice in Urban Greening Policies

According to the literature, most rooftop greening programs are concentrated in zip codes with higher income and consequently coolest urban areas due to their costly nature which raises equity issues in most large cities.^{28,29} Reviews of existing policies of green roofs show that they are often addressed in climate action, sustainable development, or stormwater management plans and do not directly cover EJ issues. However, there is an emerging body of literature regarding the analysis of different urban policies to support more spatial equitable rooftop technologies provision in cities. Most recently, two distributional factors of size and number of green roofs in nine European cities were examined by the fractal approach. The authors introduced some policies as the main reasons for green roof distribution in these cities.³⁰ Another study analyzed the distribution of green walls and roofs in Australian cities and its relationship to the existing local government policies.³¹ The findings of a study

- 22 Heckert, M., 2013. Access and equity in greenspace provision: a comparison of methods to assess the impacts of greening vacant land. *Trans. Gis* 17, 808–827.
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- 25 Zheng, Z., Shen, W., Li, Y., Qin, Y., Wang, L. 2020. Spatial equity of park green space using KD2SFCA and web map API: A case study of zhengzhou, China. *Applied Geography*, 123 : 102310.
- 26 Wu, K., Kim, S.K. 2020. Exploring the equality of accessing urban green spaces: A comparative study of 341 Chinese cities. *Ecological Indicators*.
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- 28 Deborah A. Sunter, S., Castellanos, D., M. Kammen, 2019. Disparities in rooftop photovoltaics deployment in the United States by race and ethnicity, *Nat. Sustain.* 1, 71.
- 29 Snachez, L., Reames, T.G. 2019. Cooling Detroit: A socio-spatial analysis of equity in green roofs as an urban heat island mitigation strategy. *Urban Forestry and Urban Greening* 44 : 126331.
- 30 Versini, P., Gires, A., Tchiguirinskaia, I., Schertzer, D. 2020. Fractal analysis of green roof spatial implementation in European cities. *Urban Forestry and Urban Greening* 49 : 126629.
- 31 P.J., Irga, J.T., Braun, A.N.J., Douglas, T., Pettit, S., Fujiwara, M.D., Burchett, F.R. Torpy. "The distribution of green walls and green roofs throughout Australia: Do policy instruments influence the frequency of projects?" *Urban Forestry and Urban Greening* (2017) <http://dx.doi.org/10.1016/j.ufug.2017.03.026>

in the U.S. indicated the spatial equity issue in green roof distribution in Detroit city and show that green roofs specifically were in the wealthiest part of Detroit's urban core with a predominantly white population.³²

Uneven access to urban green infrastructure and urban forest has been an important growing environmental justice (EJ) and inequitable distribution issue.^{33,34,35} The concept of environmental justice (EJ) emerged in the 1980s in the United States^{36,37} initially to respond siting toxic and environmental risks in poor neighborhoods and in communities of color.³⁸ EJ concepts have also been applied to energy development, transportation, water distribution, food supply, and land refurbishment in the face of global climate change and societal changes.³⁹

The concept of EJ generally relies on the equal right of all people to have access to natural resources and simultaneously to be protected from environmental risks. For this reason, The National Environmental Policy Act (NEPA, 1994) has forced U.S. Federal agencies to consider EJ in their activities such as green infrastructure programs under Executive Order 12898. Some scholars consider the realization of EJ policies as an inherent result of the "environmental decision-making process" in which justice for different social groups is explored through distributional and procedural patterns.⁴⁰ Others emphasize the concept of "ecological citizenship" as a tool for normative theory by which policymakers can see how to promote and/or organize "greener" political structures.⁴¹ To address and monitor the EJ implications of rooftop adoption policies, considering equity in all steps of the decision-making process and social relations in cases would help achieve new just policies or restructure existing policies. For instance, low-income residents who have not completed high school, and their low-level knowledge may place them in a situation that do not have the opportunity to participate in the environmental decision-making process, which may result in their exclusion from environmental policies such as green roof incentive plans.^{42,43} In other words, justice in environmental policymaking is concerned with the fact that how different policy decisions have impacts on various social groups and most vulnerable communities. The point here is how can we assess the suitability of existing green roofs policies from different aspects of EJ lens in our cities?

Urban heat islands disproportionately affect vulnerable, marginalized, and colored communities.⁴⁴ The urban heat island effect is associated with higher temperatures in dense urban areas compared to the urban suburbs and surroundings. One solution to reduce this effect is implementing green infrastructure – a tool used for urban greening and climate change adaptation– such as vegetated green roofs. The green and cool roofs have also increasingly been recognized as effective and innovative tools for mitigating heat impacts in these

- 32 Snachez, L., Reames, T.G. 2019. Cooling Detroit: A socio-spatial analysis of equity in green roofs as an urban heat island mitigation strategy. *Urban Forestry and Urban Greening* 44 : 126331.
- 33 Venter, Z., Shackleton, C.M., Van Staden, F., Selomane, O., A. Masterson, V. 2020. Green Apartheid: Urban green infrastructure remains unequally distributed T across income and race geographies in South Africa. *Landscape and Urban Planning*, 203 : 103889.
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- 36 Bullard, R. 1996. Environmental Justice: It's more than waste facility siting. *Social Science Quarterly* 77(3): 493-499.
- 37 Mah, A. 2017. Environmental justice in the age of big data: challenging toxic blind spots of voice, speed, and expertise. *Environmental Sociology*, 3(2): 122-133.
- 38 Schlosberg, D. 2013. Theorizing environmental justice: the expanding sphere of a discourse. *Environmental Politics* 22(1): 37-55.
- 39 Agyeman J. and Ogunyemi, Y. 2009. Environmental justice and sustainability in the former Soviet Union, Cambridge, MA: MIT Press.
- 40 Foster, S. 1989. Justice from the Ground up: Distributive Inequities, Grassroots Resistance, and the Transformative Politics of the Environmental Justice Movement. *California Law Review* 86(4): 775-841.
- 41 Latta, P.A. 2007. Locating democratic politics in ecological citizenship. *Environmental Politics* 16(3): 377-393.
- 42 A.M. Levenda , I. Behrsin, F. Disano. 2021. Renewable energy for whom? A global systematic review of the environmental justice implications of renewable energy technologies. *Energy Research and Social Science* 71, 101837
- 43 Mandarano, L., Meenar, M. 2017. Equitable distribution of green stormwater infrastructure: a capacity-based framework for implementation in disadvantaged communities, *Local Environment*, DOI: 10.1080/13549839.2017.1345878
- 44 Hsu, A., Sheriff, G., Chakraborty, T., Manya, D. 2021. Disproportionate exposure to urban heat island intensity across major US cities. *Nature Communications* 12, 2721.

areas.^{45,46,47,48,49} Lowering surface and air temperatures, as well as lower energy demand, are advantages of both cool and green roofs. A study using a systematic review of the literature regarding the heat reduction Impact of green/cool roofs Indicates a remarkable decrease of surface temperature 0.3 K per 0.1 rises of the albedo and 0.1 and 0.33 K per 0.1 increase of the roof's albedo by green and cool roofs, respectively.⁵⁰

2.2. Barriers to Green Roof Installation

There are some obstacles to installing green roofs in buildings despite their benefits as mentioned above. Firstly, implementing a green roof is expensive in both implementation and maintenance which is often called as “high initial cost”.^{51,52} Of course, the issue of equity usually exists for emerging technologies, which may be somewhat modified over time and with reduced construction and implementation costs, but it is not clear how much more will cost come down? Currently, the average construction cost per square meter of a large green roof in Philadelphia city is estimated between \$10 and \$30 per square foot, which many middle and low-income residents cannot afford. Although green roofs maybe not be currently cost-effective on homes and residential buildings in the short term, they may be justifiable on the top of commercial or public buildings where public funding can be allocated⁵³ or in the long term above the residential buildings.⁵⁴ As research shows, green roofs can lead to long-term building performance, savings, and sustainability such as reduced stormwater fees, energy consumption, and CO₂ emissions.^{55,56,57,58}

Furthermore, green roofs also have a huge issue of being hard to implement on old buildings or rowhouse roofs.⁵⁹ Green roofs require a flat roof that must be able to support twenty-eight pounds per square foot. The average city's rowhouse roofs cannot withstand the weight especially extensive green roofs.⁶⁰ Moreover, as some scholars indicate, the lack of knowledge and awareness regarding green roof benefits and installation at

- 45 Sharma, A., Woodruff, S., Budhathoki, M., Hamlet, A.F., Chen, F., Fernando, H.J.S. 2018. Role of green roofs in reducing heat stress in vulnerable urban communities—a multidisciplinary approach. *Environmental Research Letters*, 13 : 094011.
- 46 Giuseppe, E.D., D’Orazio, M., 2015. Assessment of the effectiveness of cool and green roofs for the mitigation of the Heat Island effect and for the improvement of thermal comfort in nearly zero energy building. *Archit. Sci. Rev.* 58 (2), 134–143.
- 47 Razzaghamanesh, M., Beecham, S., Salemi, T. 2016. The role of green roofs in mitigating Urban Heat Island effects in the metropolitan area of Adelaide, South Australia. *Urban Forestry and Urban Greening* 15 : 89-102.
- 48 Becha, Karishma S. 2020. The Impact of Extreme Heat on Environmental Justice Communities in California: Assessing Equity in Climate Action Plans. Master’s Projects and Capstones.
- 49 Dunn, A.D. (2010). Siting green infrastructure: Legal and policy solutions to alleviate urban poverty and promote healthy communities. *BC Envtl. Aff. L. Rev.* 37, 41–66.
- 50 Santamouris, M. 2014. Cooling the cities – A review of reflective and green roof mitigation technologies to fight heat island and improve comfort in urban environments. *Solar Energy* 103 : 682-703.
- 51 Celik, S., Binatli, A.O. 2018. Energy Savings and Economic Impact of Green Roofs: A Pilot Study. *Emerging Markets Finance and Trade* 54 : 8.
- 52 Mahdiyar, A., Mohandes, S., Durdyev, S., Tabatabaee, S., Ismail, S. 2020. Barriers to green roof installation: An integrated fuzzy-based MCDM approach. *Journal of Cleaner Production* 269, 122365.
- 53 Blackhurst, M., Hendrickson, C., & Matthews, H. S. 2010. Cost-effectiveness of green roofs. *Journal of Architectural Engineering*, 16(4), 136-143.doi:10.1061/(asce)ae.1943-5568.0000022.
- 54 U.S. Environmental Protection Agency (EPA). Green Roofs vs. Cool Roofs. Available online: <https://www.epa.gov/heatislands/using-green-roofs-reduce-heat-island> (accessed on 20 October 2021)
- 55 Clark, C., Adrianes, P., Talbot, B. 2008. Green Roof Valuation: A Probabilistic Economic Analysis of Environmental Benefits. *Environ. Sci. Technol.* 42, 2155–2161.
- 56 Shin, E., Kim, H. Benefit–Cost Analysis of Green Roof Initiative Projects: The Case of Jung-gu, Seoul. *Sustainability* 2019, 11(12), 3319.
- 57 Zhang, S., Guo, Y. 2013. Analytical Probabilistic Model for Evaluating the Hydrologic Performance of Green Roofs. *Journal of Hydrologic Engineering* 18,1.
- 58 Liberalesso, T., Oliveira Cruz, C., Silva, C.M., Manso, M. 2020. Green infrastructure and public policies: An international review of green roofs and green walls incentives. *Land Use Policy* 96 : 104693.
- 59 Procaccini, G., Monticelli, c. 2021. A Green Roof Case Study in the Urban Context of Milan: Integrating the Residential and Cultivation Functions for Sustainable Development. *Water* 13(2), 137.
- 60 Blackhurst, M., Hendrickson, C., & Matthews, H. S. 2010. Cost-effectiveness of green roofs. *Journal of Architectural Engineering*, 16(4), 136-143.doi:10.1061/(asce)ae.1943-5568.0000022.

the local level is another barrier to GR installation in most cities.^{61,62} These are the main reasons that municipalities establish incentives to encourage private buildings as well as public constructions to install these technologies. Besides the federal and state leadership on climate action and stormwater management regulations, the municipalities decide to prepare supportive requirements and incentive policies to meet green roof installation.⁶³ Thus, there are a variety of urban policies to address green roof implementation including but not limited to direct financial investment, indirect financial investment, mandatory regulations, strategic plans, sustainable policies, and other incentives such as density bonuses or tax credits for public engagement in the United States.^{64,65,66,67} Incentives can promote the market for constructing more rooftop technologies, while regulations can fix it which in turn results in shaping rooftop greening at least at a constant rate for instance in NYC where green roof installation is compulsory for all new buildings as well as those undergoing certain major renovations.

2.3. Conceptualizing EJ in the Context of Green Roof Policies

To analyze EJ in urban politics, I take the trivalent model of Schlosberg (2007) including distributive, recognition, and procedural considerations because it has been widely accepted in the literature.⁶⁸ Herein, distributive EJ refers to providing equally distributed accessibility and even rooftop technologies provision, while procedural EJ focuses on the co-creation of rooftop greening with diverse social groups in the city. Recognition EJ regards the consideration of different groups' needs, perceptions, values, and preferences in the decision-making process.⁶⁹ In this case, aside from the public green roofs which can be accessible to all people, the concept of distributive just green roofs is whether different social groups have equal access to green roof installations in terms of budget affordability and property ownership? Co-creation including co-plan, co-design, and co-production of green roofs is another important aspect of EJ called procedural justice in the context of green roofs. Moreover, we need users' perceptions and expectations regarding the suitability and functionality of green roofs which would be considered as recognition justice. It is estimated that if any rooftop provision program considers these three elements in its planning process, EJ will be supported (Fig. 1). Given this model, considering different stakeholders including land and homeowners as well as local government and policymakers in the decision-making process leads to an equitable participatory rooftop planning.

3. Methods

This study aims at investigating EJ elements in green roof policies in three American cities of New York, Chicago, and Philadelphia. To achieve this objective, a total of nine green roof policies through our framework of EJ in green roof implementation were reviewed.

- 61 Shafique, M., Kim, R., Rafiq, M., 2018. Green roof benefits, opportunities, and challenges – a review. *Renew. Sust. Energ. Rev.* 90, 757–773.
- 62 Vijayaraghavan, K., 2016. Green roofs: a critical review on the role of components, benefits, limitations, and trends. *Renew. Sustain. Energy Rev.* 57, 740e752.
- 63 Dong, J., Zuo, J., Luo, J. 2020. Development of a Management Framework for Applying Green Roof Policy in Urban China: A Preliminary Study. *Sustainability* 12, 10364.
- 64 Foster, S. 1989. Justice from the Ground up: Distributive Inequities, Grassroots Resistance, and the Transformative Politics of the Environmental Justice Movement. *California Law Review* 86(4): 775-841.
- 65 Carter, T.; Fowler, L. 2008. Establishing green roof infrastructure through environmental policy instruments. *Environ. Manag.* 42, 151–164.
- 66 Stern, M., W.Peck, S., Joslin, J. 2019. *Green roof and wall policy in north America, regulations, incentives, and best practices*. Report by Green Roofs for Healthy Cities, USA.
- 67 Savarani, S. 2019. *A review of green roof laws and policies*. Quarini Center, Frank J. Guarini Center on Environmental, Energy, and Land Use Law at NYU School of Law.
- 68 Bulkeley, H., Edwards, G.A.S., Fuller, S. 2014. Contesting climate justice in the city: Examining politics and practice in urban climate change experiments. *Global Environmental Change.* 25 : 31-40.
- 69 Langemeyer, J., Connolly, J.J.T. 2020. Weaving notions of justice into urban ecosystem services research and practice. *Environmental Science and Policy.* 109 : 1-14.

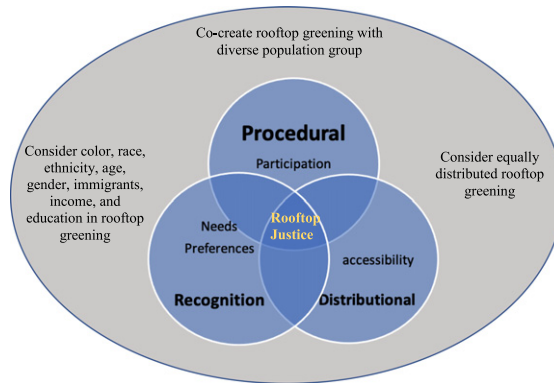


Fig. 1. Conceptualizing rooftop provision justice through recognition, distribution, and procedure (RDP) analysis.

Table 1
Rooftop technologies plans/policies analyzed

City	Plan/policy title	Date
New York, NY	*Climate Mobilization Act	2019
	Green roof property tax abatement	2013
	Green infrastructure grant program	2017
Chicago, IL	Green permit program	2014
	*Sustainable Development Policy	2016
	Green Roof Improvement Fund	2007-2016
Philadelphia, PA	Density bonus	2015
	Green roof tax credit	2015
	*Green City Clean Waters	2011

*Comprehensive plans at the city level.

3.1. Data collection

The relevant nine policies and plans were identified by reviewing city government websites and similar articles (Table 1). These policies varied in terms of their goal, content, or scale. Some of them (e.g., Climate Mobilization Act of New York) contains a broader scope in city-wide climate action; however, some other (e.g., a green roof tax credit of Philadelphia) focuses only on green roof Implementation plans.

Three big cities of New York, Chicago, and Philadelphia were selected because each of which, has a considerable number of rooftop gardens and a rich source of policies, and all current mayors are committed to addressing climate change mitigation through these technologies (e.g., NYC’s Climate Mobilization Act). A review of existing policies and best practices in metropolitan areas such as New York, Chicago, and Philadelphia can help establish a set of principles for establishing effective policies in other cities whose rooftop policies are growing. These policies allow governments to target a range of environmental health, economic development, and social equity benefits through public, private, or public-private partnerships with a set of regulations and incentives (voluntaries).⁷⁰

3.2. Policy Analysis

Focusing on current green roof policies, this research evaluates distributional, procedural, and recognitional justice factors in existing documents through responding to “applicable inquiries” (Table 2). To evaluate EJ in green roof policies, this research uses two-phase content analysis to explore a series of evidence-based on green

70 Blackhurst, M., Hendrickson, C., & Matthews, H. S. 2010. Cost-effectiveness of green roofs. *Journal of Architectural Engineering*, 16(4), 136-143. doi:10.1061/(asce)ae.1943-5568.0000022.

Table 2
Applicable inquiries in green roof policies of New York, Chicago, and Philadelphia

Procedural
Have all communities participated in the development of green roof policies?
Does the language of the policies reflect the concerns of UHI reduction in all communities?
Distributional
Do the policies support accessibility of green roofs for all communities? Are the policies in line with the different income levels of people in the city?
Has the policy provided different solutions for the implementation of green roofs in all types of buildings?
Have social vulnerability or heat equity indices been taken into account in green roof allocation?
Recognitional
Do the policies meet different needs and expectations of various communities?
Do the policies consider basic knowledge about green roof benefits among communities?

roof policies.⁷¹ In the first phase, I reviewed documents and extracted meaningful phrases in the policies which can support any aspects of EJ issue in green roofs. For example, if a statement including “based upon the income of the occupant” existed in a policy, it was realized as an EJ factor. During the second round, I categorized each phrase in one of three aspects of EJ including distributional, procedural, and recognitional. According to this approach, I analyzed whether the existing policies could support EJ concerns or not.

To analyze the plans and policies I employed a qualitative coding approach. Plans and policies in each city were coded for their responses to previously mentioned inquiries in Table 2.

4. Results

4.1. New York Policies

According to the New York City Department of Buildings (DOB), New York City is home to about 730 buildings with green roofs with a total of about 2.6 million square feet throughout the city as of 2019, according to the Sustainable CUNY.⁷² New laws 92 and 94 under the term “Sustainable Roofing Zone” as part of NYC’s Climate Mobilization Act⁷³ have been defined in the Building Code for an area of the roof with solar panels or green roofing- or a combination of the two. According to these laws, which have been mandatory since 2019, a green roof must be installed on all new buildings or those undergoing certain major renovations. These laws also permit low-income communities to use a five-year exemption if the Department of Housing and Development approves their affordability status. After reviewing three related green roof policies in New York, I found that there is more focus on distributional aspect of EJ rather than other two components, making them less cognitively and procedurally fair. In other words, concepts such as “accessible for all”, “achievable by all income groups”, and “constructable on the top of all buildings regardless of age” are amongst most frequent distributional justice principles that are mentioned in these policies. Moreover, although in two policies of “green infrastructure grant program”⁷⁴ and “Climate Mobilization Act”, there are some information regarding the installation of green roofs and their considerations, this type of up-down knowledge cannot be address the recognitional justice in which a co-production of knowledge is needed.

Moreover, there is an incentive tax abatement policy in New York that covers only \$4.50 per square foot of green roof space for owners which are about one-fourth of the total cost (\$20-25). For instance, 50% of the roof must be covered by vegetation that is resistant to drought. A four-year maintenance plan should also be prepared

71 Miles, M., Huberman, A.M. 1994. *Qualitative data analysis: An expanded sourcebook*, 2nd ed. Sage Publications, Inc.

72 New York Department of Building [online]. Available from: <https://www1.nyc.gov/site/buildings/industry/sustainability-green-roofs.page> (accessed on 25 February 2021).

73 Accessible from: https://www1.nyc.gov/assets/buildings/local_laws/1194of2019.pdf

74 Accessible from: <https://www1.nyc.gov/assets/dep/downloads/pdf/water/stormwater/green-infrastructure/green-infrastructure-grant-program-flyer.pdf>

by a registered architect or landscape architect. According to a study,⁷⁵ “within a short time, the incentive’s inadequacies became painfully apparent; in the first three years after the program took effect, only four building owners utilized the tax incentive”. Not have only a few properties taken advantage of this program but also it has not succeeded to address distributional EJ issues in the city because most people who have constructed the green roofs are affluent owners without applying to the tax abatement and are often living in the areas where are not of high stormwater management value.⁷⁶ According to the results of a study,⁷⁷ if 100 percent of all available roofs in New York are converted to green roofs, a total 0.4⁰F temperature reduction would have happened.

4.2. Chicago Policies

Chicago has an overall count of 509 vegetated roofs with more than 5.5 million square feet and is considered as one of the greatest rooftop coverage in the United States according to the Chicago Department of Planning and Development. In the new Chicago Climate Action Plan from 2008, the city sets the goal of 6,000 green roofs by 2020.⁷⁸ Chicago’s Department of Buildings (DOB) has developed an incentive policy titled “Green Elements Permit” to encourage developers and homeowners to install green roofs.

Chicago’s Sustainable Development Policy (2016) has been one of the strongest drivers in the green roof movement. According to this policy, the buildings that receive financial assistance from the city must consider sustainable elements such as green roofs. This policy has addressed multi-family low-income housing green roofs installation through proposing different choices including HOME loans, CDBG loans, Chicago Low-income Housing, Trust Fund, Low-Income Housing Tax Credits (LIHTC), TIF, tax-exempt bonds, private activity bonds, 501(c)(3) bonds, allocations of LIHTCs from the Private Activity Board, and Donation Tax Credits which seems can support different social groups’ needs and limitations.

Also, Chicago’s Zoning Code awards a Floor-Area Ratio (FAR) bonus of \$5000 for green roofs installation that covers more than 50 percent of the roof area. The FAR is available for buildings in downtown mixed-use districts that can reduce the Urban Heat Island effect in these areas that are hotter than other parts of the city. Also, according to a study,⁷⁹ a total of 2046.89 metric tons of air pollutants would be removed if all roof surfaces of Chicago are covered by green roofs. All in all, compared to New York’s policies, three related green roof policies in Chicago, are less EJ oriented. The major focus in these policies is on distributional aspect of EJ in relation to commercial and public buildings rather than emphasizing on both private and public buildings. Likewise, although in all green roof policies of “Chicago green permit program”⁸⁰ and “Chicago Sustainable Development Policy”⁸¹, there are some information regarding the installation of green roofs and their considerations, this type of up-down knowledge cannot be address the recognitional justice in which a co-production of knowledge is needed. In addition, there is not any stress on procedural aspect of EJ, making them unjust in terms of processes.

4.3. Philadelphia Policies

Unfortunately, there is no evidence regarding Philadelphia’s total number and area of green roofs, although its emergence dates to 1998 on the Fencing Academy on Race Street. The Philadelphia Water Department supports

75 Spiegel-Feld, D., Sherman, L. 2018. Expanding green roofs in New York city: Towards a location-specific tax incentive. *NYU Environmental Law Journal* 26(3): 101-143.

76 Rosenzweig, C., S. Gaffin, and L. Parshall (Eds.), 2006: *Green Roofs in the New York Metropolitan Region: Research Report*. Columbia University Center for Climate Systems Research and NASA Goddard Institute for Space Studies.

77 Savarani, S. 2019. *A review of green roof laws and policies*. Quarini Center, Frank J. Guarini Center on Environmental, Energy, and Land Use Law at NYU School of Law.

78 Chicago Climate Action Plan [online] available: <https://www.chicago.gov/city/en/progs/env/climateaction.html>

79 Yang, Y., Yu, Q., Gong, P. 2008. Quantifying air pollution removal by green roofs in Chicago. *Atmospheric Environment* 42(31):7266-7273.

80 Accessible from: <https://www.chicago.gov/city/en/depts/bldgs/provdrs/permits/svcs/green-permits.html>

81 Accessible from: https://www.chicago.gov/city/en/depts/dcd/supp_info/sustainable_development/chicago-sustainable-development-policy-update.html

Table 3
Assessment the adaptability of rooftop policies with environmental justice

Plan/policy title	Procedural EJ	Recognitional EJ	Distributional EJ
New York Climate Mobilization Act (Local Law 92 and 94)	- Not a priority in the policy	- Providing information regarding GR installation	- Accessible for all - Considering different income levels - Not considering old or existing buildings
New York green roof property tax abatement	- Not a priority in the policy	- Not a priority in the policy	
New York green infrastructure grant program	- Not a priority in the policy	- Providing information regarding GR installation	- Accessible for all - Considering different income levels for a short term - Accessible only for existing private properties which are not spatially distributed
Chicago green permit program	- Not a priority in the policy	- Providing information regarding GR benefits	- Accessible for residential and small commercial properties which are not spatially distributed - Not a priority in the policy
Chicago Sustainable Development Policy	- Not a priority in the policy	- Providing information regarding GR installation and types	
Chicago Green Roof Improvement Fund	- Not a priority in the policy	- Not a priority in the policy	- Accessible for central business district which are not spatially distributed in city
Philadelphia green roof density bonus	- Not a priority in the policy	- Providing information regarding GR	- Accessible for residential buildings in specific zones which are not spatially distributed
Philadelphia green roof tax credit	- Not a priority in the policy	- Not a priority in the policy	- Accessible for all
Philadelphia Green City Clean Waters	- Not a priority in the policy	- Providing information regarding GR benefits and types	- Considering different income levels for a short term - Not a priority in the policy

green roof installation through an expedited permit review to implement a stormwater management plan, also known as Green City Clean Waters.⁸² The City of Philadelphia also rewards Green Roof Tax Credit including 50% of the cost of constructing a green roof, up to \$100,000 to encourage the construction of new green roofs in the city. To qualify the green roof must cover 60% of the roof area. Moreover, The Philadelphia Zoning Code offers the “Green Roof Density Bonus Ordinance” in 2015 as an incentive policy to increase density in specific zoning districts of low-density multi-family residential (RM-1) and neighborhood commercial corridors (CMX-2, CMX-2.5). To receive the award, the green roof must cover at least 60% of the building’s roof area with more than 5000 square feet.⁶⁰ Table 3 summarizes the total adaptability of each policy/program in three cities with different distributional, recognitional, and procedural environmental justice considerations.

The Philadelphia’s green roof policies including “green roof density bonus”, “green roof tax credit”⁸³, and “Green City Clean Waters” have some limited considerations regarding distributional justice. Accessibility of green roofs for all people regardless of income level or land use of buildings is the only principle which has been mentioned in these documents. Like Chicago and New York’s policies, there is no direct and indirect statement showing an emphasize on both recognitional and procedural justice components in the texts. Yet, there are some

82 Philadelphia Water Department, nd. Stormwater Grants [Online]. Philadelphia, PA: City of Philadelphia. Available from: <http://www.phila.gov/water/wu/stormwater/Pages/Grants.aspx> (accessed on 15 February 2021).

83 Accessible from: <https://www.phila.gov/services/payments-assistance-taxes/tax-credits/green-roof-tax-credit/>

information regarding the installation of green roofs and their considerations which is not based on bottom-up approaches of governance.⁸⁴

5. Discussion

According to the above review and analysis, there are two classes of mandatory and incentive policies in three cities of New York, Chicago, and Philadelphia. The former category dictates some required regulations or standards to developers and property owners to include them in their building construction process; while the latter tries to encourage residents, landowners, companies, and public officials to implement green roofs in their buildings by giving them bonuses, award, tax credit or abatement policies. Both approaches have their own pros and cons. Although mandates are considered as accelerators for green roofs expansion, they also, perhaps unfairly, force private property owners to afford all the costs of provision what a societal benefit is large.⁸⁵ The implementations of incentives (e.g., Philadelphia green roof tax credit) in low-income and minority communities are usually challenging and unequal due to the lack of public financial support and the lack of the poor's capacities in local decision-making processes. The results show that most policies at best focus only on the distributional justice concept including more access to green roofs but not equitable spatial distributional and fewer focus on procedural or recognitional policies. Of all nine analyzed policies, seven policies address climate change impacts by targeting Urban Heat Islands and stormwater management.

Most incentive policies focus on financing and obligations to promote green infrastructure worldwide. The Philadelphia's Density Bonus, the New York Green Infrastructure Grant Program, and the Chicago Green Permit Program are amongst the most effective policies to address the three pillars of environmental justice in each city. Applying density bonus incentives in Philadelphia in just some specific projects as identified zones could help prevent rising property and land prices in other parts.⁸⁶ Also, some degree of conflict interests may exist between owners and the public about the potential benefits of green roofs. The large proportion of benefits of green technologies (e.g., stormwater retention) accrue to the public, while, the private owners must pay to afford it, in turn, may discourage them to install rooftop technologies. Although incentive policies should offset this burden and risk for owners and residents, further studies regarding this impact in different contexts and governance arrangements are strongly recommended.

Also, as results indicate, the green roofs provision in the studied U.S. cities is in its initial stages and needs to be more distributed and expanded in the future to cover more equitable policies. Embedding all three types of environmental justice including distributional, recognitional, and procedural in the green roof decision-making process is an important step to make equitable policies. To strengthen recognitional green roof justice, widening community knowledge about the multiple benefits of these technologies through voluntary efforts such as workshops, community meetings, local initiatives (e.g., Greenworks in the office of sustainability in the city of Philadelphia), RCOs and non-profit organizations partnerships is essential. The knowledge-sharing about rooftops technologies at local levels helps policymakers and people co-create the required policies.

6. Conclusion

Our results indicate an urgent need to restructure and redesign green roof policies in great American cities and probably other parts of the country based on EJ implications. Environmental justice in the context of green roofs planning and policies has to date received significantly less research attention according to our analysis. To raise the number and effectiveness of green roof policies in the U.S. context, we need to increase the diversity of incentive socially inclusive policies. Future research should examine new alternatives for more equitable green

84 Razzaghi Asl, S., Pearsall, H. 2022. How Do Different Modes of Governance Support Ecosystem Services/Disservices in Small-Scale Urban Green Infrastructure? A Systematic Review. *Land* 11(8):1247.

85 Stern, M., W.Peck, S., Joslin, J. 2019. *Green roof and wall policy in north America, regulations, incentives, and best practices*. Report by Green Roofs for Healthy Cities, USA.

86 U.S. Environmental Protection Agency (EPA). Green Roofs vs. Cool Roofs. Available online: <https://www.epa.gov/heatislands/using-green-roofs-reduce-heat-island> (accessed on 20 October 2021)

roof policies, especially to respond to issues such as the economic status of users, property ownerships, and minorities. Also, there is a need to strengthen community engagement in the policymaking process at different stages and scales. I have shown that some cities are expanding their Incentives and mandates to include a wide variety of residents to support EJ recognition aspect, but they simultaneously should facilitate public participation in the decision-making process. To do this, I propose a framework to highlight EJ thinking to better provide and utilize green roof policies in this growing Industry in our cities.