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School of International and Public Affairs

A Roadmap for Equitable Open Space Planning for the New York City Housing Authority:

The Public Impact of Public Space

Capstone Project

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Executive Summary

In January of 2021, The New York City Housing Authority (NYCHA) convened a team of graduate student consultants from Columbia University School of International and Public Affairs (SIPA) to study the viability of its Open Space Master Plan (OSMP) projects at a number of NYCHA campuses using a Life Cycle Cost-Benefit Analysis (LCCBA) framework. Centered around NYCHA'sConnected Communities initiative, the OSMP projects thoughtfully employ an urban design framework intended to improve the quality of life of NYCHA residents. These proposed, conceptual capital projects and their corresponding quality of life improving co-benefits range from isolation reduction, reduced adverse health outcomes, safety, and greater civic trust. After decades of disinvestment from many of these communities, these projects have the potential to begin to redress these challenges and the resultant lack of social capital in these neighborhoods. From a list of over 100 OSMP projects, we have analyzed three NYCHA campuses: Morris, Nostrand, and Van Dyke I and II. They were selected to illustrate the application of co-benefits among a broad range of communities, costs, challenges, and residents served.

The following report is the culmination of the research, insights gleaned subject matter experts, and LCCBA modeling process. As was the central objective from the project's initiation, we have undergone a rigorous process to move from data to dollars, quantifying and monetizing the co-benefits arising from the projects. The results of the analysis showed greater value than the associated project costs:

- Morris had a positive net present value of $76.9 Million and a benefit to cost ratio of $2.61 of benefit for every $1 spent.
- Nostrand had a positive net present value of $4.8 Million and a benefit to cost ratio of $1.11 of benefit for every $1 spent.
- Van Dyke I and II had a positive net present value of $59.7 Million and a benefit to cost ratio of $3.06 of benefit for every $1 spent.

We also note that the above results are likely underestimates as, for technical purposes of the model, each co-benefit is monetized in isolation. Therefore, synergies emerging from their relationships to one another are not captured in the LCCBA framework.

Though the projects demonstrate significant returns, financing remains a central obstacle in the way of moving forward on these OSMP projects. We have outlined a suite of options regarding avenues to finance the project ranging from traditional pure public and public-private methods to innovative revenue generating options . In following a rigorous Suitability, Feasibility, and Acceptability, we employed a weighting process to standardize across the available options to establish an overall ranking.

Ultimately, considering these points, the team arrived at two fundamental conclusions. Firstly, these projects will bring transformative benefits to the residents living at NYCHA campuses. And secondly, financial hurdles,

while great, can be overcome and make these projects possible. Though work is still to be done and methods to value the wide-ranging benefits of OSMP projects will be refined. We are confident that these contributions serve as an appropriate starting point to reveal the substantial returns to investment available at NYCHA campuses across New York City.

Overview of Project

To initiate the project, NYCHA first provided the team with the Connected Communities Guidebook. Released in 2020 in partnership with the Department of City Planning, the Guidebook outlines a toolkit for collaborative and inclusive open space urban design planning across more than 130 NYCHA campuses sitting on approximately 2,400 acres of land. The Guidebook outlines how urban planners and designers, as well as community based organizations and public agencies can design, envision, and use open space to foster social resilience, improve health, and bolster community.

NYCHA also provided the team with open-space master plan analysis, conceptual designs, and cost assessments of selected sites . This information puts Guidebook principles and strategies onto the page. The team reviewed these renderings to ground ourselves in how, specifically, the NYCHA Design Team and its partners envisioned activated spaces and what types of material interventions were possible. The campuses in the portfolio offered to the team were a smaller part of the broader NYCHA 'master plan' for open space (hereafter: the open space master plan, OSMP) across all NYCHA campuses. The cost estimates delineated each campus plan into smaller sub-projects with associated sub-project costs.

The team selected three campuses to use as case studies for our analysis. The team selected the campuses that 1) had a robust variety of potential interventions, 2) varied in neighborhood contexts, and 3) had diverse populations across campuses. This allowed the team to explore how different design plans could interact with, enhance, and generate synergies for the campus residents and the community.

NYCHA further connected the team to industry and thought leaders across the city who are long-term advisors and partners for the authority, and who provided valuable insights into the project (see Appendix A). The team connected with technical experts like Eva Weissman and Damian Busch of Columbia University and Barclays Bank, respectively, as well as subject matter and policy experts like Kizzy Charles-Guzman of the Mayor's Office of Resiliency; Ifeoma Ebo of the Department of Housing Preservation and Development; Sarah Kararet of the Center for Active Design; and Khyati Rathore of the Environmental Defense Fund. The team was also able to interview Nancy Owens of Nancy Owens Studio, an external architect that NYCHA partnered with to develop renderings for remodeled NYCHA sites.

Eva Weissman provided early guidance on cost benefit analysis best practices and informed our literature review research. Ifeoma Ebo and Sarah Kararet expanded the team's aperture on what benefits can accrue from open space. Ifeoma Ebo and Sarah Kararet also guided the team to additional resources, including the *Safe Places,*

Active Spaces Report from the Mayor's Office of Criminal Justice, and resources from the Center for Active Design's library. Kizzy Charles-Guzman reminded the team to look at the comprehensive range of co-benefits when evaluating environmental interventions like natural turf and water play, and introduced relevant research and existing tools. Kyathi Rathore gave an overview of her data collection and analysis processes evaluating the ecosystem services that trees provide, suggested studies that may be useful to highlight, and helped us understand a key connection - the mutually supportive relationship between the health of residents and the health of trees. Nancy Owens illuminated the original thinking behind the designs at the sites. She and her team provided an architectural approach to the space that helped solidify that these designs have multifaceted impact both above and below the surface. Finally, the team is indebted to Damian Busch for his guidance on public financing. Damian Busch provided a thorough primer on public financing structures and brainstormed with the team about how to approach the issue at hand.

The Connected Communities Guidebook outlines four major guidelines to consider in design that can better connect communities. These include community engagement, safety and security, health and resilience, and maintenance and operations. Informed by preliminary interviews, along with an early stage literature review, and technical guidance from a cost-benefit analysis expert, these design principles formed the basis of the team's co-benefit measurements.

A life-cycle cost benefit analysis of open space design is a novel venture. The team had to think creatively about how specific aspects of the available renderings could foster these principles, and how that could then be measured in dollars. In other words, how does one quantify the benefits of, for example, a playground - from a health standpoint, from a safety standpoint, from a community engagement standpoint standpoint?

An initial challenge for the team to address this question was balancing the qualitative understandings of added value with the quantitative methods of a cost-benefit analysis. To carry the example forward: while it is important to recognize that there are evident overlapping benefits to a playground (both health and safety), in cost benefit analysis methods, it should be isolated to a primary benefit, otherwise independently measuring its value to health and its value to safety may result in some level of double-counting (i.e. where does the health benefit end and the safety benefit begin?). Thus, the team determined that it would identify and quantify only the first-order benefit to various interventions from the renderings, recognizing that, ultimately, this quantified measurement will almost always be an underestimate of the true value add.

Another challenge was that there are some concepts that researchers are still grappling with how to quantify, but are critical aspects of these open space design plans. Concepts like community engagement, are hard to associate with a specific campus intervention, but the team recognizes that it flows throughout the entire design plan. Because of the difficulties to quantify this concept, the team conducted a literature review of what is commonly referred to as "social capital" and provided a qualitative discussion of its benefits. The team considers this as an additional overall benefit in addition to the isolated measurements conducted.

Ultimately, this project paired the Connected Communities Guidebook themes and principles with tangible open-space master plans to identify how various interventions could take a principle and turn it into dollars. How can we value the health, safety, and environmental improvements on these campuses? This project and this report are an attempt to answer this question.

Open Space Master Plans to be Analyzed

Of the over 130 total OSMP sites, 16 were provided to be considered as part of this analysis. Based on the site analysis and design documents, three sites were identified as ideal candidates for consideration. These 16 priority sites have lacked the most capital investment from NYCHA over the decades. Two of these sites are in Brooklyn (Nostrand and Van Dyke I & II) and one in the Bronx (Morris I & II). There is variability in terms of location, demographic composition, and historical levels of investment. The broader community contexts add another dimension of variability that should be considered when approaching an analysis. Additionally, renovations and improvement projects to NYCHA campuses occur in conjunction with planned New York City capital projects. Therefore, it is important to consider the potential impact of the master planned sites on existing City plans. In an effort to holistically quantify open space interventions and identify added value, this case study considers site drawing and plan, individual challenges, and potential to synergize with City capital projects on the three distinct NYCHA campuses.

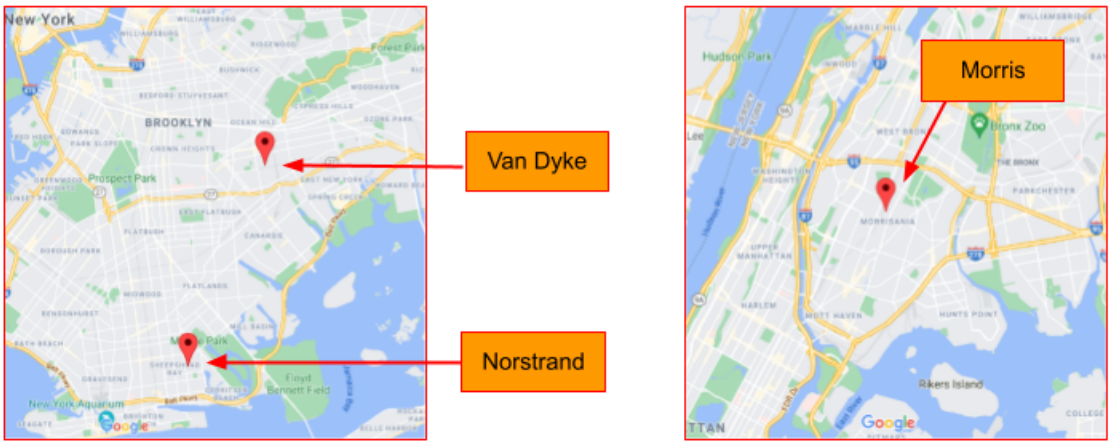

Figure 1: Location of three sites

Site 1: Nostrand

Nostrand Houses has sixteen, six-story buildings with a total 1,148 apartments housing 2,307 residents. Completed December 14, 1950, the 23.8-acre Brooklyn development is located between Avenues V and X, and Bragg and Batchelder Streets in the Sheepshead Bay neighborhood of Brooklyn. Because portions of the site are in the 100-year flood plain, there is a high frequency of street flooding. At Nostrand, there are large patches of asphalt that trap heat and are uninviting. The playgrounds are in a deteriorated state and there are too few for the number of children on the campus. When first constructed, the space features an oval center space and two playgrounds for each block. Now, the oval paths have worn away and bare soil patches are apparent. Nostrand needs new play space and recreation amenities. As per Facility Conditions Assessment (FCA), the open space plan for this site should prioritize playground deficiencies including addressing safety concerns.

The New York City Departments of Environmental Protection (DEP) and Design and Construction (DDC) is currently upgrading the water delivery infrastructure in the Brooklyn neighborhoods of Gravesend and Sheepshead Bay. The $30 million project includes the replacement of almost seven miles of century-old water mains to improve water distribution in the area.[1] The DEP is providing the funding and the DDC is managing the construction, which is anticipated to be completed in Fall 2021.

Figure 2: Playground in Nostrand

[1] $30 Million Investment In New Water Mains For Gravesend And Sheepshead Bay, Brooklyn, www1.nyc.gov/site/ddc/about/press-releases/2020/pr-091620-Gravesend.page.

Site 2: Van Dyke I and II

Van Dyke I Houses has 22 buildings, three and fourteen-stories tall with a total of 1,603 apartments housing 3,786 residents. Completed May 27, 1955, the 20.81-acre Brooklyn development is bordered by Mother Gaston Boulevard, Powell Street, Sutter and Livonia Avenues. Van Dyke II Houses is a fourteen-story building exclusively for seniors with 112 apartments housing 128 residents. Completed April 30, 1964, the 0.93-acre Brooklyn development is located at Dumont Avenue and Powell Street. Situated in the Brownsville neighborhood of Brooklyn, the site covers three blocks, but the open space for activities is clustered in one corner. Further, the elevated MTA lines along Livonia Ave creates a visual barrier south and east. Like the Nostrand campus, there are insufficient offerings for the demographics of the campus.

There are several City programs improving conditions at these campuses. The Van Dyke Houses was selected to be a part of the Mayor's Action Plan for Neighborhood Safety[2], which has been addressing lighting improvements proposed in the OSMP. The Van Dyke Houses' vision is one of the three pilots developed as part of NextGeneration NYCHA[3], a citywide effort to ensure the sustainability of NYCHA's communities for the next generation. Part of this vision is to repurpose formerly abandoned and vacant buildings and lots, clean up or demolish and redevelop to enhance the neighborhood, and expand goods and services available to residents. The OSMP can improve the community's appearance by gardening, landscaping, and designating spaces for community gardens. It can also help promote and expand recreational and sport facilities available in the neighborhood.

Figure 3: Asphalt Field in Van Dyke

[2] The Mayor's Action Plan for Neighborhood Safety, https://criminaljustice.cityofnewyork.us/programs/map/
[3] NextGeneration NYCHA Van Dyke Community Vision, https://www1.nyc.gov/assets/hpd/downloads/pdfs/services/van-dyke-report-nycha.pdf

Site 3: Morris

Gouverneur Morris I Houses consists of ten buildings, sixteen and twenty-stories tall with 1,085 apartments housing 2,845 residents. Completed August 31, 1965, the 9.57-acre Bronx development is between East 169th and East 170th Streets, and Third and Park Avenues. Gouverneur Morris II Houses has seven buildings, sixteen and twenty-stories tall with 802 apartments housing 1,945 residents. Completed August 31, 1965, the 8.24-acre Bronx development is between East 170th and East 171st Streets, and Third and Park Avenues in the Morrisania neighborhood of the Bronx. The campus orientation turns its back on the inactive street front of Park Avenue and Washington Ave is the focus of the pedestrian experience. It is a densely populated campus with limited recreation opportunities available in the surrounding neighborhood. In its current state, the site is described as having "rust, rot, and splinters" at the playgrounds, bare soil, "broken safety tiles" extensive scaffolding across the campus, and weeds. The lack of usable multigenerational open space is a missed opportunity to bring neighbors between I and II to access neighborhood amenities housed within each part of the campus.

NYCHA will use capital and operating funds to improve elevator performance—reducing the frequency and duration of outages and no-service conditions. NYCHA's Capital Projects Division (CPD) is responsible for elevator replacements and other capital repairs to a building that permit elevators to run (e.g., roof repairs to prevent flooding in elevator shafts).[4] Presently, the CDP is executing a project on elevators at the Morris Houses.

Figure 4: Playground in Morris

[4] NYCHA, 2020. "Elevator Action Plan", January 2020, https://www1.nyc.gov/assets/nycha/downloads/pdf/Elevator-Action-Plan-FINAL-20200130.pdf

Open Space Master Plan Interventions

With expansive open spaces that serve as places to relax and recreate, NYCHA campuses were planned and designed to create affordable housing in an ideal setting. Emblematic of campus developments built between the 1930s and 1960s, they are referred to as "towers-in-the park", set back from the street and adjacent to the city's public realm. Built on private land and owned by the Authority, NYCHA campuses can feel disconnected from other open public spaces in the City. These campuses and the communities within which they are situated have faced financial disinvestment. In the context of open space, this means poor upkeep coupled with increased crime and safety concerns. During the 1970s and 1980s, NYCHA and other public housing authorities embraced Crime Prevention Through Environmental Design (CPTED), which resulted in fencing off most green areas, limiting access to designated communal spaces, and fixed seating areas. These interventions created less appealing spaces and further separated NYCHA campuses from the surrounding community.

As part of the Connected Communities initiative, the current NYCHA OSMPs will reimagine play areas and open spaces. The current OSMP design interventions aim to open up and activate NYCHA open spaces while also providing connections between NYCHA campuses and the city's public sidewalks, streets, parks, institutions, retail and transit, and to do so through careful planning and design. Spaces such as playgrounds, fitness areas, and walking paths are all conducive to enhancing physical activity at all ages. While enhancing green infrastructure and promoting activity, each intervention is aimed at increasing social cohesion and building social capital. Table 1 shows the design elements that will be studied in this report. When tied to indicators, these interventions can be quantified based on the co-benefits they bring to NYCHA residents and the wider community.

Design Intervention	Health		Safety	Environment	
	Increased Physical Activity	Increased Mental Health	Crime Reduction	Temperature Cooling	Tree Coverage
Playground	✓	✓			
Basketball Court	✓	✓			
Adult Fitness	✓	✓			
Skate Park	✓	✓			
Lighting			✓		
Natural Turf				✓	
Water Play				✓	
Planting				✓	✓

Table 1: Primary Co-benefit of Selected Design Interventions in the Master Plan

SECTION 1: LITERATURE REVIEW

Moving Toward Co-Benefits: A Literature Review of Open Space Project Benefits

While little scholarship has been devoted to the study of capital improvements as they relate to *comprehensive* co-benefits in a manner directly useful for analysis and application in the Life Cycle Cost-Benefit Analysis framework such as the one we undertook, much scholarship has examined the effects of open spaces on individuals and communities by documenting the benefits in singular categories. Upon review of the academic literature on open space improvements, we find a number of co-benefit categories well supported by research, outlining the direct benefits gleaned from open space restoration and activation. Although our project differs from this previous academic work in terms of the specific open space projects to be done throughout NYCHA campuses, we find that the literature robustly captures a range of co-benefits that can be comparably applied to the planned open space projects in NYCHA's Master Plan. Broadly, there are four areas of social co-benefits that are identified as arising from the presence of additional, usable, and improved open space areas in a community: health, public safety, environment, and social capital and cohesion.

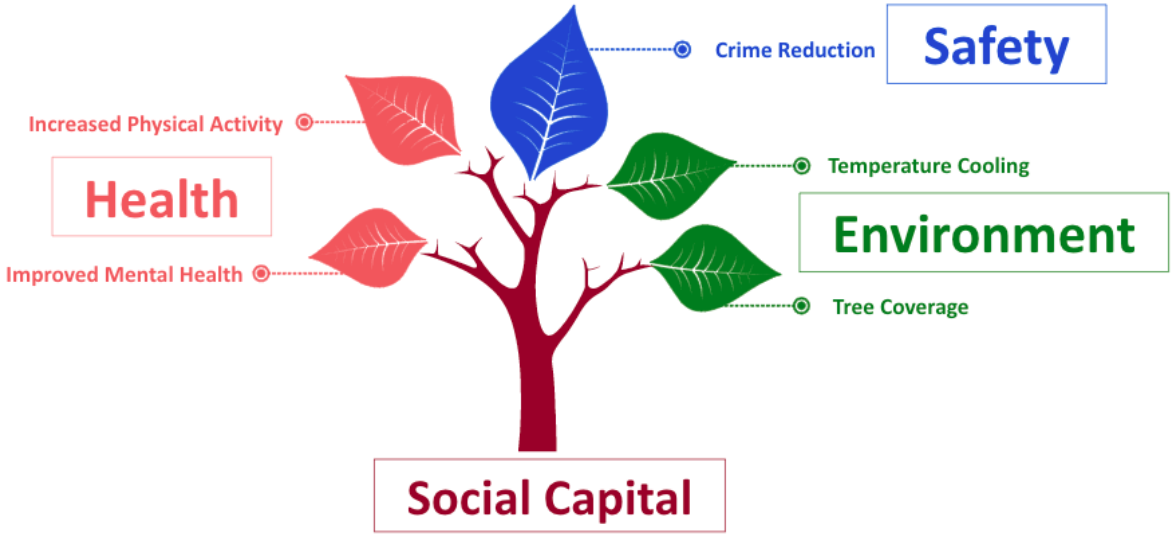

Figure 5: Co-benefit Tree

Health

Public open spaces have a meaningful effect on residential quality of life. They offer a variety of opportunities for stress reduction, improved connection with others, and physical activity. Each of these contribute tangibly to improved health outcomes. Nevertheless, despite the benefits to regular exercise and activity, the vast majority of Americans do not engage in enough physical activity to prevent chronic illness with only 25% of the adult

population reaching minimum standards of physical activity to decrease the likelihood of type 2 diabetes, heart disease, and some forms of cancer.[5] However, though such a state of poor health affecting a large portion of the populations is troubling, there are effective design choices which can be adopted to alter the built environment in such a way that works to redress and reverse the adverse effects of low activity and lack of access to public open spaces. As a result, increasing the ease with which individuals can integrate behavioral changes conducive to a more physically active lifestyle serves as a viable mechanism for bettering the public health of a community.

Health disparities, like those previously mentioned, are especially true in the contexts of predominantly low socio-economic status areas and communities of color, both of which face adverse health outcomes at higher rates than wealthier, majority non-Hispanic White populations. Research has shown that individuals are more likely to experience poorer mental health when confronting poverty, elevated levels of social isolation, and low stimulation.[6] These observed inequities extend beyond the scope of mental health into physical health as exemplified by the fact that Black Americans face chronic diseases at higher rates and at younger ages than Whites in the United States.[7] These gaps in both physical and mental health affecting marginalized groups can be ameliorated by holistic interventions with an eye toward expansive perspectives on the determinants of health that go beyond traditional means of health care.

The scholarly literature contains strong evidence linking access to quality public spaces as a notable factor in remedying deficient mental and physical health. Various studies have examined multiple variables to identify the role that open spaces play in reducing the incidence of chronic illness and mental health. Controlling for individual and regional covariates, individuals living in urban areas with more green space have lower mental distress and higher well-being on average.[8] This may be particularly true for parks with lots of natural features, as studies show that nature can reduce stress and promote relaxation.[9] Time spent in nature enhances focus and concentration in adults and children. Children with attention deficit hyperactivity disorder (ADHD) experience milder symptoms when they play outside.[10] Paquet et al. found that the characteristics of available public open spaces in a community correlated with increased or decreased levels of cardiometabolic risk.[11] Specifically, they found that size, areas designed for active use, and the level of greenery were inversely related with

[5] Centers for Disease Control. *Lack of Physical Activity,* https://www.cdc.gov/vitalsigns/aahealth/index.html.
[6] McDaid D, Park AL, Wahlbeck K. The Economic Case for the Prevention of Mental Illness. Annu Rev Public Health. 2019 Apr 1;40:373-389. doi: 10.1146/annurev-publhealth-040617-013629. Epub 2019 Jan 2. PMID: 30601725.
[7] Centers for Disease Control. *Vital Signs: African American Health*, https://www.cdc.gov/vitalsigns/aahealth/index.html
[8] White, Mathew P., Ian Alcock, Benedict W. Wheeler, and Michael H. Depledge. "Would You Be Happier Living in a Greener Urban Area? A Fixed-Effects Analysis of Panel Data." Psychological Science 24, no. 6 (June 2013): 920–28.
[9] Stigsdotter, Ulrika K et al. "Health promoting outdoor environments--associations between green space, and health, health-related quality of life and stress based on a Danish national representative survey." Scandinavian journal of public health vol. 38,4 (2010): 411-7. doi:10.1177/1403494810367468.
[10] Faber Taylor, A. and Kuo, F.E.(. (2011), Could Exposure to Everyday Green Spaces Help Treat ADHD? Evidence from Children's Play Settings. Applied Psychology: Health and Well-Being, 3: 281-303.
[11] Catherine Paquet, Thomas P. Orschulok, Neil T. Coffee, Natasha J. Howard, Graeme Hugo, Anne W. Taylor, Robert J. Adams, Mark Daniel, Are accessibility and characteristics of public open spaces associated with a better cardiometabolic health?, Landscape and Urban Planning, Volume 118, 2013, Pages 70-78, ISSN 0169-2046

cardiometabolic risk.[12] Though public open spaces do not seemingly have a causal link to decreases in cardiovascular risk profiles, improved health outcomes are mediated by the activities that high-quality park and open spaces promote in individuals.

Researchers have shown that decreased distance to inviting open spaces of any size is associated with recreational walking.[13] However, it is important to note that the magnitude of these effects were dependent upon total distance between an individual's home and open spaces. Adults residing within 1.6 kilometers of a large open space were more likely to reach a threshold level of 150 minutes or more of walking per week; the authors clarified that, while large spaces are superior to small spaces, the quality of an open space may be of greater importance in encouraging individuals to reach sufficient levels of walking to maximize health benefits.[14] The importance of quality recurs throughout the body of literature. When examining the restorative effects of parks on an individual's mental health, larger parks tended to have values above the 50th percentile of reported values, but some smaller parks performed at similar levels of increasing the likelihood of restoration so long as they were of exceptional quality.[15] As a consideration for NYCHA's work, these results are especially promising in terms of potential actions to improve the health of residents. NYCHA campuses are filled with open spaces with proximity to residents well suited to encourage healthy behaviors in its residential population. The Connected Communities framework and the OSMP plans are designed to increase the level of quality of these open spaces. Therefore, there is high reason for confidence that these planned projects would have substantial effects on residents' health.

However, prior to looking at the improvements in health that may emerge within the NYCHA population, it is necessary to understand the context of state of health within NYCHA. Due to decades of community disinvestment, individuals of lower socioeconomic status and communities of color have borne the effects of severe health challenges as a result of discrepancies in access to traditional healthcare, but also due to differences in their surrounding environment. As the above research has shown, this environmental discrepancy can have lasting adverse effects, especially on the most vulnerable. NYCHA is no exception to this. Nearly 80% of NYCHA's older residents have more than one chronic condition affecting their long-term health.[16] Given that more than 1-in-5 NYCHA residents is over the age of 62, this represents a serious public health issue.[17] In addition to this, the NYCHA campuses, as they stand currently, are not designed in such a way to influence active habits that improve health such as those described above. In 2015, 31% of older NYCHA residents stated

[12] Ibid.
[13] Sugiyama T, Francis J, Middleton NJ, Owen N, Giles-Corti B. Associations between recreational walking and attractiveness, size, and proximity of neighborhood open spaces. Am J Public Health. 2010;100(9):1752-1757. doi:10.2105/AJPH.2009.182006
[14] Ibid.
[15] H. Nordh, T. Hartig, C.M. Hagerhall, G. Fry, Components of small urban parks that predict the possibility for restoration, Urban Forestry & Urban Greening, Volume 8, Issue 4, 2009, Pages 225-235, ISSN 1618-8667
[16] Parton HB, et al., Health of Older Adults in New York City Public Housing: Findings from the New York City Housing Authority Senior Survey, (May 2011).
[17] NYCHA, (2020). *NYCHA 2020 Fact Sheet,* https://www1.nyc.gov/assets/nycha/downloads/pdf/NYCHA-Fact-Sheet_2020_Final.pdf

that they had not engaged in any physical activity in the previous month when asked.[18] This reality illustrates the need to adapt and revitalize NYCHA campuses to invite the development and active participation in forming healthy habits.

Thoughtfully improving and adding open spaces to NYCHA campuses, as a result, offers immense opportunities to improve the well-being of the thousands of New Yorkers whom NYCHA serves. NYCHA's endeavors to improve open space at campuses and establish attractive facilities that foster physical activity and use of green spaces will have beneficial effects on residents' physical and mental health. Considering this in the appropriate context, investment in open spaces will not only enhance the appearance of NYCHA campuses but improve residential standards of living.

Public Safety

There is a growing body of research supporting a variety of interventions to improve public safety at the community level going beyond increased levels of enforcement. Each community is unique and faces its own set of challenges with respect to its public safety and this ought not be neglected. To begin improving public safety at the individual neighborhood level, successful models have shown the need to engage with community members and residents as local stakeholders, providing them with a central role in diagnosing the causal elements influencing the level of safety and its solutions.[19] Improving residential safety is not a direct function of deterrence via increased enforcement but instead includes a host of social, political, and historical factors. While redressing these underlying factors is complex and requires concerted action across societal-level sectors, there remain actionable steps to improve public safety through thoughtful improvements of the built environment.

Place-based interventions and intentional environmental design have been thoroughly examined by researchers as a means to improve public safety. These research projects led to a new approach to improve public safety through neighborhood activation. This approach builds on the principles of Crime Prevention Through Environmental Design (CPTED), a theory developed by analyzing visible ownership of space, community empowerment, and the promotion of "informal neighborhood social control" along with its impact on crime.[20] CPTED relates to interventions in the built environment that range from "greening" areas, improving area lighting, wayfinding, and infrastructure. Many interventions of this sort have been studied by researchers and academics, identifying the degree to which each affects the level of crime in a community.

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[18] Parton HB, et al., Health of Older Adults in New York City Public Housing: Findings from the New York City Housing Authority Senior Survey, (May 2011).

[19] NYC Mayor's Office of Criminal Justice, (2017). *Neighborhood Activation Study,* http://criminaljustice.cityofnewyork.us/wp-content/uploads/2018/11/Neighborhood-Activation-Study_Studio-Gang_Public_Version.pdf

[20] Branas, et al. (2020). *Reducing Violence Without Police: A Review of Research Evidence*, Submitted to Arnold Ventures by the John Jay College Research Advisory Group on Preventing and Reducing Community Violence, https://johnjayrec.nyc/wp-content/uploads/2020/11/AV20201109.pdf

Perhaps, though not initially intuitive, revitalizing a community's access to high quality green, open spaces have a measurable effect on crime reduction and residential perception of the level of safety. Researchers have undertaken quasi-experimental studies across large American cities and observed meaningful reductions in crime. By considering community violence as a symptom of structural forces affecting a population's public health, additional tools for improving public safety begin to emerge. Transformational green space in communities facing long-term histories of blight and vacant areas has been shown to have considerable effects not only on crime rates but also on residents' perceptions of crime. This has transformative effects on neighborhood residents' beliefs surrounding the level of crime and safety in a given area. The restoration of blighted and vacant areas with improved greening resulted in a statistically significant drop of 39.3% in the perception of the presence of crime and vandalism.[21] Perhaps, more importantly than the perception of crime alone, community members expressed "reduced safety concerns" with respect to leaving their homes which coincided with a 76% increase in use of local public open spaces.[22] In and of itself, these results are striking and profound but also indicate that a sense of safety coincides with gains in public safety and community use of spaces which, as supported by the literature, improve health outcomes and foster connection. In this way, it is clear that the co-benefits act synergistically, magnifying the individual benefits of open space.

Taking note of the improved use of public open space is especially important given that current research findings support the role of greening spaces as they are believed to catalyze a variety of social factors, interacting with one another and mediating against crime by the following mechanisms: stress reduction, improved perceptions of quality of life, greater mental restoration and resilience, community enfranchisement, and civic pride.[23] Notably, in the City of Philadelphia, researchers discovered that the number of gun assaults decreased as tree cover increased -- this observed relationship between tree cover and gun assaults was even more apparent in lower income areas.[24] Greening areas have profound, noticeable effects on the level of safety within a community and carry over across varying localized neighborhood contexts. Analysis of over 10 years of data in Philadelphia confirmed statistically significant reductions in gun violence irrespective of the area of the City.[25] These findings exhibiting the relationship between greening areas and crime levels remain broadly consistent throughout the literature. Researchers at Yale University and Drexel University School of Public Health found the same inverse relationship with respect to crime and tree coverage.[26] According to their study of New Haven, Connecticut, they found that an increase of 10% in tree canopy coverage was correlated to a decrease of 15% in violent crimes

[21] Branas et al., Citywide cluster randomized trial to restore blighted vacant land and its effects on violence, crime, and fear. Proceedings of the National Academy of Sciences Mar 2018, 115 (12) 2946-2951; DOI: 10.1073/pnas.1718503115
[22] Ibid.
[23] Shepley M, et al. The Impact of Green Space on Violent Crime in Urban Environments: An Evidence Synthesis. Int J Environ Res Public Health. 2019 Dec 14;16(24):5119. doi: 10.3390/ijerph16245119. PMID: 31847399; PMCID: PMC6950486.
[24] Branas, et al. (2020). *Reducing Violence Without Police: A Review of Research Evidence*, Submitted to Arnold Ventures by the John Jay College Research Advisory Group on Preventing and Reducing Community Violence, https://johnjayrec.nyc/wp-content/uploads/2020/11/AV20201109.pdf
[25] Ibid.
[26] Gilstad-Hayden, et al. (2015) *Research note: Greater tree canopy cover is associated with lower rates of both violent and property crime in New Haven, CT*, Landscape and Urban Planning, Volume 143, 248-253, DOI: https://doi.org/10.1016/j.landurbplan.2015.08.005

and a 14% decrease in property crimes.[27] Considering the findings above, improving public open spaces with the addition of tree cover and vegetation provide unique opportunities to reduce violence without means of active enforcement and enhance residents' affinity to their community.

Moving beyond the addition and improvement of green spaces to more traditional approaches to community safety like increased passive surveillance and lighting investments have a mixed record in the literature regarding their effects on decreasing crime. In particular, the addition of closed-circuit television (cctv) and security cameras to an area appear to have inconsistent effects on crime and public safety, as reported in scholarly research.[28] Lighting improvements, much like passive surveillance methods like cameras, have not always yielded significant results that translate in safety gains. However, in a review of the literature, it is clear that lighting's effects withstand scrutiny as an appropriate non-policing method for violence reduction and prevention with experimental methods showing that areas with improved lighting experienced a 20% reduction in overall crime relative to control groups.[29] Broadly, there are two prevailing explanations for improved lighting's effect on crime: The first relates to more visibility and surveillance of potential offenders and the second relies on the signal that lighting improvements connote, greater "community cohesion" and community reinvestment, both of which mediate against crime.[30] Researchers also found that lighting improvements did not decrease crimes occurring during night hours more than those during daylight, which implies that improvements in lighting have a more potent effect on affecting crime than simply creating more visibility, thereby supporting the second hypothesis.[31] Thus, this underscores the importance of community cohesion and social capital as an element in improving the level of crime in an area and the means by which the built environment can influence community connection and empowerment.

More recently, Crime Lab New York led a study at NYCHA campuses in which researchers used a randomized control trial (RCT) experimental design over the course of 5 months in 2016 to ascertain the effect of lighting on nighttime outdoor index crimes taking place at NYCHA developments. Index crimes are considered to fall under the most serious categorization of crimes and are comprised by the crimes of motor vehicle theft, felony assault, grand larceny, robbery, burglary, and murder and non-negligent manslaughter.[32] They found that the additional lighting resulted in a 36% decrease in index crimes occurring at night.[33] These associated effects were equivalent to an increase of 10% of police officers servicing the campuses and provided an expected cost-benefit

[27] Ibid.
[28] Branas, et al. (2020). *Reducing Violence Without Police: A Review of Research Evidence*, Submitted to Arnold Ventures by the John Jay College Research Advisory Group on Preventing and Reducing Community Violence, https://johnjayrec.nyc/wp-content/uploads/2020/11/AV20201109.pdf
[29] Ibid.
[30] Welsh, B.C. and Farrington, D.P. (2008), Effects of Improved Street Lighting on Crime. Campbell Systematic Reviews, 4: 1-51. https://doi.org/10.4073/csr.2008.13
[31] Ibid.
[32] Chalfin, Aaron, et al. "Reducing crime through environmental design: Evidence from a randomized experiment of street lighting in new york city." Journal of Quantitative Criminology (2019): 1-31.
[33] Ibid.

ratio of 4 to 1.[34] Due to this, lighting improvements prove to be a promising, cost-effective avenue to reduce crime levels, not only on the basis of widespread review of the evidence by researchers, but because of its proven effectiveness in the context of NYCHA campuses.

It is self-evident that public safety's importance cannot be understated. The presence of crime and community violence must be addressed and reversed for communities to truly flourish. While not always at the forefront of methods to improve safety in a community, there is a sufficient body of evidence to pursue a design approach to reduce crime. NYCHA's capital improvement projects can make a significant impact on not only the level of crime on its campuses but also on residents' own sense of safety. As a result, open spaces enhance public safety on a more fundamental level, comprising both the physical and psychological components that affect individuals.

Environment

Effective environmental interventions such as planting and green infrastructure can have meaningful co-benefits, most important of which include temperature cooling and improved air quality. In New York City, extreme heat poses a severe health threat, making it the most fatal of all extreme weather events according to the NYC Department of Mental Health and Hygiene.[35] Every summer, there are an average of 450 heat-related emergency room visits, 150 heat-related hospital admissions, 13 heat stroke deaths, and around 115 excess deaths from heat-related causes.[36] By 2050, average annual temperatures in New York are projected to increase by 4.1 to 5.7°F due to climate change.[37] The urban heat island effect, which can lead to higher city temperatures by as much as 22°F after sunset than in surrounding areas, compounds the city's rising temperatures.[38]

[34] Ibid.
[35] NYCEM, 2014. "NYC'S Risk Landscape: A Guide to Hazard Mitigation", November 2014, https://www1.nyc.gov/assets/em/downloads/pdf/hazard_mitigation/nycs_risk_landscape_a_guide_to_hazard_mitigation_final.pdf
[36] Charles-Guzman, Kizzy. "Cool Neighborhoods NYC: A Data-Driven Approach to Keep Communities Safe and Adapt New York City to Rising Temperatures and Extreme Heat Events." 100th American Meteorological Society Annual Meeting. AMS, 2020.
[37] Rosenzweig, C., Solecki, W. NYC Panel on Climate Change. (NPCC). (2015). Building the Knowledge Base for Climate Resiliency: NYC Panel on Climate Change 2015 Report. New York Academy of Science 1336: 1–149.
[38] U.S. Environmental Protection Agency, "Urban Heat Island Basics," in Reducing Urban Heat Islands: Compendium of Strategies, Draft (2008), https://www.epa.gov/sites/production/ files/2017-05/documents/reducing_urban_heat_islands_ch_1.pdf.

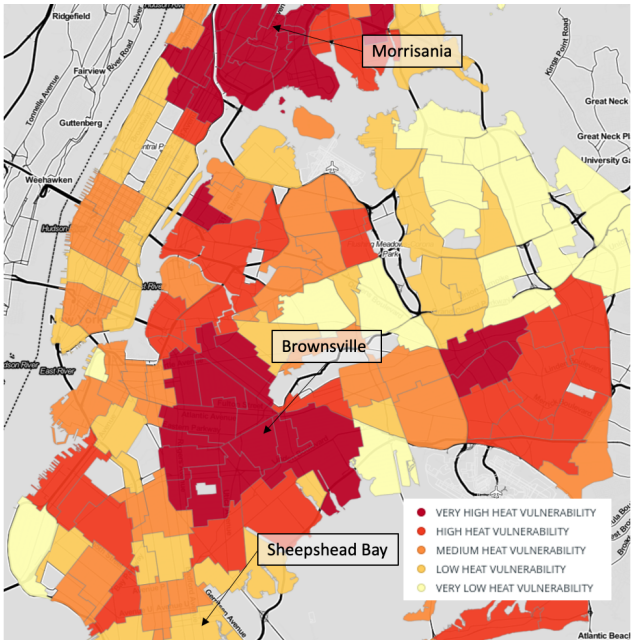

Figure 6: HVI, Selected Sites

Communities of color and low-income communities are disproportionately affected by extreme heat. Researchers have found that deaths during heat waves were more likely to occur in black (non-Hispanic) individuals than other race/ethnicities, at home than in institutions and hospital settings, and among those living in census tracts that received greater public assistance.[39] The same study found that deaths during heat waves were more likely among residents in areas of the city with higher relative daytime summer surface temperature and less likely among residents living in areas with more green space.[40] Neighborhoods that have faced decades of disinvestment often lack social infrastructure and built environment features like cool gathering spaces, shading, and green space that mitigate the impacts of extreme heat. According to a recent study by Hoffman et al., formerly redlined areas across the United States are consistently hotter than non-redlined areas, with land surface temperatures as much as 7°C hotter than adjacent non-redlined areas.[41] New York City's Heat Vulnerability Index (HVI) maps the impacts of extreme heat at a neighborhood level. Developed by the Department of Health and Columbia University, the HVI analyzes environmental and social factors by census tract across the five boroughs to identify which neighborhoods are at higher risk for heat-related deaths. The twelve neighborhoods that rank highest are low-income neighborhoods with residents who are predominantly people of color. These communities include Bushwick and Brownsville in Brooklyn and Morrisania in the Bronx, where two of the NYCHA sites analyzed later are located (Figure 6). The City's ongoing Cool Neighborhoods program includes strategies to mitigate and adapt to the threat of extreme heat in high-risk

[39] Madrigano, Jaime et al. "A Case-Only Study of Vulnerability to Heat Wave-Related Mortality in New York City (2000-2011)." Environmental health perspectives vol. 123,7 (2015): 672-8. doi:10.1289/ehp.1408178
[40] Ibid
[41] Jeremy S. Hoffman, Vivek Shandas, and Nicholas Pendleton, "The Effects of Historical Housing Policies on Resident Exposure to Intra-Urban Heat: A Study of 108 US Urban Areas," Climate 8, No. 12 (2020), https://doi.org/10.3390/cli8010012.

neighborhoods identified by the HVI. The program includes design strategies like planting street trees in targeted neighborhoods.

Illness associated with heat is the most common cause of weather-related deaths in the United States. Heat-Stress Illness (HSI) ranges in severity from relatively mild heat cramps to life-threatening heat stroke.[42] HSI was the primary cause of environmental exposure-related injuries treated in emergency departments in the U.S. from 2001 to 2004.[43] Estimates of total health care costs based on Medicare claims data associated with hyperthermia were more than $36 million for 2004–2005.[44] studies have shown a non-linear relationship between temperature and morbidity.[45] These studies have focused on a variety of outcomes impacted by heat, including cardiovascular disease, respiratory diseases, and asthma. There are also studies utilizing emergency dispatch data to demonstrate a strong association between morbidity rates and temperature increases.[46] Among the elderly, emergency department visits and hospitalizations for a variety of health conditions are more frequent during extreme heat events.[47] One recent study focused on morbidity due to HSI revealed a significant association between mean monthly maximum temperature and HSI hospitalization rates observed in the state of Illinois, corroborating the direct impact of high temperature on human health.[48]

Moreover, temperature is one of the fundamental characteristics of the indoor environment. The indoor temperature affects several human responses, including thermal comfort, perceived air quality, sick building syndrome symptoms and performance in work.[49] According to NYC Planning, in 2014 to 2018, 4.4% residents in Brooklyn and 3.2% in the Bronx work at home.[50] This percentage is expected to significantly increase as a result of the work from home policy during COVID-19 pandemic. A study showed an average 2% decrease in work performance per degree centigrade of temperature increase when the temperature is above 25 °C.[51] However, heat conditions in some low-income areas are not well-controlled due to insufficient cooling facilities, like air conditioners.

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[42] Argaud, Laurent, et al. "Heat waves and heat-related illness: Preparing for the increasing influence of climate on health in temperate areas. Commentary." JAMA, the journal of the American Medical Association 298.8 (2007): 917-919.
[43] Sanchez, et al. Nonfatal Natural and Environmental Injuries Treated in Emergency Departments, United States, 2001–2004, Family & Community Health: January 2010 - Volume 33 - Issue 1 - p 3-10 doi: 10.1097/FCH.0b013e3181c4e2fa
[44] Rebecca S. Noe, Jill O. Jin, and Amy F. Wolkin, 2012: Exposure to Natural Cold and Heat: Hypothermia and Hyperthermia Medicare Claims, United States, 2004–2005 American Journal of Public Health 102, e11_e18
[45] Li M, Gu S, Bi P, Yang J, Liu Q. Heat waves and morbidity: current knowledge and further direction-a comprehensive literature review. Int J Environ Res Public Health. 2015;12(5):5256-5283. Published 2015 May 18. doi:10.3390/ijerph120505256
[46] Calkins, M.M., Isaksen, T.B., Stubbs, B.A. et al. Impacts of extreme heat on emergency medical service calls in King County, Washington, 2007–2012: relative risk and time series analyses of basic and advanced life support. Environ Health 15, 13 (2016).
[47] Fuhrmann, C.M., Sugg, M.M., Konrad, C.E. et al. Impact of Extreme Heat Events on Emergency Department Visits in North Carolina (2007–2011). J Community Health 41, 146–156 (2016). https://doi.org/10.1007/s10900-015-0080-7
[48] Jagai JS, Grossman E, Navon L, Sambanis A, Dorevitch S. Hospitalizations for heat-stress illness varies between rural and urban areas: an analysis of Illinois data, 1987-2014. Environ Health. 2017 Apr 7;16(1):38. doi: 10.1186/s12940-017-0245-1. PMID: 28388909; PMCID: PMC5384150.
[49] Seppanen, Olli, William J. Fisk, and David Faulkner. "Control of temperature for health and productivity in offices." (2004).
[50] NYC Planning Factfinder, (2021), American Community Survey Data, https://popfactfinder.planning.nyc.gov/profile/119/economic?comparator=2
[51] Ibid

At warmer outdoor temperatures, there is a strong correlation between indoor and outdoor temperature: each unit of drop in outdoor temperature would lead to 0.41 unit drop in indoor temperature[52]. Therefore, for buildings without cooling facilities, exterior cooling is extremely important and effective for reducing interior temperature.

Evaporative cooling systems and surface water are highly effective cooling interventions in urban planning. Passive direct evaporative cooling can occur in outdoor space with the aid of natural wind flow, for example, through the use of fountains or water play. A study has shown that these can lead to air temperature reduction of 3-8 ℃ when relative humidity is less than 50%.[53] Another effective intervention, natural turfs, use similar principles for surface cooling through evapotranspiration. However, unlike trees they do not provide shade, so the cooling effect of turf is highly dependent on availability of water for irrigation. Combination of tree canopy and natural turfs in urban parks results in 1-2℃ cooler air temperatures.[54]

Besides the benefit of temperature cooling, environmental interventions can directly and indirectly affect local and regional air quality by altering the urban atmospheric environment. Trees remove gaseous air pollution primarily by uptake via leaf stomata, though some gases are removed by the plant surface. In 1994, trees in New York City removed an estimated 1,821 metric tons of air pollution at an estimated value to society of $9.5 million. These standardized pollution removal rates differ among cities according to the amount of air pollution, length of in-leaf season, precipitation, and other meteorological variables. Large healthy trees greater than 77 cm in diameter remove approximately 70 times more air pollution annually (1.4 kg/yr) than small healthy trees less than 8 cm in diameter (0.02 kg/yr).[55] Moreover, recent study also revealed that exposure to plant diversity is protective of immune diseases and allergic respiratory diseases, like asthma, and pointed out that A 1-SD increase in overall greenness exposure was associated with a 3.8% increase in adult-asthma rate.[56] Asthma costs the U.S. economy more than $80 billion annually in medical expenses, missed work and school days and deaths, according to new research in the Annals of the American Thoracic Society. Total per-person annual costs of asthma averaged $4912 (in 2003 dollars), with direct and indirect costs accounting for $3180 (65%) and $1732 (35%), respectively.[57]

In addition to air quality improvements, planting interventions provide cooling benefits such as shading and evapotranspiration. According to a 2008 EPA report, tree and vegetation interventions can reduce temperatures

[52] Nguyen et al. “The relationship between indoor and outdoor temperature, apparent temperature, relative humidity, and absolute humidity.” Indoor Air. 2014; 24(1): 103-112. doi:10.1111/ina.12052.
[53] Low Carbon Living CRC, (2017). “Guide to Urban Cooling Strategies”, http://www.lowcarbonlivingcrc.com.au/sites/all/files/publications_file_attachments/rp2024_guide_to_urban_cooling_strategies_2017_web.pdf
[54] Ibid
[55] Nowak, David J. "The effects of urban trees on air quality." USDA Forest Service (2002): 96-102.
[56] Geoffrey H. Donovan, Shawn M. Landry, Demetrios Gatziolis, The natural environment, plant diversity, and adult asthma: A retrospective observational study using the CDC's 500 Cities Project Data, Health & Place, Volume 67, 2021, 102494, ISSN 1353-8292
[57] Cisternas, Miriam G., et al. "A comprehensive study of the direct and indirect costs of adult asthma." Journal of allergy and clinical immunology 111.6 (2003): 1212-1218.

by 2–9°F in peak summer months.[58] In addition to providing cooling benefits, trees and vegetation can produce direct energy savings, which research has suggested could reduce carbon emissions in U.S. metropolitan areas by roughly 1.5–5%. By increasing shaded space, trees can reduce the maximum surface temperature of the roofs and walls of buildings by 20–45°F. Furthermore, one report that assesses the ecosystem services of trees in two NYCHA developments, Carver Houses and Tilden Houses have found significant positive impact including carbon sequestration, removal and storage, avoided stormwater runoff and air pollution reduction that is dependent on the type, size and health condition of the tree coverage.[59]

Literature that pertains to environmental benefits of public housing improvement interventions such as planting, natural turf and water play highlights their importance on temperature cooling, air quality improvements, carbon emission reduction and related health benefits. In NYC where the heat island effect has led to health deterioration, particularly among vulnerable populations, the proposed interventions are expected to improve the surrounding environment of NYCHA housing and reduce environment-induced sickness.

Social Capital and Cohesion

Social capital refers to the amount and quality of trust, norms, and networks available to individuals in a community as a function of belonging to that community. It is important to distinguish between the quantitative and qualitative dimensions of social capital, even though it may be difficult to measure either. Social scientists divide social capital into the two by referencing social bridges and social glue, where bridges are the stock or quantity of connections between individuals and groups, and glue is the strength or quality of those connections.[60]

Although social capital may be difficult to measure, it is very possible to observe. Because social capital translates into communities with higher degrees of cohesion and civic participation, it can be observed in the ways in which cohesion and civic participation can be observed. Specifically, that means voter participation and participation in official civic discourse such as council meetings; participation in unofficial civic participation, such as protests and other demonstrations; participation in community organizations such as parent teacher associations and tenants associations; and, though less observable, participation in casual interactions and unprogrammed social behavior, such as sidewalk encounters and local park use.[61] The degree to which neighbors interact with each other does not directly translate into a cohesive community, however, since it's the quality and outcome of interaction that determines cohesiveness. Cohesiveness can then be observed through surveys which aim to determine an individual's sense of trust and belonging in the community.

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[58] EPA. "Reducing urban heat islands: compendium of strategies-cool pavements." (2008).
[59] Rathore, Kyathi, (2019). "Ecosystem Services of NYCHA campuses", EDF Climate Fellowship Report.
[60] Robert E. Lang & Steven P. Hornburg (1998) What is social capital and why is it important to public policy?, Housing Policy Debate, 9:1, 1-16, DOI: 10.1080/10511482.1998.9521284
[61] Roberts, Martin, and Martin Roche. "Quantifying social capital: Measuring the intangible in the local policy context." Radical Statistics 76 (2001): 15-28.

An interesting example of this is found by the study observing community dynamics during tree inventory studies on two NYCHA campuses. The tree conditions are significantly better, and the shared spaces are cleaner in the community, with more social contact in these spaces and resident participation in community events.[62] It was also observed that more community gardens are present on this campus.[63] The report detailed that "a strong correlation between the social resiliency and tree health and density density."[64] The reciprocal circle of "better environment increases community resiliency while stronger community cohesion continues to improve the environment" shows how other benefits from activated open spaces can enhance social capital and cohesion.

Social capital and financial capital are different and often exist independently. High income communities can lack in social capital, particularly wealthy suburbs. Conversely, some low-income communities have been observed to be "rich" in social capital. And although the two types of capital can complement each other, meaning that having higher social capital can lead to accumulating financial resources, and vice-versa, a more immediate and pertinent result of having social capital which is commonly obtained through the acquisition of financial capital instead is a higher quality of life.[65]

The review of site interventions as it pertains to their potential to increase NYCHA residents' social capital focuses on their ability to improve the quality of life of residents. It has been proposed by scholars of urban studies that the built environment can be a catalyst for social interaction, a concept that needs little recognition outside scholarly circles, but that nonetheless has been observed and documented, particularly in the use of parks and public spaces. In this manner, the proposed interventions at NYCHA facilities are expected to alter the quantity and quality of interaction between residents and therefore have an effect on the "bridges" and "glue" of communities in NYCHA properties.

[62] Rathore, Kyathi, (2019). "Ecosystem Services of NYCHA campuses", EDF Climate Fellowship Report.
[63] Ibid
[64] Ibid
[65] Robert E. Lang & Steven P. Hornburg (1998) What is social capital and why is it important to public policy?, Housing Policy Debate, 9:1, 1-16, DOI: 10.1080/10511482.1998.9521284

SECTION 2: MONETIZING CO-BENEFITS

CBA Explained

In this section, we will monetize the three co-benefits of Health, Public Safety, and Environment using a Life Cycle Cost Benefit Analysis (LCCBA). LCCBA is a common practice for evaluating a designed approach in monetary terms. In a CBA, various methodologies and techniques are used to quantify the social value of interventions beyond their financial values. Due to the difficulty of quantifying social cohesion and human capital, which are more intangible benefits, and more a combination of all other effects on the community, social capital will not be indirectly monetized. We will qualitatively analyze how the site plans have the potential to affect social capital.

Monetizing Health Benefits

In order to quantify the health benefits from the campus designs, we first determined where we saw direct health benefits arising. It was evident that many areas of the campus design are dedicated to spaces to increase physical activity (playgrounds, walking paths, fitness areas, even skatepark concepts). Thus, we saw an opportunity to view direct health benefits from the interventions to expand physical activity spaces.

Next, we assessed what type of health outcomes from physical activity were relevant to the local communities. Based on Community Health Profiles, we recognize that cardiovascular disease and childhood obesity are at elevated levels across these communities. We also recognized that the general cost of healthcare is a perennial pressure, so we wanted to also note how physical activity could address this pressure. Finally, literature and research has shown a connection between physical activity and mental health, which we wanted to capture for this project as mental health is a key social concern. Thus, ultimately, we set out to explore how physical activity could impact cardiovascular disease, childhood obesity, general healthcare, and mental health, and then how we could turn these connections into monetized values.

It is worth noting, again, that these spaces (like playgrounds or fitness areas) can provide additional social benefits that go beyond physical health. For example, a frequented community playground can generate stronger senses of community ownership, pride, and build social connections between neighbors and community members being in proximity and sharing in the space. These weave into the intangible social capital of the community fabric. Moreover, there are clear ways to view how a playground could not only address health, but could also address an aspect of safety - which we consider later. While this is, again, a valid consideration, when it comes to monetizing the value of the playground, we consider this a secondary benefit, and do not monetize for risk of double counting.

Finally, the “benefits” expressed here represent a benefit to residents and society broadly. As we will show, reducing cardiovascular disease generates benefits for both the individual at risk (i.e. a NYCHA resident) as well

as, for example, the medical system. Thus, these savings/benefits are not, necessarily, speaking directly to savings/benefits to NYCHA as an organization nor, necessarily, its agency budget. However, we must accept that NYCHA serves as a pillar of its community and that something like cost savings to a local hospital to treat cardiovascular disease will have ripple effects back through the community. This requires NYCHA, policymakers, and budget-minded individuals, to take a wider aperture to concepts of costs and benefits in these examples.

Physical Health

Cardiovascular disease

According to the Center for Disease Control,[66] in the United States, chronic heart (cardiovascular) disease is the leading cause of death in the US. It accounts for roughly one in three deaths nationally and imposes over $200 billion in costs on our healthcare system. Likewise, in New York, an estimated 35% of deaths statewide are a result of cardiovascular disease. A 2018 NY State Department of Health survey estimated that roughly 8% of New Yorkers reported having some cardiovascular disease episode, however the survey further notes that the estimates are significantly higher for older individuals and those of lower socioeconomic status.[67] Thus, in areas like Central Brooklyn and South/Central Bronx where these campuses are located, premature deaths (before age 65) due to heart disease are more than double the NYC average. In Brownsville, for example, 74 out of every 100,000 premature deaths are attributed to heart disease. The NYC average is 33. In Morrisania it is 54 out of every 100,000.[68]

Studies show that physical activity can reduce the prevalence of cardiovascular diseases such as coronary heart disease (CHD) - the most prevalent cardiovascular disease. For our measurement, we have identified two studies that represent a low and a high end impact. In one study, conducted in 1988, researchers found that regular exercise can reduce CHD incidence by 7.8% (78 out of 1000 cases).[69] In a follow up study, researchers demonstrated the reduction can be as high as 41%.[70]

Next, we identified a separate study that estimates the costs of coronary disease across different time horizons.[71] The study employs economic modeling techniques to develop the per adult per year direct medical spend on

[66] CDC, *Heart Disease and Stroke*, https://www.cdc.gov/chronicdisease/resources/publications/factsheets/heart-disease-stroke.htm
[67] NYSDOH, (2018). Cardiovascular Disease, NYS Adults 2018, BRSS Brief, https://www.health.ny.gov/statistics/brfss/reports/docs/2004_brfss_cardiovascular_disease.pdf
[68] NYC Department of Health and Mental Hygiene, "Heat-related Deaths in New York City, 2013," Epi Data Brief, No. 47 (August 2014), https://www1.nyc.gov/assets/doh/downloads/pdf/epi/datatable47.pdf
[69] Hatziandreu, Evridiki; Koplan, Jeffrey; Weinstein, Milton, et al. 1988. "A Cost-Effectiveness Analysis of Exercise as a Health Promotion Activity," https://ajph.aphapublications.org/doi/pdf/10.2105/AJPH.78.11.1417
[70] Sundquist, Kristina. Qvist, Jan, Johansson, Sven-Erik. 2005. "The long-term effect of physical activity on incidence of coronary heart disease: A 12-year follow-up study" https://www.sciencedirect.com/science/article/abs/pii/S0091743504005699?via%3Dihub
[71] Russell, M.W.; Huse, D.M.; Hamel, E.C., et al. "Direct Medical Costs of Coronary Artery Disease in the United States," https://pubmed.ncbi.nlm.nih.gov/9605051/#:~:text=First%2Dyear%20direct%20medical%20costs,estimated%20to%20be%20%241%2C051%20annually

coronary heart disease, and estimates that a year of direct medical spend/treatment of CHD amounts to roughly $14,000 (CPI adjusted) per person. Five years totals $24,000 and ten years reaches above $43,500.

It is important to note that these costs reflect a total medical spend, which includes costs to health insurance. Thus, to calculate the savings benefit from improved physical activity we build this generalized equation:

$$(1)\ Site\ adult\ population \times assumed\ CHD\ prevalence \times physical\ activity\ impact \times treatment\ costs$$

First, we input the number of adults at the site. Next we multiply this by the assumed CHD prevalence, which is given by the NYS Department of Health study. This gives us an assumed number of individuals in the site who are affected by CHD. Then, we multiply that by physical activity's estimated impact on CHD. For example, if there are an assumed 50 individuals who are affected by CHD and we understand physical activity can reduce CHD by 8% at the low end and 40% on the high end, then we assume that we could remove four to twenty people from CHD risk by improving physical activity. Finally, we multiply these results by the treatment cost estimates across time to arrive at our low and high end cost savings. The four to twenty individuals in our example would no longer need CHD treatment, generating various savings across time. Putting it all together, we arrive at these estimated values:

CHD	Morris	Nostrand	Van Dyke
1 year treatment cost (low)	$291,842	$149,393	$237,801
1 year treatment cost (high)	$1,534,042	$785,272	$1,249,977
5 year treatment cost (low)	$484,668	$248,101	$394,920
5 year treatment cost (high)	$2,547,616	$1,304,118	$2,075,864
10 year treatment cost (low)	$869,242	$444,963	$708,281
10 year treatment cost (high)	$4,569,093	$2,338,907	$3,723,017

Table 2: Savings from reduced CHD medical spending per site

Thus, if OSMP sites can encourage regular physical activity in adults, we estimate it can lead to medical cost savings at these sites anywhere between $150,000 and $4,000,000.

However, this may be an underestimate. We assumed that around 8% of the NYCHA population has CHD. This is based on the NY State Department of Health statewide estimate. While data is not available on exact prevalence of cardiovascular disease at these NYCHA sites, the higher than average premature death rates due to

heart disease as reported in the Community Health Profiles in the surrounding neighborhoods implies that prevalence may be higher at NYCHA sites than a statewide average. If this was the case, the total potential reductions in CHD, and hence, cost savings could be higher.

Personal healthcare expenditure

In addition to specific reductions to healthcare expenditures on cardiovascular disease, we also attempted to measure the impact of physical activity's impact on general personal expenditures. Physical activity has general health benefits that create additional marginal savings and health improvements across a lifetime.

In a 2014 study, researchers used national level data to analyze the differences in expenditures between physically active individuals, physically inactive individuals, and insufficiently active individuals.[72] The note that, "fewer than half of United States adults met minimal guidelines for aerobic activity and almost one-third were physically inactive in 2011." To conduct their study, researchers took healthcare spending panel data and matched it to survey data on physical activity. They concluded that personal healthcare spending for physically active individuals was $750 less per person per year (CPI adjusted) than insufficiently active individuals. The savings doubled when they compared healthcare spending between physically active and inactive individuals. This aids our understanding of the value of generalized health benefits that can arise from physical activity unspecified to any disease.

Our calculation is represented below. We follow the study's own calculation and remove from the general population an assumed 6% of the population with physical impairment or who are pregnant. Next, we use the percentage of inactive and insufficiently inactive individuals in the Northeast region, as provided by the study - 35%, with an additional 20.7% insufficiently active. We, then, for sake of calculation, assume a 1% change in population that transitions from physically inactive to physically active and a 1% change from insufficiently active to active. A 1% change in physical activity behaviors would mean anywhere from 10-15 people at each site deciding to become regularly active as a result of OMSP implementation. If 1% of each population can transition into a physically active lifestyle as a result of the interventions, yearly savings/benefits could range between around $10,000 and $20,000. We follow this logic for our calculations:

$$(2)\ Adult\ population\ at\ site\ \times (1 - physical\ impairment\ rate) \times 35\%\ inactive \times 1\%\ assumed\ activity\ change\ in\ population\ \times CPI\ adjustment\ (yr\ to\ yr) \times \$762\ savings\ per\ year$$

$$(3)\ Adult\ population\ at\ site\ \times (1 - physical\ impairment\ rate) \times 21\%\ inactive$$

[72] Carlson SA, Fulton JE, Pratt M, Yang Z, Adams EK. Inadequate physical activity and health care expenditures in the United States. Prog Cardiovasc Dis. 2015;57(4):315-323. doi:10.1016/j.pcad.2014.08.002

$\times$ 1% *assumed activity change in population* $\times$ *CPI adjustment (yr to yr)*
$\times$ \$1537 *savings per year*

Personal healthcare spend	Morris	Nostrand	Van Dyke
Adult population	**3278**	**1678**	**2671**
CPI adjustment (2017 to 2021)	1.07	1.07	1.07
Assumed prevalence of physical impairment	6%	6%	6%
Adult population w/o impairment	3,097	1,586	2,524
Physically inactive	35%	35%	35%
# of physically inactive	1084	555	883
Insufficiently active	21%	21%	21%
# of insufficiently active	679	347	553
Assumed inactive to active (%)	1%	1%	1%
Inactive to active (#) persons	11	6	9
Assumed insufficient active to active (%)	2%	2%	2%
Insufficient active to active (#) persons	14	7	11
Savings per year (inactive -> active)	\$16,669	\$8,533	\$13,582
Savings per year (insufficient -> active)	\$10,353	\$5,300	\$8,436

Table 3: Other personal healthcare savings per adult per year

Childhood obesity

According to the Journal of Global Pediatric Health in 2019, childhood obesity reached "epidemic" levels in the United States.[73] An estimated 1 in 6 children nationally are presenting with obesity. Meanwhile, in New York City, rates are even higher. A reported one in five kindergarten students have obesity.[74] However, obesity is not evenly distributed across the city. Sociodemographic and socioeconomic factors can influence which populations and neighborhoods experience higher obesity rates.

In a 2010 study, researchers looked at neighborhood-level resources across New York City to determine which factors may influence obesity.[75] They found that area income, food availability, and physical activity resources are

[73] Sanyaolu A, Okorie C, Qi X, Locke J, Rehman S. Childhood and Adolescent Obesity in the United States: A Public Health Concern. Glob Pediatr Health. 2019;6:2333794X19891305. Published 2019 Dec 1. doi:10.1177/2333794X19891305
[74] NYCDOH, "Obesity", https://www1.nyc.gov/site/doh/health/health-topics/obesity.page
[75] Black JL, Macinko J, Dixon LB, Fryer GE Jr. Neighborhoods and obesity in New York City. Health Place. 2010 May;16(3):489-99. doi: 10.1016/j.healthplace.2009.12.007. Epub 2010 Jan 7. PMID: 20106710.

associated with obesity. A 2018 study further studied changes in obesity prevalence within New York City between 2004 and 2014 and found that the Black population obesity rate climbed 10%.[76] Non-white Latino obesity climbed 15%. The CDC makes clear that lower socioeconomic status, namely lower family income and lower levels of education are associated with the childhood obesity prevalence.[77]

Areas like Brownsville, Morrisania, and to a lesser degree, Sheepshead Bay, where our case study sites are located are and where income and education levels are lower than citywide averages, are thus disproportionately affected by obesity. Using NYC's most recent Community Health Profiles, the reported obesity rate for children in these neighborhoods are 23%, 24% and 17% respectively, and Children at these campuses constitute around 10% of the total number of children in the surrounding neighborhood.[78]

Longitudinal studies show that obese and overweight children struggle to reduce their weights over time, and often remain obese and/or overweight into adulthood.[79] This has significant effects on lifetime costs. Long-term average medical costs for overweight and obese individuals are substantially higher. These costs arise because obesity can lead to additional comorbidities, as well as additional healthcare needs like arthritis. They also reduce productivity due to higher incidences of illness, injury, and disability.[80] In fact, in the long run, lifetime productivity losses may be larger than additional lifetime healthcare costs.[81] A recent economic modeling study showed that the lifetime cost of being overweight was over $60,000 in healthcare spend, and over $90,000 in lost productivity.[82] For obese individuals, the lifetime values were over $100,000 and $140,000 respectively. Thus, it is crucial that efforts are made to reduce obesity and overweightness as early as possible, particularly in economically vulnerable populations.

Research emphasizes that reducing obesity levels requires a multifaceted approach, and physical activity is an essential aspect of achieving this goal. Playgrounds and other active spaces for youth can aid in achieving regular and recommended levels of physical activity to stem the effects of obesity and overweightness.

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[76] Rummo P, Kanchi R, Perlman S, Elbel B, Trinh-Shevrin C, Thorpe L. Change in Obesity Prevalence among New York City Adults: the NYC Health and Nutrition Examination Survey, 2004 and 2013-2014 [published correction appears in J Urban Health. 2018 Aug 20;:]. J Urban Health. 2018;95(6):787-799. doi:10.1007/s11524-018-0288-9

[77] CDC, *Obesity*, https://www.cdc.gov/chronicdisease/resources/publications/factsheets/heart-disease-stroke.htm

[78] Census data (via the American Communities Survey, accessible on NYC Population FactFinder) provides the number of children under 19 years old in a given Neighborhood Tabulation Area (NTA). NYCHA provides the number of children at a given campus. For Morris and Van Dyke the exact percentages are 11.67% and 9.37% respectively. Nostrand's share is smaller at 4.69%.

[79] Gordon-Larsen P, The NS, Adair LS. Longitudinal trends in obesity in the United States from adolescence to the third decade of life. Obesity (Silver Spring). 2010 Sep;18(9):1801-4. doi: 10.1038/oby.2009.451. Epub 2009 Dec 24. PMID: 20035278; PMCID: PMC2929301.

[80] Trogdon JG, Finkelstein EA, Hylands T, Dellea PS, Kamal-Bahl SJ. Indirect costs of obesity: a review of the current literature. Obes Rev. 2008 Sep;9(5):489-500. doi: 10.1111/j.1467-789X.2008.00472.x. Epub 2008 Mar 5. PMID: 18331420.

[81] Lee BY, Adam A, Zenkov E, et al. Modeling The Economic And Health Impact Of Increasing Children's Physical Activity In The United States. Health Aff (Millwood). 2017;36(5):902-908. doi:10.1377/hlthaff.2016.1315

[82] Lee BY, Adam A, Zenkov E, et al. Modeling The Economic And Health Impact Of Increasing Children's Physical Activity In The United States. Health Aff (Millwood). 2017;36(5):902-908. doi:10.1377/hlthaff.2016.1315

According to a 2019 report from the NYC Comptroller, NYCHA oversees 796 playgrounds across the five boroughs.[83] While numerous, the Comptroller's report outlines how New York City in fact ranks poorly in comparison to other large cities when it comes to play areas for children. The report emphasizes that in addition to the need to expand playground access, particularly in Brooklyn, that these playgrounds should be "stimulating, accessible, clean, and safe." In each of the campus plans the team reviewed, NYCHA's designs delineated robust space for inviting and stimulating playgrounds. Thus, NYCHA's design plans are addressing the concerns in the Comptroller's report by increasing the number of playgrounds accessible to communities, while also designing creative, activated and attractive playground spaces to get youth engaged in greater amounts of physical activity.

Below we calculate the benefits of reducing childhood obesity by an assumed 1% at our case sites. We begin with this general equation:

$$(4)\ Obesity\ savings = number\ of\ children\ at\ site \times community\ obesity\ rate \times lifetime\ cost\ of\ obesity \times assumed\ 1\%\ reduction$$

We are given the number of children (under 18 years old) at each site. We multiply this by the Community Health Profile rate of obesity in the respective community. We then use the lifetime cost of obesity (combining healthcare and productivity costs) and multiply the assumed number of obese children by the lifetime cost. We then reduce this value by 1%, assuming that the site plans can lead to increased physical activity that can shave off 1% of these overall costs.

	Morris	Nostrand	Van Dyke
% of obese children	24%	17%	23%
# of children at site	1501	607	1238
Calculated obese children	360	103	285
Lifetime cost of obesity	$240,000	$240,000	$240,000
Assumed reduction in obesity	1%	1%	1%
Savings from reduced childhood obesity	**$864,576**	**$247,656**	**$683,376**

Table 4: Calculated savings from reducing childhood obesity

The results show that reducing obesity in children at our three sites could result in $250,000 to $850,000 in lifetime benefits across the sites.

[83] NYC Comptroller, (2019). "State of Play: A New Model for NYC Playgrounds", https://comptroller.nyc.gov/reports/state-of-play-a-new-model-for-nyc-playgrounds/

This calculation does not account for the impact of physical activity on potentially overweight children, only obese. While we do have the lifetime cost of overweightness ($63,000 + $92,000), we do not have statistics on overweightness in the community. Like obesity, physical activity also can reduce overweightness. If we were to add this into the calculation, we would likely see even greater savings.

In addition, it is worth noting that the lifetime cost of obesity was based on a model written in 2017 that projected roughly 8 million obese youth by 2020.[84] However, in 2021, this number is approaching 14 million, according to the CDC.[85] This discrepancy may imply that the originally calculated lifetime cost may be an underestimate.

Mental Health

The links between poor mental health and the stressors faced in communities with shared characteristics similar to those of NYCHA campuses are well established. In New York City, reported levels of depression fall in line with the national average.[86] However, this does not hold across NYCHA campuses. For example, through door to door surveys across five NYCHA campuses in the Rockaways, more than 1-in-3 NYCHA residents report that their mental health is directly affected by the living conditions in NYCHA housing which results in elevated levels of stress and depression.[87] Notably and unsurprisingly, perceptions of safety have a profound effect on depression rates. In New York City, neighborhoods in which New Yorkers felt unsafe had depression rates nearly double the City's average rate of 17%.[88] This is particularly concerning and warrants remediation. Recent research conducted has shown interventions in the built environment to be a powerful tool in shaping positive mental health outcomes in community members.

Components of the OSMP are well suited to address this disparity in mental health outcomes. The project's emphasis on providing improved outdoor areas with increased green space are able to improve the mental health of residents with respect to mitigating feelings of depression. In the City of Philadelphia, greening neighborhoods has resulted in statistically significant reductions in feelings of depression. After conducting a cluster randomized control trial across Philadelphia with varying levels of greening, researchers witnessed a large

[84] Lee BY, Adam A, Zenkov E, et al. Modeling The Economic And Health Impact Of Increasing Children's Physical Activity In The United States. Health Aff (Millwood). 2017;36(5):902-908. doi:10.1377/hlthaff.2016.1315
[85] CDC, Obesity, https://www.cdc.gov/chronicdisease/resources/publications/factsheets/heart-disease-stroke.htm
[86] NYC Dept. of Health, (2018). "Depression Among NYC Adults", NYC Vital Signs, Vol. 17, No. 2, https://www1.nyc.gov/assets/doh/downloads/pdf/survey/depression.pdf
[87] RPA, (2020). "The Impacts of Living in NYCHA: Needs for Residents' Health in the Rockaways and Beyond", https://s3.us-east-1.amazonaws.com/rpa-org/pdfs/RPA_The_Effects_of_Living_at_NYCHA.pdf
[88] NYC Dept. of Health, (2018). "Depression Among NYC Adults", NYC Vital Signs, Vol. 17, No. 2, https://www1.nyc.gov/assets/doh/downloads/pdf/survey/depression.pdf

reduction in self-reported depressive feelings.[89] The results in poorer neighborhoods was even more striking than the general findings in which poor areas experienced a reduction of 68.7% in self-reported depression[90].

To capture these improvements in monetary terms, as with the monetization of other co-benefits, we must undergo a process of determining the number of cases averted and multiply this figure by its associated cost. In this case, it is necessary to first determine an expected baseline for depression at each of the sites using New York City data on rates of depression given perceptions of lower levels of safety and the stressors described above multiplied by the individual campus population. Following this, we multiply the baseline by the percentage decrease and the cost of treating depression to arrive at the amount saved, representing the monetized value of the co-benefit. This process is depicted by the equations listed below:

$$(5)\ Case\ Baseline\ =\ Campus\ Population\ \times\ Percentage\ Affected\ (17\%)$$

$$(6)\ Monetized\ Benefits\ =\ Case\ Baseline\ \times\ Percentage\ Reduced\ (68.7\%)\ \times\ Cost\ of\ Treatment$$

In order to determine the individual annual cost of depression, we use the following figures to make the calculations:

1. Annual Spending on Depression Treatment is $71 Billion.[91]
2. The rate of depression incidence in the nation in a given year is 9.5%[92]

Assuming an adult population of over 255 Million, the incidence of depression cases would approximate 24.2 Million. Dividing total spending on depression nationwide by the number of cases provides the individual cost to treat depression annually. Under the following assumed values, this results in $2,945 as the value of the annual cost to treat depression.

Moving systematically through these processes provides a method to quantify and value the benefits gained by the OSMP project interventions with respect to mental health improvements at each of the three campuses. The following table, figure 5, presents the results of carrying out these calculations. Morris would receive $1.6 Million in annual benefits from the improved greening in the OSMP project plans. Similarly, Nostrand and Van Dyke would expect to see $0.8 Million and $1.3 Million, respectively.

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[89] South EC, Hohl BC, Kondo MC, MacDonald JM, Branas CC. Effect of Greening Vacant Land on Mental Health of Community-Dwelling Adults: A Cluster Randomized Trial. JAMA Network Open. 2018;1(3):e180298. doi:10.1001/jamanetworkopen.2018.0298

[90] Ibid

[91] Winerman, L. (2017, March). The cost of treatment. Monitor on Psychology, 48(3). http://www.apa.org/monitor/2017/03/numbers

[92] Johns Hopkins Medicine, 2021. Mental Health Disorder Statistics, https://www.hopkinsmedicine.org/health/wellness-and-prevention/mental-health-disorder-statistics

	Morris	Nostrand	Van Dyke
Campus population	4,779	2,285	3,909
Percentage of residents affected by depression	17%	17%	17%
Calculated number of individuals affected by depression	812	388	664
Depression reduction	68.7%	68.7%	68.7%
Number of depression cases reduction	558	267	457
Cost of depression treatment	$2,945	$2,945	$2,945
Annual Savings from reduced depression	**$1,643,721**	**$785,918**	**$1,344,487**

Table 5: Monetized Benefits of Depression Reduction

Monetizing Public Safety Benefits

While public safety interventions can be expansive, ranging from after school programs to community watch groups, for the sake of conducting the Cost-Benefit Analysis of the Master Plan capital improvements, limitations regarding quantification and monetization offer greatest support for examining the effects of traditional approaches to community-level crime reduction. As a result, this analysis builds off of previous research regarding lighting improvements. Lighting interventions are well supported in the literature as a primary example of cost-effective, non-policing approaches to enhancing public safety.

To determine the annual monetized benefits of the planned lighting improvements at each of the sites, we first ascertained the expected number of index crime incidents annually. Based upon the research conducted, index crimes represent more serious crimes that more accurately reflect a community's level of public safety. The index crimes examined are murder, rape/sexual assualt, robbery, assault, burglary, larceny, and motor vehicle theft. Using state level data for county index crime rates, we identified that the Bronx has an index crime rate of 2,467.5 index crimes per 100,000 residents and Brooklyn has a rate of 1,852.5 index crimes per 100,000 residents.[93] In order to determine *expected* total index crimes for the examined NYCHA campuses, we multiply the campus populations over 100,000 by the borough index crime rate. This allows us to determine the index crime rate for the campus population. After obtaining the campus index crime rate, we can estimate and analyze the public safety co-benefits of crime more granularly, calculating expected the amount of murders, rapes, robberies, assaults, burglaries, larcenies, and motor vehicle thefts. This generalized equations for these calculations is as follows:

[93] New York State Division of Criminal Justice Services. *Index Crimes Reported: 2015 - 2019 by County and Agency*, https://www.criminaljustice.ny.gov/crimnet/ojsa/indexcrimes/county_totals.htm

(7) $Campus\ Index\ Crime\ Rate\ = \frac{NYCHA\ Campus\ Population}{100{,}000} \times Index\ Crime\ Rate\ per\ 100,000$

(8) $Expected\ Number\ of\ Crimes\ by\ Type\ = \frac{Crime\ Type}{Total\ Number\ of\ Index\ Crimes} \times Campus\ Index\ Crime\ Rate$

For example, using these above equations and assuming that crime is distributed uniformly by population, location, and time of occurrence, we could estimate the *expected* number of annual index crimes at the Nostrand campus, which according to the available data outlined above provides results of a campus index crime rate equal to 42.33, given by the calculation $\frac{2{,}285}{100{,}000} \times 1,852.5$. Using this estimate of expected index crimes, we can follow the process depicted by equation 2 above, multiplying this figure by percentage of murders comprising index crime (crime type over the total number of index crimes) which we found to be equal to 0.21% in 2019 to arrive at 0.09 *expected* murders annually for the Nostrand campus.

Having established a methodology to calculate the expected rates of individual index crimes per campus, illustrated by the example above, we are able to undergo the process of monetizing the total benefits of crime reduction via lighting improvements. As discussed above in the literature review, through recent randomized controlled trials at NYCHA campuses, researchers found that improving the level of lighting at NYCHA campuses resulted in a drop of 36% in the nighttime index crime rate across treated NYCHA sites.[94] Using the observed crime reducing effect of lighting improvements, we can calculate the expected number of crimes reduced as a result of lighting interventions given by equation 9. We also multiply this figure by 50% due to the assumption of uniform time distribution of occurrence, meaning that we assume 50% of crimes occur during the night and 50% occur during daylight.

(9) $Expected\ Reduction\ in\ Crime\ by\ Type\ = Expected\ Number\ of\ Crime\ by\ Type\ \times 36\% \times 50\%$

Monetizing this improvement in public safety is simply a matter of multiplying the social cost for the given crime type by its expected reduction. It is important to note that the social cost of crime encompasses components beyond those directly involved with damage to property or individual harm in the case of violent crime. These costs also incorporate costs associated with police response, municipal services, and victim psychological harm, for example. The values for each of these costs are listed in table 6 below and come from the work of Cohen and Piquero, and McCollister et al. [95][96] These costs are determined by technical processes and evaluative methods accepted as standard practice by social scientists. However, before continuing, we strongly

[94] Chalfin, Aaron, et al. "Reducing crime through environmental design: Evidence from a randomized experiment of street lighting in new york city." Journal of Quantitative Criminology (2019): 1-31.
[95] Cohen, M.A., Piquero, A.R. New Evidence on the Monetary Value of Saving a High Risk Youth. J Quant Criminol 25, 25–49 (2009). https://doi.org/10.1007/s10940-008-9057-3 Note: This refers to the valuation for burglary.
[96] McCollister, Kathryn E., et al. The cost of crime to society: New crime-specific estimates for policy and program evaluation, Drug and Alcohol Dependence, Volume 108, Issues 1–2, 2010, Pages 98-109, https://doi.org/10.1016/j.drugalcdep.2009.12.002.

believe that it is important to recognize the fundamental limitation that any monetized value placed fails to capture the true, full cost of loss of life and trauma resulting from violence.

Crime	Social Cost per Incident (2008 Dollars)	Social Cost per Incident Adjusted for Inflation (2021 Dollars)
Murder	$8,982,907	$11,192,702
Rape/Sexual Assault	$240,776	$300,007
Robbery	$40,514	$52,718
Assault	$107,020	$133,347
Burglary	$35,000 (2007 Dollars)	$45,815
Larceny	$3,532	$4,401
Motor Vehicle Theft	$10,772	$13,442

Table 6: The Social Cost per Index Crime Incident by Type

We can now compile the series of equations 7-9 outlined above and apply them to the context of each individual NYCHA campus to identify the expected number of index crime incidents, the reduction as a result of lighting improvements, and the total value of monetary benefit from reducing crime.

The Nostrand campus contains a residential population of 2,285 individuals. Following the calculations discussed above, one could reasonably expect, on the basis of area crime rates, 0.09 murders, 0.75 rapes, 3.57 robberies, 8.18 assaults, 2.84 burglaries, 25.28 larcenies, and 1.63 motor vehicle thefts per year as a baseline rate of index crime across the site. Operating under the assumption of a reduction in index crime of 36% as found in the Chalfin study, Nostrand would correspondingly see a reduction in its annual expected murder rate of 0.02 murders, 0.13 rapes, 0.64 robberies, 1.47 assaults, 0.51 burglaries, 4.55 larcenies, and 0.29 motor vehicle thefts. The social benefits of improved public safety are considerable. The decrease in expected murders and assaults alone would correspond to respective safety gains valued at $179,000 and $196,000 annually. In total, following the same process for each index crime type, the reduction in both the violent and property categories of index crimes would bring annual campus benefits equal to approximately $500,000 per year.

Applying the same valuation calculations to the Van Dyke I and II which houses a residential population of 3,909 individuals, one would reasonably expect, on the basis of area crime rates, 0.15 murders, 1.27 rapes, 6.11 robberies, 13.99 assaults, 4.85 burglaries, 43.24 larcenies, and 2.78 motor vehicle thefts per year as a baseline rate of index crime across the site. Assuming the same reduction in index crime of 36%, the Van Dyke campuses would correspondingly see a reduction in its annual expected murder rate of 0.03 murders, 0.23 rapes, 1.10

robberies, 2.52 assaults, 0.87 burglaries, 7.78 larcenies, and 0.50 motor vehicle thefts. These reductions represent significant monetized co-benefits. The decrease in expected murders and assaults alone would correspond to respective safety gains valued at $306,000 and $336,000 annually. In total, the reduction in both the violent and property categories of index crimes would bring annual campus benefits equal to approximately $850,000 per year for the Van Dyke I and II campuses.

Finally, the Morris campus in the Bronx contains a residential population of 4,779 individuals. As done for the previous sites in Brooklyn, considering surrounding area crime rates, Morris could expect 0.28 murders, 2.16 rapes, 11.80 robberies, 29.76 assaults, 5.84 burglaries, 63.82 larcenies, and 4.23 motor vehicle thefts per year as a baseline rate of index crime across the site. Using the standard assumption of a 36% reduction in index crime, Morris would see a reduction in its annual expected murder rate of 0.05 murders, 0.39 rapes, 2.13 robberies, 5.36 assaults, 1.05 burglaries, 11.49 larcenies, and 0.76 motor vehicle thefts. Given the number of prevented index crimes, the campus would receive gains in public safety attributable to avoided murders and assaults valued at $566,000 and $714,000 annually. In sum, the total reduction in both the violent and property categories of index crimes would bring annual campus benefits equal to approximately $1,600,000 per year.

Monetizing Environmental Benefits

Environmental interventions may bring extensive co-benefits to the sites. For the three environment-related interventions, water play, natural turf and planting, we look into their respective co-benefits. Based on data availability, our model monetizes temperature cooling as the main co-benefit for natural turf and water play, and uses existing estimates to quantify a range of ecological co-benefits from tree planting.

Temperature Cooling

Our model constitutes an attempt to quantify the monetized benefit of decreased air temperature due to water play and natural turf, two environmental interventions. According to Low Carbon Living CRC, a water play facility can lead to air temperature reduction of 3-8℃ when relative humidity is less than 50%, and natural turf in urban parks could result in 1-2℃ cooler air temperatures.[97] Our model quantifies only the direct effects of temperature cooling on NYCHA residents through avoided increase in morbidity and loss in productivity.

Morbidity

Morbidity refers to heat stress hospitalization cases. Heat stress is defined as a constellation of explicit effects of hot weather on the body. These effects include heat or sun stroke (hyperthermia), heat syncope/collapse, heat exhaustion, heat cramps, heat fatigue, heat edema, and other/unspecified clinical effects attributed to excessive heat exposure. Heat stress hospitalization cases refers to the number of residents admitted to a NYC hospital

[97] Low Carbon Living CRC, (2017). "Guide to Urban Cooling Strategies", http://www.lowcarbonlivingcrc.com.au/sites/all/files/publications_file_attachments/rp2024_guide_to_urban_cooling_strategies_2017_web.pdf

during the months of May-September for the effects of heat and light due to weather conditions or undetermined cause. In Morrisania, the 5-year average annual heat stress hospitalization rate is 1.3 per 100,000 population, and the rates for Brownsville and Sheepshead Bay are 3.3 and 1.2, respectively.[98]

According to a recent study focusing on the relationship between air temperature and the number of heat stress hospitalizations, a 1 °C increase in maximum monthly average temperature is associated with a 0.12 increase in rate of hospitalizations per 100,000 population.[99] Total and mean per person hospital charges in 2014 dollars were $167.7 million and $20,050, respectively.[100] Then our model monetizes the benefit of reduction in heat-related morbidity through the reduction in heat stress hospitalization costs.

$$(10)\ Reduction\ in\ Heat\ Stress\ Hospitalization\ Cost\ per\ Intervention$$
$$= Temperature\ reduced \times Increase\ in\ Hospitalizations\ per\ 100,000\ Population\ per\ °C$$
$$\times \frac{NYCHA\ Campus\ Population}{100{,}000} \times Heat\ Stress\ Hospitalization\ Costs\ per\ Case$$

In the equation above, the increase in rate of hospitalizations per 100,000 population per degree centigrade is 0.12; heat stress hospitalization costs per case is $20,050 in 2014 dollars. For example, a water play intervention would reduce temperature by 8°C and population/100,000 in Morris is 0.048. Reduction in heat stress hospitalization cost per water play in Morris = $8\ °C \times 0.12 \times 0.0048 \times \$20{,}050 = \$919.86$ in 2014 dollars. After inflation adjustment, the annual benefit in 2021 dollars will be $1,039.44. Thus, by our calculations, we arrive at these estimated values:

	Morris	Nostrand	Van Dyke
Water Play	$1,039.44	$496.99	$850.22
Natural Trufs	$259.86	$124.25	$212.55

Table 7: Annual Benefit for Reduction in Heat Stress Hospitalization (2021 dollars)

Productivity

While the effects of temperature on comfort are broadly recognized, the effects on worker productivity have also received increasing attention. An increasing amount of evidence shows that indoor environmental conditions substantially influence health and productivity. In a review written by Seppanen et al, it was concluded that an

[98] NYHD, 2021. Environment and Health Data Portal, http://a816-dohbesp.nyc.gov/IndicatorPublic/VisualizationData.aspx?id=2410,4466a0,100,Summarize
[99] Jagai, J.S., Grossman, E., Navon, L. et al. Hospitalizations for heat-stress illness varies between rural and urban areas: an analysis of Illinois data, 1987–2014. Environ Health 16, 38 (2017). https://doi.org/10.1186/s12940-017-0245-1
[100] Ibid

average relationship of 2% decrease in work performance per degree °C when the temperature is above 25 °C.[101] Moreover, a unit drop in exterior temperature would lead to 0.41 unit drop in interior temperature in high temperature days.[102] According to NYC Planning, in 2014 to 2018, 4.4% residents in Brooklyn and 3.2% in the Bronx work at home.[103] This percentage is expected to significantly increase as a result of the work from home policy during the COVID-19 pandemic. For those residents who work from home, the avoided decrement in work performance could also be another benefit stream from temperature cooling. We further assume that, in New York City, there are 90 days (June to August) per year when the highest daily temperature is over 25 °C.

The model monetized the second benefit stream of temperature cooling by calculating the avoided decrement in working performance for residents who work at home during the high temperature days, reflected by earnings.

(11) $Total\ Earning\ for\ Residents\ Who\ Work\ at\ Home\ at\ High\ Temperature\ Days\ (Jun - Aug) = Number\ of\ Household\ in\ each\ Site \times Median\ Household\ Income \times \%\ of\ Residents\ Who\ Work\ at\ Home \times \frac{90}{365}$

(12) $Avoided\ Decrement\ in\ Work\ Performance\ in\ High\ Temperature\ Dyas\ (Jun - Aug) = Temperature\ reduced \times 0.41 \times \%\ Decrease\ in\ Work\ Performance\ per\ °C\ Increase \times Total\ Earning\ for\ Residents\ Who\ Work\ at\ Home\ at\ High\ Temperature\ Days\ (Jun - Aug)$

We use median household income because data for average household income is not available and assume that the income in each site is balancely distributed so that the mean and median level of household income are equal.. In the equation above, *percentage decrease in work performance associated with every °C increase* is 2%. For example, Morris has 1,593 households with median household income of $26,910 (2018 dollars). 3.2% of people work at home. Therefore, Total Earning for Residents Who Work at Home in High Temperature Days (Jun-Aug) = 1,593 ×$26,910 ×3.2% ×$\frac{90}{365}$ = $338,243.22 in 2018 dollars. And a water play would reduce air temperature by 8°C. A Water Play's Annual Benefit of Avoided Decrement in Work Performance in High Temperature Days (Jun-Aug), reflected by earnings = 8°C×0.41 ×2% ×$338,243.22 = ×$22,188.76 in 2018 dollars. After inflation adjustment, the annual benefit in 2021 dollars from a water play on productivity should be $23,520.08 in Morris. Thus, by our calculations, we arrive at these estimated values:

[101] Seppanen, Olli, William J. Fisk, and David Faulkner. "Control of temperature for health and productivity in offices." (2004).
[102] Nguyen JL, Schwartz J, Dockery DW. The relationship between indoor and outdoor temperature, apparent temperature, relative humidity, and absolute humidity. Indoor Air. 2014;24(1):103-112. doi:10.1111/ina.12052
[103] NYC Planning Factfinder, (2021), American Community Survey Data, https://popfactfinder.planning.nyc.gov/profile/119/economic?comparator=2

	Morris	Nostrand	Van Dyke
Water Play	$23,520.08	$53,468.82	$42,023.51
Natural Trufs	$5,880.02	$13,367.08	$10,505.88

Table 8: Annual Benefit for Avoided Decrement in Work Performance on High Temperature Days Reflected by Earnings (2021 dollars)

For the comprehensive moenitized annual benefit of temperature cooling effect from two co-benefit streams, morbidity and productivity, we arrive at these estimated values:

	Morris	Nostrand	Van Dyke
Morbidity	$1,299.30	$621.24	$1,062.77
Productivity	$29,400.10	$66,835.40	$52,529.39

Table 9: Total Annual Benefit from Temperature Cooling on Each Site (2021 dollars)

Tree Coverage

Planting brings a wide range of co-benefits, such as air quality improvement, temperature cooling and carbon dioxide emission reduction, and energy savings. Due to the multiple existing attempts to quantify co-benefits resulting from increased tree coverage and care, our approach is to monetize these benefits in a comprehensive way.

The National Tree Benefit Calculator is an accessible tool that calculates the ecosystem services of added tree coverage through five different categories, stormwater runoff avoided, property value increase, building energy conservation, pollution reduction and CO2 emission reduction. Specifically for the increase in property value, it is modeled after the number of Leave surface Area, which assumes that buildings with more leaf surface coverage would be of higher value. Building energy conservation is calculated by reduced electricity use for cooling and natural gas for heating. CO2 reduction includes both sequestration in the tree roots and the avoided CO2 emission from energy use.

In the model, as we only have information about the number of new trees but do not about what specific species they will be on the campuses, we used the average benefit of the top 5 most common trees in New York City, London Planetree, Norway Maple, Honeylocust, Pin Oak and Callery Pear.[104]

[104] Natural Tree Benefit Calculator, 2019, http://www.treebenefits.com/calculator/

Our model assumed that each tree, when planted would be a 3 inch caliper. With steady growth and maturity over the course of our evaluation period. For the sake of calculation, the increase of ecosystem services is modeled to be constant over the years.

The results have shown that at the beginning, each tree on the three sites will have $37.20 dollars worth of benefit, with $8.70 added per year of growth, which when adding up over long enough periods of time, will be significant. It is also worth noting that the ecosystem services of tree coverage quantified in the model are all direct benefits, and do not include categories such as social and community health. At the same time, tree benefits have a strong association with the maintenance and care they receive, which are not accounted for here.

Currently the most popular tree type on the three sites evaluated is London Planetree, a non-native species to New York City, which in the tree health evaluation has been observed to be in relatively adverse conditions.[105] Therefore, if during the implementation of the new OSMP, species that are more adapted to the local climate and soil can be planted, the overall health condition and benefit from ecosystem services will most likely be higher.

[105] Rathore, Kyathi, (2019). "Ecosystem Services of NYCHA campuses", EDF Climate Fellowship Report.

SECTION 3: RESULTS

	Morris	Nostrand	Van Dyke
Total Benefit	$124,674,897.79	$49,311,983.09	$88,741,291.61
Total Cost	$47,793,600.00	$44,484,392.00	$29,011,863.00
Net Benefit	$76,881,297.79	$4,827,591.09	$59,734,428.61
Benefit-Cost Ratio	2.61	1.11	3.06

Table 10: LCCBA results

Over the course of 60 years and using a social discount rate of 3%, each of these communities would receive greater benefits than the project cost. In the Bronx, the benefit to Morris would exceed $124 Million. Compared to its expected project costs nearing $48 Million, it would create approximately $2.61 in social benefit for every dollar spent. In Brooklyn, our positive net present value findings hold, as well. Both the Nostrand and Van Dyke I and II campuses generate benefits beyond their costs. Nostrand has a final benefit calculation of $49 Million and Van Dyke I and II has a total benefit calculation of $88 Million. Subtracting their respective project costs leaves each with benefits of $5 Million over costs for the Nostrand campus and $60 Million for Van Dyke I and II campus. This provides $1.11 and $3.06 of calculated benefits for every project dollar spent.

In every examined case, when held up against the LCCBA framework, these capital improvements provide notable returns in benefits. However, it is important to take note of two matters. Firstly, we must recognize that these valuations are, in reality, likely underestimates because they do not capture the synergistic beneficial effects that crime reduction, environment, and health have on one another. Secondly, most of the benefits considered are population dependent; Nostrand, having considerably less residents than the other assessed campuses and a final positive value of benefits after removing costs, illustrates how robust these findings are. Therefore, from the perspective of Cost-Benefit Analysis, moving forward on the projects represents a worthwhile investment in these NYCHA campuses.

SECTION 4: FINANCING

Funding Context

Renovations and upgrades as outlined in the OSMP renovations would traditionally be funded through NYCHA's capital budget. The capital budget is intended to address the infrastructure improvements, modernizations, and upgrades as well as major repairs across 325 NYCHA developments and more than 170,000 units. The budget consists of federal, state, and city grants, as well as other sources like community development block grants (CDBGs) and disaster recovery grants. NYCHA's capital budget has faced serious headwinds in recent years. There are several trends that have impacted the capital budget and NYCHA's capital plans, which are outlined below.

Federal disinvestment

Federal grants have traditionally comprised the bulk of NYCHA's capital funds, but this funding stream has been consistently insufficient to meet NYCHA's capital needs and has waned significantly over time. Since 2001, the federal government has reduced cumulative support by over $1 billion.[106] In 2020, federal allocations for NYCHA's capital budget were $550 million[107], down from an (inflation-adjusted) $680 million in 1999.[108]

As the federal government disinvested, the City stepped in to support NYCHA. Since 2015, the City has increased its support over 75%.[109] In the most recent five year capital plan (2020-2024), NYCHA estimates $4.5 billion in total capital funding. $2.8 billion (61%) will be City grants and $1.2 billion (26%) in Federal grants.[110] However, relying this heavily on City support comes with risks. Municipal budgets are subject to balancing requirements and at the mercy of local economic conditions, not to mention administration changes can lead to completely reoriented priorities and budgetary focus. More pragmatically, any feasible City budget would be unable to realistically meet the full scale of NYCHA's capital needs.

To fully fund NYCHA's capital needs, the federal government would need to increase its support eighty-fold. Thus, meaningful and direct federal funding for NYCHA's capital budget is unlikely to manifest soon.

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[106] NYCHA, (2020). "Five Years Operating Plan: Calendar Years 2020 - 2024", https://www1.nyc.gov/assets/nycha/downloads/pdf/2020-2024-Operating-Plan-Narrative-FINAL_Aug.pdf
[107] Ibid
[108] NYC Independent Budget Office, (2003). "Federal Changes May Mean Less Housing Aid for the City", Inside the Budget, No. 116, July 21 2003. https://ibo.nyc.ny.us/newsfax/insidethebudget116.pdf
[109] CBC, 2020. "NYCHA'S 2020 Operating Budget: Inefficiencies Challenge the Fiscal Outlook", March 12 2020, https://cbcny.org/research/nychas-2020-operating-budget, accessed 4/19/21
[110] NYCHA, (2020). "Five Years Operating Plan: Calendar Years 2020 - 2024", https://www1.nyc.gov/assets/nycha/downloads/pdf/2020-2024-Operating-Plan-Narrative-FINAL_Aug.pdf

Aging development infrastructure, increasing costs

While federal support has diminished, the total cost of necessary repairs is increasing exponentially. NYCHA's housing stock has aged considerably and is rapidly deteriorating. Most developments -- including those represented in this study-- are now older than 60 years. The most recent Physical Needs Assessment (PNA) in 2017 concluded that there is well over $30 billion in needed repairs.[111] This is nearly double the previous PNA conducted in 2011 - only 6 years earlier - and is quintuple that of the 2006 PNA. Alarmingly, a March 2021 NYCHA report places the present value at $40 billion and states that repairs are increasing by $1 billion per year.[112] This incessant pressure places the capital budget in a reactive and responsive position with limited ability to look forward and plan big.

Federal monitor and HUD agreement

Finally, NYCHA's 2019 agreement with HUD requires that NYCHA prioritize specific widespread structural deficiencies. Thus, more than four-fifths of the most recent $4.5 billion five-year capital plan is directly devoted to meeting requirements of the HUD Agreement (like lead abatement, improving heating systems, etc.). This leaves a remaining $600m over five years for "quality of life improvements, energy, safety and security, and other compliance areas".[113]

Recent developments

In July 2020, NYCHA announced the Blueprint for Change plan, and outlined a set of ideas and strategies to reorganize the Authority and secure the capital financing required to stabilize and improve physical conditions at its 300 developments and 175,000 apartment units.[114] This is the first ever comprehensive plan for every property and building in NYCHA's portfolio. The capital strategy includes the creation of a Public Housing Preservation Trust that would enable the Authority to address $18 billion to $25 billion in capital needs across roughly 110,000 apartments. When combined with NYCHA 2.0 strategies across the other 62,000 units that will be converted under PACT/RAD, the Blueprint plan would address the physical needs across the entire portfolio.[115]

The creation of a NYCHA Preservation Trust would allow NYCHA to enter into a long term ground lease with the new entity. In return, the trust would have oversight on construction, infrastructure improvements and

[111] NYCHA, 2018. "NYCHA 2.0, Part 1: Invest to Preserve, Assuring Quality Affordable Housing for all NYCHA Residents." https://www1.nyc.gov/assets/nycha/downloads/pdf/NYCHA-2.0-Part1.pdf
[112] NYCHA, 2021. "NYCHA Transformation Plan", March 2021, https://www1.nyc.gov/assets/nycha/downloads/pdf/NYCHA_Transformation_Plan_Exec%20Summary_FINAL.pdf
[113] Ibid
[114] NYCHA. (2021). A Blueprint for Change: Facts About NYCHA's a Blueprint for Change Ideas [Fact Sheet]. https://www1.nyc.gov/site/nycha/residents/blueprint-for-change/fact-sheet.page
[115] NYCHA, 2018. "NYCHA 2.0, Part 1: Invest to Preserve, Assuring Quality Affordable Housing for all NYCHA Residents," https://www1.nyc.gov/assets/nycha/downloads/pdf/NYCHA-2.0-Part1.pdf

NYCHA staff who would continue to maintain and manage the properties. This mechanism would allow NYCHA to access a different federal funding stream to generate revenue, and use that revenue as collateral to borrow money to pay for repairs.

A major pillar of NYCHA 2.0 is Permanent Affordability Commitment Together (PACT). PACT leverages a partnership model to lease land and buildings to private and nonprofit developers, who leverage tenant rent collection to conduct needed repairs and serve as on site property managers. This removes the cost burden, while NYCHA still maintains ownership and control over major decisions.

Financing Strategies

1) Further integrate OSMP development into planned PACT conversions

During the partner solicitation phase for a PACT conversion, NYCHA could consider including OSMP renovations as a requirement or place it has priority for partnership as an on-site manager. Currently, NYCHA's resource for developers requests that potential partners only "should consider" the Connected Communities Guidebook in their urban design proposals.[116] Studies that quantify open space benefits can contribute to the importance and prioritization of the urban design components of the campus, providing more reason to inform partner developers that winning proposals must demonstrate critical effort towards upgrading and renovating the open space.

A policy mandate would greatly improve the feasibility of this option. However, in the absence of one, HUD monitors activities related to building conditions including pest control and playground safety. Greenspace is often home to pests and many NYCHA playgrounds are in disrepair. There may be an opportunity to tie the OSMP interventions to maintenance improvements in pest control and safety thereby requiring them in developer proposals.

2) Leverage the Public Housing Trust model

Conservancies, non-profit organizations that financially support public parks, are an increasingly popular park management model. There are more than 30 conservancies with formal licenses with the NYC parks department (such as Central Park Conservancy, Friends of the Highline, and Bryant park Corporation) that collectively raise about $125M annually. Van Cortlandt Park Alliance, a non-profit conservancy without a formal license with NYC Parks, raises $600,000 annually for the 11,000 acre park but is unable to take advantage of real estate opportunities, development projects (partnerships, BID).

Through the NYC Public Housing Preservation Trust, a new, fully public entity created through State legislation, NYCHA could apply and accept grants, awards, and donations from public and private entities

[116] NYCHA, 2020. "NYCHA PACT Round 9", RFEI Release, November 2020. https://www1.nyc.gov/assets/nycha/downloads/pdf/PACT%20Round%209%20RFEI.pdf

without a formal license with NYC parks department.[117] Existing organizations funding improvements of NYC open space include: The Landscape Conservation Catalyst Fund, Network for Landscape Conservation; The Climate Adaptation Fund, Wildlife Conservation Society; The Natural Climate Solutions Accelerator, The Nature Conservancy; Coordination and Collaboration in the Resilience Ecosystem, Climate Resilience Fund ; NYC Green Relief & Recovery Fund, City Parks Foundation.

The NYC Green Relief & Recovery Fund[118], administered by the nonprofit City Parks Foundation, aims to supply green and open space projects with funding for their shortfall. Through a competitive application process, they award grants of up to $100,000 to larger nonprofits. Through the Trust, NYCHA can raise funding through ground leases of the development sites, sales of air rights, major private donations, concessions (restaurants), and taxes (in the case of Business Improvement Districts BIDs). The NYC Parks Department does concessions for parks (City Charter, Chapter 14, Section 362) that generate revenue to the city (e.g., vendors, restaurants).[119] NYCHA could explore how it could do concessions for these spaces through the Trust.. If federal law permits, the revenues generated could be financially segregated to support green space maintenance, which is a continuing expense for NYCHA.

NYCHA could pilot a partnership for existing or new organizations to lease large amounts of designated open spaces on NYCHA campuses. The program could offer incentives to invest in creative greening and cooling projects while ensuring that partner organizations are able to manage maintenance and safety. If successful, the pilot could be expanded across the NYCHA system. For example, Partnerships for Parks, a public-private program of City Parks Foundation (CPF) and NYC Parks, offers programming to encourage residents to use and care for their local parks and green spaces.[120] NYCHA can engage in CPF by leasing their designed open space for revenue generating activities operated by CPF and holding free recreational activities for NYCHA residents. Existing programs like Living Lots NYC, the Amboy Community Farm by Project EATS at Marcus Garvey Apartments, and community gardens across the city are already leveraging open space to augment community resources.

3) Identify revenue generating or contracting opportunities within the OSMP

A non-traditional strategy to finance OSMP renovations would be to utilize current aspects of the open space plans for revenue generating opportunities, and/or creatively expand on plans to incorporate such opportunities. The revenue generation can offset the costs of development and upkeep. The open space plans include recreational field improvements and constructions, which can be leased for sport and recreation leagues to generate revenue. Another creative solution is to add solar panels to the roof or parking areas. The electricity generated can offset energy costs for the buildings. They can be a source of revenue if charging stations are added

[117] Assembly Bill A11149, The New York State Senate. (2020). https://www.nysenate.gov/legislation/bills/2019/A11149
[118] https://cityparksfoundation.org/nyc-green-fund/
[119] New York City Charter, Chapter 14, Section 362.
[120] PKF O'Connor Davis, LLP , (2020). "Financial Statements: 2017 & 2018", Produced for City Parks Foundation. https://cityparksfoundation.org/wp-content/uploads/2020/01/City-Parks-Foundation-FS-FY18-FINAL.pdf

that require a fee to use. Some space can be leased for advertising purposes and signage. It would be important to consider the ethical ramifications of any products being advertised on the campus.

4) Impact bonds

Impact bonds are a non-traditional financing strategy. Investors purchase a social impact bond backed by a credit-worthy party to address certain social, health, and/or environmental outcomes. The yield is adjusted based on measured performance benchmarks. Investors are paid back at yield from various credit-worthy parties. However, if the specified benchmarks are not met the repayment would come from the issuer.. For example, a bond would be issued that purports the specific capital plan could reduce population obesity rates by 20% over 10 years. If this target is hit, the credit-worthy party will repay the investors with interest. If the target is not met, the investors would be repaid by the City, which typically guarantees NYCHA bonds.. Therefore, there is equal incentive for the investors, NYCHA, the City and the credit-worthy parties (various NGO sources) to meet the impact benchmarks. In theory, NYCHA can afford repayment with interest because achieving the social/environmental outcome will generate long-term cost savings that would be greater than the cost of the initial capital project. A capital project that may cost $10 million dollars could generate $20 million dollars in cost savings over the long term through, for example, averted public hospital visits and medicare/medicaid costs. This present valued cost-benefit analysis would need to be performed to support the case from a whole-of-city budget perspective.

In practice, there are serious pragmatic hurdles to consider. First, from a measurement standpoint, it is difficult to pin social outcomes to specific interventions. Populations would need to be carefully tracked and monitored over time to demonstrate the impact. This would create a logistical challenge, not to mention ethical dilemmas of how much population 'tracking' is allowed. Second, NYCHA may not necessarily be the ultimate beneficiary of the social outcomes arising from the OSMP. For example, declining obesity rates will not necessarily reduce NYCHA's operating costs, however, they can reduce the strain on medicare/medicaid expenditures at medical points of service. From a Citywide public expenditure perspective this is reasonable, but when considering the actual repayment event - the repayments may most appropriately be apportioned from *other* city agency budgets, which presents obvious logistical and political challenges. More concretely, if the cost savings that come from OSMP are relevant to the NYC Health and Hospitals system, then perhaps, NYC H+H would be the more relevant agency to issue repayment on the bond. However, figuring out the degree to which certain agencies are benefiting from social improvements generates instant coordination and budget negotiation challenges. Lastly, at a fundamental level, NYCHA must be able to provide strong credibility in both implementation and follow through to attract investors to accept the higher risks of the capital intervention.

Ultimately, a study like this one can offer the elemental justification for an impact bond by providing links between the OSMP and social and environmental outcomes, however, practical issues remain. Historically, the City has viewed social impact bonds as lacking pricing benefits and bureaucratically burdensome. There is stronger rationale for an environmental impact bond because environmental outcomes, it could be argued, are

less influenced by confounding variables. There are clear, observable measurements that can be conducted regarding reductions to flooding, damage, etc. from particular weather events. The cost savings from improved environmental factors would be more likely reaped by NYCHA as well, removing the cross-agency coordination and negotiation concerns.

Feasibility Matrix

We used the SFA model to analyze our financial strategies. This analysis helps to identify the key considerations of each strategy in terms of suitability, feasibility and acceptability[121]. In setting up our matrix, we broke out our primary categories (Suitability, Feasibility, Acceptability) into subcategories with corresponding questions and assigned them weights. The sub-categories were scored 1 to 10, with 10 being the highest, and their weighted average was totalled. Based on our analysis (see Appendix C), the option to leverage the Public Housing Preservation Trust the largest score (21.7). The option to finance through impact bonds received a score of 19.7. The strategy of PACT integration and Revenue generation scored 17.1 and 15.5 respectively. A simplified version of this analysis (table 11), ranks the options for each category from 1 (strongest) to 4 (weakest).

Financial Strategy Options				
	PACT Integration	**Leverage Trust**	**Revenue Generation**	**Impact Bonds**
Suitability	4	2	3	1
Feasibility	1	2	4	3
Acceptability	4	1	3	2
Overall Ranking	3	1	4	2

Table 11: Feasibility matrix

With respect to suitability, which considers the strengths, weakness and effectiveness, Impact Bonds scored highest because of the potential to raise the largest capital . PACT integration scores lowest because it relies on contractor support to accept open space requirements with lack of policy mandates and would occur slowly site by site. Considering feasibility, which includes whether the options are realistic, organizationally possible, legal, ethical, and possible considering resources, PACT integration scores highest because it has been done through NYCHA 2.0 for sites through RAD conversions. Revenue Generation scores lowest because some ideas may be problematic from an ethical perspective or legal perspective. The acceptability category considers financial risk, sustainability and whether the option is acceptable for stakeholders. Leveraging the trust scores highest because it builds relationships with stakeholders, brings in residents and offers the least risk. PACT integration scores lowest because there are mixed options by NYCHA residents on the conversion of properties and mandating OSMP designs may not be agreeable for contractors considering lack of policy justification. Ironically, PACT integration had the highest feasibility score but the lowest with respect to suitability and acceptability. Analyzing

[121] JOHNSON, G., and SCHOLES, K. (1997). Exploring Corporate Strategy, Fourth Edition, Prentice Hall, New York. [Chapter 8]

the strategies based on these three categories illuminated how politics, sentiments, and resource constraints can impact their success as options. When scored overall, the strategy with the highest score is leveraging the trust to support open space capital projects.

Funding and Policy Recommendations

The feasibility matrix shows that overall, NYCHA should raise funding by leveraging the trust to accept grants, awards, and donations from public and private entities. This strategy also includes other creative financing options such as ground leases of the development sites, sales of air rights, and concessions. However, it will not be possible to fund all the OSMP site projects by leveraging the Trust alone. To actualize this vision, NYCHA will need to utilize a combination of the four strategies.

NYCHA can pilot several site designs to showcase the success and feasibility of the projects. While there are case studies on open space and active design work reflected in the Connected Communities guidebook, this pilot should focus on data collection. NYCHA should collect co-benefit indicator metrics to make a case for larger funding such as an impact bond. In addition to collecting metrics on resident health and mobility, NYCHA can determine the actual impact of these interventions on social capital by surveying the residents using the Connected Communities framework. This work can be enhanced if additional presently unavailable but quantifiable benefits are included. For example, maintenance savings would show significant justification for green infrastructure improvements such as synthetic turf.

While creative financing can help make these spaces possible, policy interventions can encourage wider adoption of green space. NYCHA should support policy and code changes that mandate or promote green infrastructure, social cohesion/connection, and open space projects. NYCHA and the trust should join the Play Fair for Parks campaign, a multi-year advocacy effort that elevates parks and open space issues in NYC with the Play Fair Coalition and more than 300 groups and organizations. These relationships can be leveraged to form further partnerships to support elements of open space design. In collaboration with HDC, HPD, and NYS HCR, NYCHA should propose a bill to establish a Social Impact Bond framework for a wide variety of purposes. The State can for example agree to provide matching funds if the entity making the request could bring sufficient resources. If NYCHA can secure funding through donations to its trust and the State provides matching support, the Impact Bond can become a high return option with less risk, allowing for the completion of the ambitious OSMP.

CONCLUSION

From the outset of this endeavor, it has been clear that these Open Space Master Plan Projects would make considerable, necessary improvements to NYCHA campuses and greatly impact residents' quality of life.

However, it was unclear to what degree this would occur. We have detailed a process above that begins to make strides in evaluating what these projects can mean to a community. On the basis of the work conducted, we provide a snapshot of what these investments in NYCHA's communities could bring to the Morris, Nostrand, and Van Dyke I and II campuses. Our results were significant. These projects each brought positive returns ranging from nearly $5 Million to well over $60 Million.

Having established the viability of these projects on the basis of measuring benefits relative to costs, ultimately, this underscores the importance of the work yet to be done. Investing in these communities using the Connected Communities Guidebook and the OSMP is a transformative choice, both financially and socially. As already outlined, securing the necessary funding to complete these projects is challenging but possible. This report has listed a series of potential approaches and strategies to begin acquiring funds that can translate the plans into reality. According to the SFA analysis the most favorable path is leveraging the newly created public housing trust, raising funding from public and private entities. Pursuing these partnerships is promising and can help NYCHA build adequate funding sources to begin breaking ground on these open space improvements.

As NYCHA moves into its next phases, we believe that the above report provides a sound foundation to begin taking steps toward progressing on realizing the vision outlined in its Connected Communities framework. The actions that lie ahead will better the lives of the thousands of New Yorkers that NYCHA serves daily. The analysis above is but one glance into the potential that already lies within each of the campuses. Though by necessity, an LCCBA model can be distant in its efforts to isolate and assign valuations, it would be a gross error to simplify what these projects bring to the dollar value returns. These benefits go beyond increasing safety and physical activity, however important that they may be. These OSMP projects will have effects lasting decades, improving the lives of thousands of NYCHA's residents and supporting NYCHA's mission. In conclusion, from the qualitative to the quantitative assessments, proceeding with these projects is shown to be both valuable and worthwhile.

APPENDICES

Appendix A. Interviews

NAME	TITLE	ORGANIZATION	SUMMARY
Damian Busch	Director, Public Finance; Lecturer	Barclays Bank; Columbia University, School of International and Public Affairs	- Overview of municipal public finance structures and systems; - Detailed descriptions of NYCHA's options and financing strategies; - Brainstormed avenues for financing that directly informed our financing section.
Ifeoma Ebo	Director, Predevelopment Planning	New York City Department of Housing Preservation and Development (HPD)	- Focused on public safety concerns and benefits; - Expanded perspective on definitions of public safety; - Emphasized how minor changes, like more people using a playground, becomes "eyes on the ground" for public safety; - Directed to the *Safe Places, Active Spaces* Report from MOCJ.
Kizzy Guzman	Deputy Director	New York City Mayor's Office of Resiliency	- Suggested and illustrated the big picture view to account for multiple co-benefits in the environmental interventions such as natural turf, water play and tree coverage. - Introduced multiple tools and existing studies that can help quantify benefits of air pollution reduction and increased tree coverage, and introduced Khyati Rathore's work
Sara Karerat	Director, Applied Research	Center for Active Design	- Provided early advice on how to consider benefits and the importance of isolating design interventions to measure their benefits, while recognizing they are overlapping and interacting; - Offered CfAD resources.

Nancy Owens	Founding Principal	Nancy Owens Design Studio	- Provided in depth discussion about the site plans that her studio designed; - Elaborated on intention and rationale for design aspects. For example, how turf is also beneficial for stormwater. This made clear that there are primary, secondary, and even tertiary benefits to sites.
Khyati Rathore	Special Projects Manager, Defend Our Future	Environmental Defense Fund	- Discussed her work as an EDF Climate fellow entitled, "Ecosystem Services of NYCHA campuses" (2019) - Shared an overview of data collection and analysis processes - Discussed the connection between the health of residents and health of trees
Eva Weissman	Adjunct Associate Professor	Columbia University, School of International and Public Affairs	- Provided initial insight into cost benefit analysis best practices, including shared resources on other similar social cost benefit analyses; - Aided in literature review by providing scope of the research field around these issues from a CBA perspective.

Appendix B. Acronyms

CDBGs	Community Development Block Grants
CHD	Coronary Heart Disease
CPI	Consumer Price Index
CPF	City Parks Foundation
CPTED	Crime Prevention Through Environmental Design
FCA	Facility Conditions Assessment
HSI	Heat Stress Illness
LCCBA	Life-Cycle Cost-Benefit Analysis
NPV	Net Present Value
NYCHA	New York City Housing Authority
OSMP	Open Space Master Plan
PACT	Permanent Affordability Commitment Together
PNA	Physical Needs Assessment
RAD	Rental Assistance Demonstration
RCT	Randomized Control Trial
SFA	Suitability, Feasibility, and Acceptability

Appendix C. SFA Model Explained

SFA Matrix stands for Suitability, Feasibility and Acceptability Matrix. We used the SFA model to analyze our financial strategies. In setting up our matrix, we broke out the categories with the below questions. The sub-categories were scored 1 to 10, with 10 being the highest.

Financial Strategy Options						
	Strategy	**Weight**	**PACT Integration**	**Leverage Trust**	**Revenue Generation**	**Impact Bonds**
	S&O	0.2	2	9	8	7
	T&W	0.2	5	5	3	8
Suitability	**Solve Problem**	0.6	6	8	7	9
	Organization	0.4	8	7	6	3
	Realistic	0.3	7	6	4	4
	Resources	0.1	8	7	3	5
Feasibility	**Ethical/Legal**	0.2	9	7	4	8
	Sustainable	0.2	7	4	5	9
	Risks	0.3	6	7	3	5
Acceptability	**Stakeholders**	0.5	2	9	5	7
		Total	**17.1**	**21.7**	**15.5**	**19.7**

Suitability is the extent to which the strategic opportunity is suitable for the company.

- Does it take advantage of Opportunities and Strengths ?
- Does it take Threats and Weaknesses into consideration?
- Does the option have the desired effect?

Feasibility is the extent to which the strategic option is feasible. This involves looking at strengths and weaknesses that arise from an internal analysis.

- Can the organization 'handle' the option?
- Are the expectations realistic?
- Does the organization have the right resources?
- Is the option ethical and legal?

Acceptability: the acceptability of a strategic choice arises by examining at two criteria: financial and stakeholder.

- Is it financially sustainable?
- Does it take big financial risks
- Is it acceptable for stakeholders?

Appendix D. List of Figures and Tables