Can New York City become a 15-minute garden city?

By

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Abstract

The spatial distribution of urban agriculture in cities is not well studied, and scholars have tended to overlook localized effects and physical access issues when contemplating urban agriculture (UA) futures. To address this gap, we ask: what is the current spatial distribution of community gardens in New York City (NYC), and what land-use policies will enable more accessible garden futures? We adopt the concept of the 15-minute city to map the future of community gardens in NYC. We analyze garden distribution in NYC using remote sensing and spatial regression and design an optimization-based spatial planning approach to evaluate the feasibility of turning NYC into a 15-minute garden city. Our results indicate that more than half of the city residents have access to a garden within 15-minute walking distance, and that neighborhoods with lower income, lower rates of white residents, lower rates of owner occupancy, and higher rates of educational attainment have higher rates of access. The most cost-effective increases in household access to gardens arise from developing new gardens on vacant parcels, which outperform modeled gardens sited on all other land uses, though a strategy of siting gardens on a range of land uses is required to maximize household access. By mapping gardens, analyzing their distribution, and modeling how to scale-up UA, this paper presents a novel spatial planning approach to expand urban amenities and ecosystem service benefits for a more just, sustainable, and resilient city. This spatial planning approach enables participatory planning processes for UA futures in a variety of urban contexts.

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Sam

Table of Contents

List of Tables

List of Figures

1. Introduction

Urban agriculture (i.e., growing food in or around cities) is expected to expand dramatically in the twenty-first century (Cohen & Wijsman, 2014). This food-growing is increasingly the subject of municipal planning (Horst et al., 2017); however, to plan for more just, sustainable urban agriculture (UA) futures, practitioners require better knowledge and tools for expanding UA.

City planners and policymakers can take multiple approaches to support urban agriculture, including integrating UA into long-term plans, facilitating opportunities for meaningful participation around formal UA planning efforts, channeling funding to food justice organizations, permanently protecting land for urban agriculture, and integrating urban agriculture into anti-displacement efforts (Horst et al., 2017). Though these strategies hold promise at the site level, cities have struggled to holistically plan for UA across scales (Taylor & Lovell, 2015). This spatial dimension of planning is particularly important for types of UA with effects that depend on their location, such as community gardens. In addition to producing food, community gardens have a variety of localized social, economic, and environmental benefits specific to their users and neighbors (Ilieva et al., 2022)

Planning for multi-functional green spaces like community gardens has proven challenging (Hansen et al., 2019), and this is reflected in scholarly work addressing community garden locations, their spatial distribution in cities, and efforts to spatially plan for scaling UA to-date. In this paper, we seek to address these limitations in strategic planning of UA by mapping existing community gardens in New York City (NYC) and piloting a novel, parcel-level optimization model for exploring community garden futures. We explore the impacts of land use choices on democratizing walking access to community gardens, which we define in terms of the 15-minute city (Moreno et al., 2021). This framing achieved popular resonance in 2023 (Stanford, 2023) and planners and policymakers have begun to coalesce around this vision for sustainable urbanism (Pozoukidou & Angelidou, 2022). In response, we adopt the “15-minute garden city” as an analytical frame for our research and conceptualize community gardens as a crucial service which enhances well-being (Ilieva et al., 2022).

New York City (NYC) has long been recognized in North America as a leader in the urban agriculture movement, with a constellation of actors leveraging UA to advance food and environmental justice in their neighborhoods (Campbell, 2016). While UA in NYC has been the focus of substantial scholarship, recent events highlight the importance of developing tools to effectively plan for UA futures in NYC and beyond. The recent election of food-focused Eric Adams, the creation of the new Mayor's Office of Urban Agriculture, and the promulgation of one of the United States' first comprehensive municipal food systems plans (Food Forward NYC: A 10-Year Food Policy Plan, 2022) reveal a window of opportunity to highlight the value of novel tools for UA planning.

Efforts to strategically plan community gardens are limited by the relative dearth of information available about the distribution of existing gardens (Hawes et al., 2022; Kremer & DeLiberty, 2011). Scholars have previously documented community garden locations in NYC but works to date have focused on combining various secondary databases. A 2008 study used a dataset provided by the Council on the Environment of New York City, which documented 636 gardens (Voicu & Been, 2008). A 2020 study used NYC Parks Department and GrowNYC (a local non-profit) data, and found 488 gardens (Butterfield, 2020). We advance on these data collection efforts by using additional secondary sources and incorporating remote sensing to gather a more robust sample (identifying 846 total gardens). Similar remote-sensing based approaches to identifying garden locations have previously been documented in Chicago, Portland, and Detroit (Hawes et al., 2022; McClintock et al., 2016; Taylor & Lovell, 2015).

Literature assessing the relationship of community garden location to neighborhood-level socio-demographic features and indicators of neighborhood trajectory in cities is limited. The most recent study of the spatial distribution of UA in New York City showed that gardens were more prevalent in neighborhoods with lower incomes, greater non-White populations, and higher educational attainment (Butterfield, 2020), demonstrating that garden distribution in NYC is relatively equitable at present, but that "creative class intrusion" arising from a revalorization of the environmental and social capital of gardens may be present (Checker, 2011; McClintock et al., 2018).

With this intrusion looming on the horizon, NYC presents a compelling case study for exploring how planners can effectively connect the current state of community gardening with different visions of UA futures. Existing works addressing scaling UA in NYC have focused on assessing potential food production capacity and have not yet analyzed physical access to gardens. A 2014 study discussed the prospects for rooftop gardening and vacant land for scaling and found that meeting the produce needs of the city through UA is not possible (Ackerman et al., 2014). A 2018 work further discussed the role of vacant land and its potential to facilitate the expansion of UA in NYC; the authors used land cover information at the parcel level to assess the extent of suitable vacant land for scaling UA (Hara et al., 2018).

UA scaling assessments in other cities have taken differing approaches to mapping needs and identifying potential sites. Some efforts have sought to prioritize census geographies for the siting of community gardens, without addressing site suitability or availability (Parece et al., 2017). Others only consider vacant land for scaling up (Thapa et al., 2021), ignore biophysical limitations to UA, such as the slope of land (Haberman et al., 2014), or don’t account for the physical dimension of access as determined by street/sidewalk networks (Newell et al., 2022). We extend upon these works by incorporating additional indicators of site suitability (sun, shade, and slope) and by explicitly analyzing residential proximity to parcels assessed as suitable for UA. By explicitly analyzing the location of both community gardens and the households they serve, we expand on existing work by explicitly addressing localized effects of community gardens beyond food provision, which is but one of one of many benefits that UA brings to communities (Ilieva et al., 2022)

In response to these gaps, this paper has four primary research questions: 1) where are community gardens in NYC today?; 2) Which socio-demographic and neighborhood trajectory factors are associated with residential proximity to gardens, and who has access today?; 3) where could future community gardens be sited?; and 4) which neighborhoods are targeted for garden siting based on land use policy and garden expansion choices? To answer question 1, we used remote sensing to compile a dataset of community gardens. To address question 2, we used a spatial lag regression model to explore the relationship between residential distance to existing gardens and various socio-demographic factors. We answered question 3 using a raster analysis of indicators of biophysical suitability. Finally, to address question 4, we used location allocation analysis in ArcGIS Pro to analyze 15-minute garden city under different land-use policies and garden expansion scenarios.

We find that more than 50% of New Yorkers already have access to the “15-minute garden city,” and confirm previous work indicating that NYC community gardens are distributed in a manner consistent with justice narratives, but with some indication of potential future gentrification. Our most aggressive garden expansion scenario models a future where nearly 99% of New Yorkers have walking access to a garden from their homes. We demonstrate the impact of land use choices for varying garden expansion programs; we determine that, per unit area, suitable UA sites located on vacant land yield the greatest increase in households with access to the 15-minute garden city. The spatial outputs of our optimization analysis represent what we call *opportunity maps* for scaling community gardens in New York City, which can inform more effective participatory and collaborative scenario-based planning processes aimed at assessing the potential of specific sites to become community gardens.

2. Methods

To address our research questions, we first utilized remote sensing alongside a series of map overlays to compile a comprehensive dataset of community garden locations. To understand the relationship between residential distance to existing gardens and a series of literature-informed factors, we employed a spatial lag regression model. We applied raster analysis to an array of data on land use, land cover, shade, sun, and slope to assess biophysical suitability for gardening across NYC. Location allocation analysis in ArcGIS Pro was used to assess who and where currently has access to the 15-minute garden city, and to execute our spatial optimization procedure for democratizing household access to gardens under various land-use policies and garden expansion scenarios.

2.1 Remote Sensing

To map gardens across NYC, we conducted systematic visual interpretation of 1m resolution Google satellite imagery (nominal years 2019–2022), available via the HCMGIS plugin in QGIS. We cross-checked each identified garden using digital ground truth audits, using the go2streetview plugin in QGIS (nominal years 2017–2022). Gardens were identified based on a set of inclusion criteria, which referred to both visual indicators described in the literature (Hawes et al., 2022; Taylor & Lovell, 2012) and NYC-specific indicators, which we identified through an iterative interrater reliability exercise. These indicators included, but were not exclusive to: 1) signage identifying the garden or marking it as communal space; 2) evidence of public access to the space; and 3) open parcels with significant tree cover. Although not unheard of, rooftop community gardens are rare (Ochoa et al., 2019), and rooftop sites were excluded from our analysis. We split NYC into 1021 1x1km grids and randomly assigned half of these to two research team members for inspection. To support data collection, we curated a set of auxiliary data layers, documented in Table S1 (*GreenThumb Garden Info*, 2022; *Mapping Agricultural Production in New York City (M.A.P. NYC)*, 2022; *MapPLUTO Release 22v3*, 2023). We used Google searches to identify garden names, histories, and affiliations, and to confirm gardens identified with less than 100% certainty via the remote sensing exercise and compiled a point file including all gardens that met our inclusion criteria.

2.2 Spatial Regression

To explore linkages between garden access across NYC and selected socio-demographics, we conducted spatial regression, using literature-informed socio-demographic characteristics as independent variables and distance from residences to gardens as the dependent variable.

In a comprehensive investigation of urban gardening in Detroit, Hawes et al. (2022) identified affluence, built form, education, household composition, race/ethnicity, and urban decline (reframed as neighborhood trajectory for this study) as variables which had previously been associated with garden distribution. While retaining the thematic resolution derived in Hawes et al., 2022, we identified 15 factors of interest in NYC (Table S2). These data were sourced from the American Community Survey (ACS) and from local and national sources (*Computer Generated Building Footprints for the United States*, 2018; *HUD Aggregated USPS Administrative Data On Address Vacancies*, 2017; *NYC Department of City Planning's (DCP) Housing Database*, 2017). ACS data were accessed via NHGIS (Manson, Steven et al., 2022). Our scale of analysis was the census tract.

We collated all data in a GIS environment and projected to a common reference system (NAD83 / UTM zone 18N). For categorical variables (e.g., education level, race), we used percentages of census tract population. For numeric variables (e.g., income) we calculated the mean for each census tract (or median, in the case of household income). For building density, we used building footprint polygons and calculated density at the census tract by dividing the aggregated building footprints by the total area of each polygon. Before regression, we normalized the independent variables to yield meaningful coefficients (Gelman, 2008).

As the dependent variable, we calculated the euclidean distance between each residential parcel and the nearest garden. Using garden centroids as destination pixels, we calculated a 1m-resolution distance raster surface for NYC. Using v.rast.stats in GRASS GIS, we calculated the average euclidean distance to a garden from each parcel with residences. We then calculated census tract level average residential distance to garden, weighted by the number of residential units in each parcel.

We used spatial regression to assess which of the 15 sociodemographic and built environment factors are associated with residential distance to urban gardens. We used a supervised, stepwise variable selection approach to reduce model dimensionality, which we implemented in R (R Core Team, 2020), using the glmulti package (Calcagno & Mazancourt, 2010). We used a genetic exhaustive search algorithm to iterate over distinct model variations, and referred to the Akaike Information Criterion (AIC) as the best fit criterion for each model. The best formula for our model identified by this process had no collinearity or redundancy but demonstrated significant spatial autocorrelation (Moran's I = 0.726). To account for this, we ran the Lagrange Multiplier Test, which indicated that a spatial lag model would provide the most robust estimates of coefficients. We executed this analysis in R via the spdep (Bivand, 2017) and spatialreg packages (Bivand et al., 2013).

2.3 Scaling-up community gardening

To explore the effects of land use decisions on community garden futures in NYC, we used a multi-criteria, raster-based suitability analysis and an ArcGIS-based spatial optimization tool called Location Allocation. With these tools, we ran three garden-expansion scenarios (50, 100, and unlimited new gardens) under our 5 land-use policies (Table 1), thereby enabling the modeling of the spatial matchmaking of gardens (both existing and hypothetical) to specific households across the city.

Table 1. Land-use policy definitions and identified candidate sites

Land-Use Policy	**Acceptable Land Uses**	**Ownership**	**Number of candidate sites identified**
1	Vacant	Publicly-owned	2,192
2	Vacant	Any	10,183
3	Vacant, Parking Lots	Any	21,444
4	Vacant, Churches, and Schools	Any	13,685
5	Vacant, Multi-family residential, Commercial, Industrial	Any	38,210

Our analysis relied on an inventory of suitable parcels which met land use, ownership, and biophysical criteria. At 1m-resolution, we assessed land use (*MapPLUTO Release 22v3*, 2023), ownership (*MapPLUTO Release 22v3*, 2023), slope (*NYC Topobathymetric Data*, 2017), land cover (*Land Cover Raster Data (2017) – 6in Resolution*, 2017), and sunlight availability (*NYC Topobathymetric Data*, 2017) for the entirety of NYC (Table S3). We used raster algebra and conditionals in QGIS to create a binary layer of suitable space, which was then summarized at the parcel level using the Zonal Statistics tool. Only parcels with 100 square meters or more of space suitable for gardening were designated as candidate sites.

To allocate gardens to the locations which would benefit the most New Yorkers, we relied on the Location Allocation tool in ArcGIS Pro. This model determines the cost/distance matrix between “facilities” (i.e., gardens) and “demand points" (i.e., parcels with residences) using a network data source and generates a spatial optimization output based on user choices (Table 2). We constructed a local network data source using street centerlines (*NYC Street Centerline (CSCL)*, 2023) to represent the possible walking paths that NYC residents might take to a given community garden in their neighborhood. This algorithm allocates demand (i.e., household use of community gardens) to specific facilities (i.e., community gardens, either already existing or those proposed by our scaling scenarios).

Table 2. Inputs to location allocation model in ArcGIS Pro Network Analyst Extension

Location Allocation Construct	**Data set imputed into location allocation layer**	**Number of records**	**Date**	**Source**
Demand Points	Parcels with at least 1 residential unit	764,870 (comprising 3,658,322 total residential units)	2022	*MapPLUTO Release 22v3*, 2023
Facilities (required)	Community gardens meeting inclusion material, based on grid search and map overlays	846	2022	Remote sensing
Facilities (chosen)	Derived via suitability analysis	50-1874, depending on garden expansion scenario	2022	Derived (Table 1)
Network	NYC Street Centerlines	N/A	2022	*NYC Street Centerline (CSCL)*, 2023

We leverage two of the “problem types" provided by the Location Allocation tool. The Maximize Coverage and Minimize Facilities problem type allocates as many gardens as necessary to maximize total 15-minute access. We refer to this garden expansion program as “Maximum Coverage” (MC). The Maximize Coverage problem type sites a predetermined number of gardens (50, 100) to maximize increases in 15-minute access. We chose 50 and 100 gardens to represent approximate increases of 5 and 10% in the number of gardens. Access is defined using 800m on the street network, a standard approximation for 15 minutes’ walk.

The outputs of our scenario analysis in ArcGIS Pro indicate which specific households are allocated to gardens and how many households are allocated to each garden (both existing and modeled) under each of our scenarios. We summarize these outputs using NYC’s Community Board Districts (CDs) geographies to quantify neighborhood-level access to the 15-minute garden city. Community Districts (CDs) participate in and advise the city on service delivery, land use planning, and the city budget process (*Community Boards Explained*, n.d.).

To better understand how our model is siting gardens in different neighborhoods, we grouped New York’s 59 CDs into two groups based on their rate of household poverty. We grouped the 20% of CDs (N = 12) with the highest poverty rates in the city together (hereby referred to as ‘under-resourced CDs’), and grouped all other CDs (N = 47) together. We calculated the marginal increase in household access rate from the baseline for each land-use policy/garden expansion scenario combination by CD. This derived indicator is then averaged for each scenario comparison for both disadvantaged CDs and all others, enabling the use of T-tests to test whether under-resourced CDs have lower marginal increases in access as land use policies change. We account for the increased likelihood of false positives in our multiple testing by adjusting our p-values using the FDR approach (Storey, 2002).

3. Results

Our modeling shows that 53.3% of New Yorkers currently have access to the 15-minute garden city, and that near universal access (98.9%) is possible. This access is dispersed unevenly across the city, but in a largely justice-oriented manner; we find that neighborhoods with lower income, larger non-White populations, and lower proportions of owner-occupancy in housing are associated with increased garden proximity. However, we also observe that higher educational attainment is associated with increased garden proximity. Investment in a more limited garden expansion program yields significant gains in access, with the magnitude of gains tied to the ambition of land-use policy. We find that vacant land provides the greatest per unit area return with respect to increased household access, but siting gardens on suitable non-vacant parcels is necessary to maximize access to the 15-minute garden city. Greater land-use policy ambition leads to more gardens in neighborhoods with lower rates of poverty, reflecting both the existing distribution of gardens and the different land use mix across NYC neighborhoods.

3.1 Half of NYC households have the 15-minute garden city, but access is uneven.

NYC's 846 existing gardens make the "15-minute garden city" a reality for many New Yorkers. To spatialize this phenomenon, we identified residences within a 15-minute (800m) walk of existing gardens. Of NYC's 764,870 residential parcels (encapsulating 3,658,322 total residential units), 1,948,546 households (53.3% of total) currently have 15-minute walking access to a garden. However, certain boroughs – Brooklyn, Manhattan, and the Bronx – are driving this citywide access figure (Table 3).

Table 3. Number of residential units and number/percent with 15-minute access by borough

Borough	**Total Residential Units**	**Allocated Residential Units**	**Percent Units Allocated**
Brooklyn	1,071,194	686,759	64.11%
Manhattan	951,608	568,886	59.78%
Bronx	566,359	367,154	64.83%
Queens	891,070	302,716	33.97%
Staten Island	178,078	23,021	12.93%

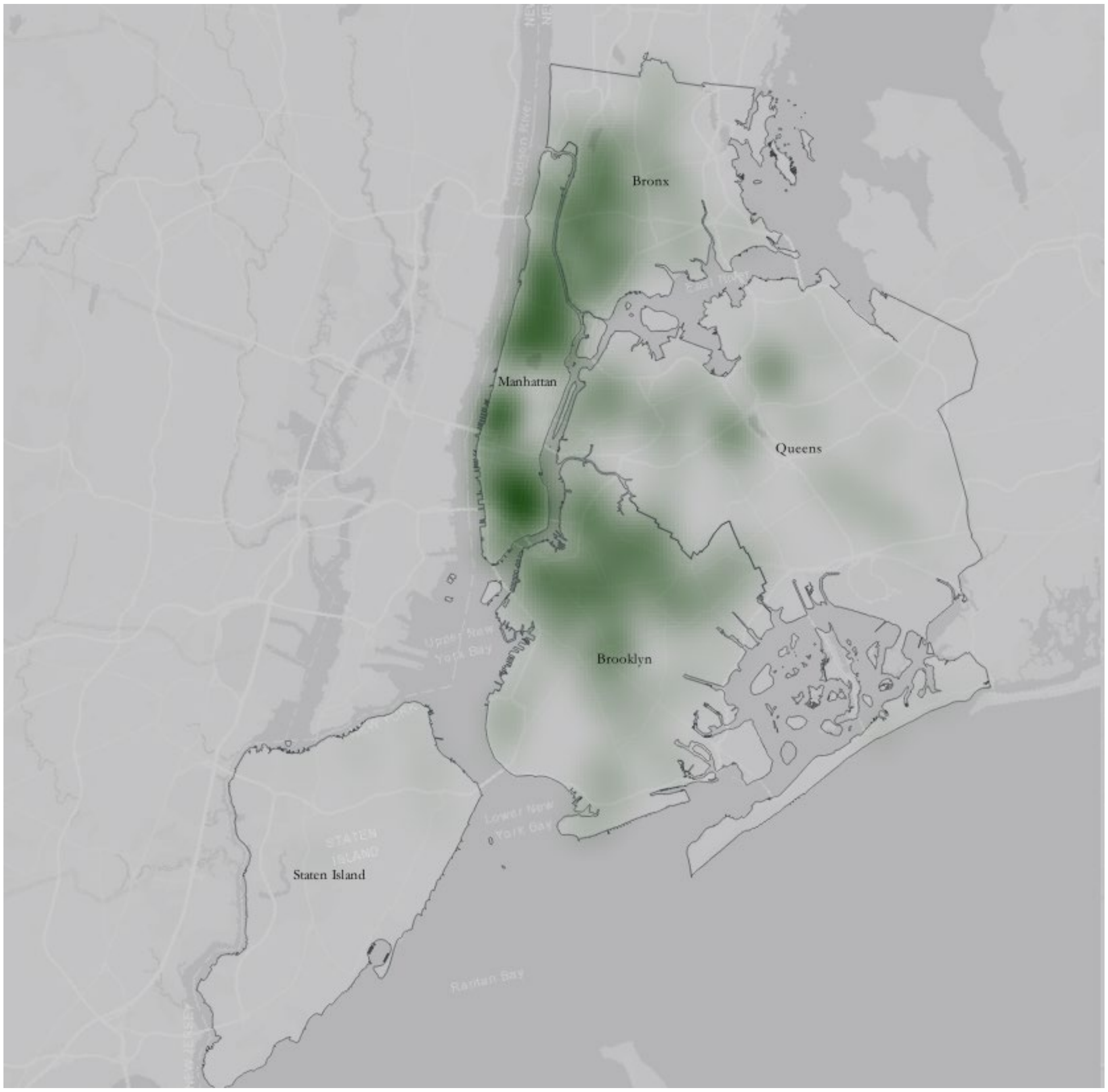

Figure 1. Heatmap depicting the number of households with access to a garden, in green.

To assess neighborhood-level variations in these access figures, we utilize Community Board District geographies (*Boundaries of Community Districts*, 2023). Thirteen CDs, representing 19.26% of NYC households, have rates of 15-minute garden access of greater than 90%; ten CDs, representing 17.6% of households, have access rates lower than 20% (Tables S5 and S6). We observe that neighborhoods with lower income, lower rates of white residents, lower rates of owner occupancy, and higher rates of unemployment (Table 4) have higher rates of access.

Table 4. Socio-demographic characteristics of Community Board Districts, by quartile of proportion of households with 15-minute garden access

Quartile of access	Median Household Income ($)	% residents, White	% Owner-occupied housing units	% College educated	% Unemployment	% US Citizens or nativity
1	85,294	44.1	51.6	41.3	3.46	65.5
2	69,583	27	39.8	33.3	3.7	53
3	67,030	27.9	22.2	38.1	4.97	63.5
4	60,632	27.4	16.8	39.8	5.03	74.5

Note. Amongst the 59 CBs, the minimum proportion of access is 0.01% (Staten Island CD 3). The top boundary for values for each quartile are as follows: quartile 1 - 27.39%, quartile 2 - 50.39%, quartile 3 - 85.95%. The maximum value and top bound of quartile 4 is 98.76% (Manhattan CD 9).

3.2 Access related to socio-demographics

To further explore the socio-demographics of garden access, we utilize spatial lag regression. Results show that a range of factors related to neighborhood trajectory, built form, race and ethnicity, affluence, and education are significantly associated with the distance of New York City’s existing socially-engaged community gardens from residences. We find that gardens are more likely to be located further in space from areas with more white residents, higher rates of home ownership, and higher median household income. Notably, we also find that higher neighborhood rates of post-secondary education are associated with residences being closer to gardens.

Table 5. Spatial lag regression results

Grouped Category	**Socio-demographic factor**	**Result**
Neighborhood trajectory	Vacancy (2013-17)	34.83***
Neighborhood trajectory	Demolition	-13.49
Built form	% Owner-occupied (ownership)	49.59***
Race and ethnicity	% residents, White	55.15***
Race and ethnicity	% US Citizens or nativity	-13
Affluence	Household Income	39.54*
Affluence	Unemployment	-14.47
Education	% College educated	-55.68***

*Note. Spatial regression model coefficient estimates [*** $p < 0.001$; ** $p < 0.01$, * $p < 0.05$]. Analysis performed at the census tract level. Underlying data is normalized. Positive coefficients indicate the direction of each factor's relationship to average residential distance to the nearest community garden (i.e., negative = associated with gardens being closer, positive = associated with gardens being further)*

3.3 Can all city residents enjoy 15-minute access?

Our Maximum Coverage (MC) Location Allocation tests allow us to assess the feasibility of achieving universal access (i.e., all residential households have 15-minute walking access to a community garden) under different land-use policies. Our most expansive scenario requires 1,874 new gardens and achieves 98.8% coverage (Table 6). Our more limited scenarios still achieve significant increases in access. Land-Use Policy 2, which includes both publicly and privately owned vacant parcels, reaches 90.2% citywide access under the MC scenario, with 671 additional gardens chosen by our spatial optimization procedure. This model result yields an average marginal increase in citywide access to gardens of 2,013.6, far higher than any other scenario's marginal access increase number in MC modeling (Table 7).

Table 6. Number of new gardens and resulting citywide access level under the five MC scenario tests

Land Use Policy	**New gardens**	**Total gardens**	**% of households with walking access**	**Average marginal access granted per new garden**
1. Vacant (only publicly owned)	472	1,318	66.33%	306.03
2. Vacant (all parcels)	671	1,517	90.20%	2,013.60
3. Vacant, Parking Lots	1,743	2,589	96.60%	441.16
4. Vacant, Churches, and Schools	1,631	2,477	95.58%	447.69
5. Vacant, Multi-family residential, Commercial, Industrial	1,874	2,720	98.80%	422.69

3.4 Strategic spatial planning of gardens

While our MC modeling points to key trends in land use planning, building hundreds of new gardens is not practical in the short-term. To assess more realistic access implications across land-use policies, we model optimal site selection under garden expansion programs involving the selection of 50 and 100 new sites (Table 7).

Table 7. Citywide access and average marginal household access added per modeled garden under our limited garden expansion policies across each of our five land-use scenarios

Land Use Policy	**Garden expansion scenario**	**Percentage of households with access**	**Marginal access granted per new garden**
Base	-	53.26%	-
Vacant (only publicly owned)	50	60.93%	5,610.68
	100	63.21%	1,669.22
Vacant (all parcels)	50	67.06%	10,092.24
	100	73.04%	4,380.32
Vacant land, Parking Lots	50	69.92%	12,186.26
	100	76.78%	5,022.36
Vacant land, Churches, and Schools	50	70.08%	12,301,14
	100	76.84%	4,948,86
Vacant, multi-family residential, commercial, industrial	50	71.27%	13,176.26
	100	78.31%	5,147.68

We find that with 50 new gardens on publicly owned vacant land, we can expand 15-minute access to 280,534 new households (a 7% increase). If we consider all vacant parcels (i.e., Land-Use Policy 2), we nearly double this expansion (504,612 new households, a 14% increase, visualized in Figure 2). The creation of 50 new gardens under Land-Use Policy 5 yields citywide access of 71.27%, representing an average per garden increase of 13,176.26 new households. When we model adding 100 gardens under the most ambitious land-use policy, total citywide access increases to 78.31%; however, the average marginal in access tied to each garden drops to 5,147.68. These decreasing marginal returns to access are observed in all 100 garden scenarios. Nonetheless, nine of ten limited growth scenarios yield a higher marginal access rate than the average households served by existing gardens (2,303.25 households per garden), highlighting the significant impact that strategic placement of sites has on increasing access.

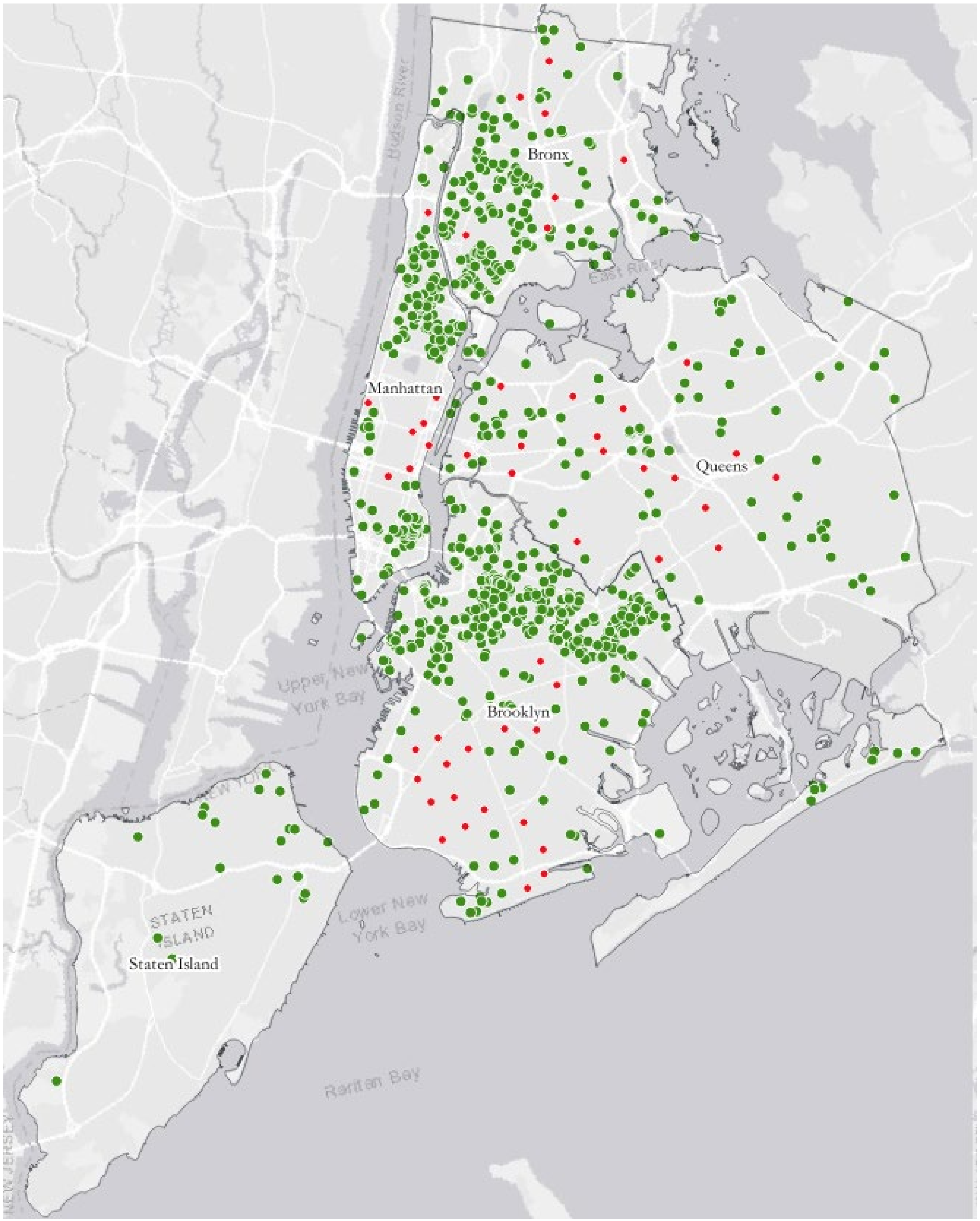

Figure 2. Example of spatial output of Maximize Coverage analysis

Note. Figure 2 depicts Land-Use Policy 2 under 50 garden expansion scenario. Existing, documented gardens are green and candidate sites selected by our spatial optimization procedure are red.

We find that vacant parcels offer the highest per m^2 increases in household access (Table 8). This may seem counter to our macro-level modeling, which showed that land-use policies incorporating sites on non-vacant land uses performed higher when assessing city-wide access. However, vacant lots, especially privately-owned vacant lots, have the dual advantage of being both well-scattered throughout the city and relatively small, meaning that acquired sites reach residents more efficiently.

Table 8. Characteristics of parcels selected for siting in our 50 and 100 garden expansion scenarios

Land Use Category	***# parcels selected in all 50/100 scenarios***	***Average Households Served p/sq. m^2 parcel area***	***Average size of parcel site (m^2)***
Churches and schools	129	6.81	13283.59
Commercial and Industrial	33	6.48	5531.61
Mixed Residential & Commercial	43	7.33	15208.34
Parking facilities	15	14.53	3886.30
Public non-vacant	11	8.17	4647.62
Residential	111	8.33	15591.28
Vacant land	449	15.88	2435.16
All	*791*	*12.38*	*6923.92*

Given the complexity of land use planning on a city scale, simulation results are not prescriptive and instead should be used to assess generalized land use patterns and scaling potential. However, if all scenarios include certain sites, this may reveal sites with particularly high access potential. Yet, we observed limited direct overlap in candidate sites across land-use policies; under more expansive land-use policies, spatial optima were based around candidate sites not available in more restrictive land-use policies. For example, we observed only 2 instances of overlap between policy 1 and 2, revealing that the much greater extent of privately owned vacant parcels across the city yielded better options in terms of marginal returns to access. The only land-use policy comparison with significant overlap was the 50-garden expansion scenario under Policies 2 and 4; 13 of 50 (more than 25%) sites selected were identical, demonstrating that vacant lots remain a valuable component of scaling strategy when also considering schools and churches as sites for gardens.

While direct overlap in site selection across land-use policies was limited, we observed a number of examples of what we call “indirect overlap”, or clusters of gardens in particular neighborhoods across land-use policies. Our model’s predilection for siting gardens in certain neighborhoods reasonably follows from our finding of spatial clustering in existing garden locations. Different types of indirect overlap tell us different things about the land use requirements for gardens in particular neighborhoods (Table S4). For example, in Manhattan CD 8 (Upper East Side – Roosevelt Island), an average of 4.3 gardens are selected across 3 of 5 land-use policies. Manhattan CD 8 did not receive any gardens in Policy 1 and 2 because of the existing land use mix in this neighborhood; other CDs, such as Brooklyn CD 11, received multiple gardens in all five land-use policies.

Land use choices for garden siting have equity implications. Scaling up only on vacant land yielded comparatively more gardens in neighborhoods with higher poverty rates than our more expansive land-use policies. These effects are more pronounced when siting a larger number of gardens, and we only detect statistically significant effects of land-use policy on equity in our 100 garden scenarios. For example, when we compare our results from Policy 2 (all vacant parcels) to Policy 4 (all vacant, plus churches and schools), we find that under-resourced neighborhoods see a much smaller increase in garden access under Policy 4 (adjusted p-value: .02). These trends hold in more expansive land-use scenarios, as well – for example, when we compare Policy 3 to Policy 5, we find that gardens are less preferentially sited in under-resourced neighborhoods under Policy 5 (adjusted p-value: 0.03).

4. Discussion

Our results indicate that more than half of the city already has 15-minute garden access, that community gardens are relatively equitably distributed across the city, and that land-use policy decisions can lead to significant variations in garden access at both neighborhood and city scales. Our study is the first to connect the current state of UA access to possible UA futures, which allows us to identify three major points of emphasis: 1) relationships between garden proximity and key socio-demographics in NYC aren't universally replicated in other city-level studies of the spatial distribution of community gardens, 2) attention to certain guiding principles can make community gardening more accessible in NYC, and 3) future work should build on the limitations of our work to develop a more robust vision of strategic garden planning.

4.1 Mapping gardens in more cities

A variety of literature has sought to understand how the presence or absence of gardens relate to a range of socio-demographic factors in communities (Hawes et al., 2022). In our spatial regression analysis, we conceptualize access using a novel indicator of garden proximity to residences in neighborhoods and investigate how socio-demographic factors discussed in the urban agriculture literature relate to this novel measure, and we document significant relationships between garden proximity and vacancy, rates of home ownership, racial composition, affluence, educational attainment. Many, but not all, of the insights provided by previous scholars studying the relationship between the presence/absence of community gardens and these specific socio-demographic factors apply to NYC.

Vacancy and Homeownership

The location of urban gardens is bound up with the development trajectory of neighborhoods. We find that community gardens tend to be farther from neighborhoods with higher rates of vacancy and higher rates of home ownership. Vacant parcels are often understood as spaces of opportunity, with potential to cultivate neighborhood revitalization (Reynolds & Cohen, 2016; C. M. Smith & Kurtz, 2003), and community gardens are often built to confront issues wrought by disinvestment (Kinder, 2014). However, as was the case in a recent analysis of Detroit, we find that high levels of vacancy today do not presage community gardens, and the relationship between vacancy and gardens likely evolves as community gardens and other community-led investments address the broader consequences of disinvestment that accompany vacancy (Hawes et al., 2022).

Race

We found that gardens tend to be farther from whiter communities in New York City. This contrasts to previous work which found that the presence of gardens in Detroit and Portland tended to be racially stratified in favor of white populations (Hawes et al., 2022; McClintock et al., 2016). However, it reiterates findings from Philadelphia, Toledo, and, notably, a previous study of New York, which found associations between the presence of community gardens and Communities of Color (Burdine & Taylor, 2018; Butterfield, 2020; Meenar & Hoover, 2012).

Affluence

Affluence in neighborhoods has been shown to relate to reduced presence of community gardens spaces in past reviews of the literature and studies of New York City (Butterfield, 2020; Opitz et al., 2016; Voicu & Been, 2008). However, findings across cities are inconsistent (Hawes et al., 2022). In some cases, community garden activities in wealthier neighborhoods correspond with the rise of the local food movement and increased demands for sustainable lifestyles (Butterfield, 2020; Campbell, 2016) while in other contexts gardening is heralded as a response to food and economic insecurity (Kortright & Wakefield, 2011; Taylor & Lovell, 2015). In our study of New York City community gardens, we found higher median household income to be a predictor for community gardens being further away from residences, lending support to the base of literature finding that community gardens are located more often in lower income communities. This finding, in concert with our finding about white populations being located further from gardens, may indicate that community gardening in NYC is more connected with justice movements than other contexts (Reynolds & Cohen, 2016).

Education

Though whiteness and affluence in NYC neighborhoods predict gardens to be further away, one notable measure traditionally associated with social and economic capital – educational attainment – predicts shorter residential distance to gardens in our modeling. Previous studies of the relationship between educational attainment and community garden occurrence in NYC have shown a statistically significant link here, though this significance has dropped out in the past when adjusting for spatial clustering (Butterfield, 2020). Therefore, our findings of a statistically significant association, even when adjusting for spatial autocorrelation, lend increased support to this finding, which may represent preliminary evidence of early stages of gentrification in neighborhoods with an increasing rate of educational attainment and gardens located nearby (McClintock et al., 2016; Sbicca, 2019). Quantitative assessments of the relationship between community gardening and gentrification are scarce (Hawes et al., 2022), despite recent evidence that the form and function of green space is important to gentrification outcomes (Kim & Wu, 2021). Further research should aim to address gentrification risk more holistically in the context of urban space greening.

4.2 Guiding principles for making UA more accessible in NYC

The 15-minute garden city represents a tangible goal that planners and community advocates can collaboratively work towards in pursuit of food justice and the localized benefits of UA. Based on our results, we identify three overarching guiding principles that stakeholders should consider as they seek to broaden access to UA: for siting new gardens, vacant land outperforms other land uses in increased access per unit area, land use choices when scaling UA impact the equity of the resulting spatial distribution of gardens due to different land use mixes across neighborhoods, and successful UA scaling will require effective and sustained stakeholder engagement. These principles, and the analysis that generated them, can support future strategic spatial planning for UA.

Vacant land can form the cornerstone of UA futures in NYC

Our per-square-meter results clearly indicate that investments in vacant land will help community gardens reach more people more efficiently than investments in other types of land in New York City. Furthermore, vacant land tends to be lower cost than land with structures (Haughwout et al., 2008), representing an opportunity for more affordable land acquisition, which is especially beneficial given the documented challenges in securing land tenure for UA (Horst et al., 2017). These factors yield a win-win for those engaged in scaling UA in NYC.

Land use choices affect equity

Though our results demonstrate that the current spatial distribution of gardens in New York City is relatively equitable, existing community gardens, particularly in gentrifying neighborhoods, have both historically and presently face development pressures, and some struggle to fundraise to maintain their operations (Reynolds & Cohen, 2016). This condition shows that urban agriculture futures are not guaranteed to be equitable in New York City. Because land uses exist in different densities across the city, inequities have the potential to emerge when planners and garden advocates focus scaling efforts on sites with particular land uses.

Planners must also be aware of the risk of green-driven displacement when siting new urban green space (Anguelovski et al., 2022; Sbicca, 2019). Scholars have previously documented links between the siting of new green infrastructures and gentrification, including in the case of community gardens in the US (Braswell, 2018; Butterfield, 2020; Voicu & Been, 2008). Green gentrification can occur even when the motive for siting urban green spaces (including community gardens) is mitigating environmental injustice through their distribution (Wolch et al., 2014). Dispersing green infrastructure may support an equitable distribution of the social and ecosystem services proffered by gardens while also mitigating the creation of new gentrification pressures arising from spatial concentration of new green infrastructure (Newell et al., 2022; Wolch et al., 2014).

Scaling up UA requires diverse stakeholder participation

Vacant land can form the bedrock of scaling efforts in NYC community gardens, but vacant land is not optimally positioned to maximize citywide access by itself. We demonstrate that universalizing the 15-minute garden city requires siting gardens on non-vacant land uses, which points to the need for partnerships with a variety of stakeholders to successfully scale up the 15-minute garden city. This echoes the existing shape of the NYC UA community, which is not composed of a single “narrow constituency,” but instead includes a range of organizations and communities with distinct and unique goals related to, amongst other things, managing land in their neighborhoods and changing local relationships to the food system (Campbell, 2016; Saldivar-Tanaka & Krasny, 2004; C. M. Smith & Kurtz, 2003).

Technical analyses such as ours will not independently facilitate the radical land use transitions or build the social networks necessary to realize the 15-minute garden city, and putting these models (as well as their implications) into the hands of New Yorkers supports city- and neighborhood-level goals for UA. With effective framing, support, and training for community advocates, this analysis can be merged with on-the-ground knowledge about existing gardens and who they serve, as well as the context of any parcel being considered for a new community garden, to better understand how to reconcile desires for community gardens with other acute community needs making demands on limited space, resources, and capacity in neighborhoods.

4.3 Future work and limitations

Though our work addresses gaps in existing UA scaling literature, our analysis is limited in several ways. Future work could expand upon our framing of 15-minute access to gardens by incorporating a more comprehensive dataset of sidewalks and walking paths into the network data source, as well as adding biking and public transit networks into its modeling (Logan et al., 2019). Our analysis is also limited in its conceptualization of garden typology and capacity; we allocate household demand to existing and modeled gardens based on the presence/absence of gardens in neighborhoods, rather than their size, function, or capacity for growing food and/or absorbing compost (Ambrose et al., 2020; CoDyre et al., 2015; Dorr et al., 2023). Further, our model’s focus on allocation of demand does not explicitly spatialize the distribution of localized benefits of UA; though some studies have sought to address this gap (Zhang et al., 2022), questions remain as to the efficacy of the methodologies used to assess these phenomena in space or their incorporation into spatial modeling. Notably, our study excludes rooftop gardens based on our paper's focus and definition of access; future work may attempt to blend ground-level and rooftop garden operations (Goldstein et al., 2016).

It is critical to reiterate that, while we position our work as an asset to future participatory and collaborative planning dialogues, our analysis cannot be understood as a definitive approach to spatial planning for community gardens. Planning scholars have discussed the pitfalls of a top-down, "technician's" approach to planning, and documented the importance of integrating local knowledge into plans at length (Corburn, 2003; Goodspeed, 2016). However, other literature has discussed the utility of quantitative and spatial analytical approaches in enhancing participatory and collaborative dialogues, through a framing of quantitative planning inquiry and geovisualization as "knowledge technologies," which can be defined as "vehicles for the introduction, application, and creation of knowledge." (Goodspeed, 2020)

Our work is limited by its value-agnostic approach to optimizing UA site placement (i.e. its singular focus on maximizing households with proximity to gardens), which excludes community priorities and existing land use plans for the sites we identify from explicit consideration. Given that the most effective scenario-based planning initiatives integrate robust discussions of community values and goals (Goodspeed, 2020), future work should prioritize integrating explicit community priorities into analyses the creation of scenarios and spatial planning models, taking a page from multi-criteria decision analysis literature (J. P. Smith et al., 2021). Doing so can help transform the *opportunity maps* we generate in this paper into community-driven *investment plans*.

5. Conclusion

As a recognized leader in the North American urban agriculture movement, with a burgeoning integration of food systems and urban agriculture into its planning, New York represents a compelling case study city for piloting a novel spatial planning approach for UA. To address our research questions, we first adopted a remote sensing-based data gathering process and regression analysis piloted in Detroit and adapted this for New York City (Hawes et al, 2022). Our results reiterate findings from previous studies of NYC (e.g., Butterfield, 2020) using a more comprehensive dataset and add to a body of literature documenting the unique, distinct dynamics of garden locations and their relationship to race, income, and education across a variety of North American cities (c.f. Hawes et al, 2022).

Our location allocation modeling represents the first study of community garden access that links both existing and modeled gardens to specific households, enabling the derivation of a series of maps, indicators, and tables that can function as a knowledge technology designed to enhance dialogue about UA futures. Through our inquiry, we find that more than half of New York City has access to the "15-minute garden city," and that existing access, despite its uneven dispersion across the city, is justice-oriented.

Our model is configured to optimize the siting of future community gardens based on maximizing residential proximity to gardens. Our Maximum Coverage scenarios visualize the possibilities for expanding UA under a variety of land-use policies and garden expansion scenarios. We demonstrate that achieving near universal access to the 15-minute garden city is possible, though not feasible in the short-term based on the significant investment of resources such a move would require. However, our more conservative garden expansion scenarios show that even modest investments in advancing UA in New York City can substantially increase the number of households with access to the 15-minute garden city. Our results underscore the importance of land use policy for the determination of future outcomes in city-wide and neighborhood-level access to gardens; we find that vacant land provides the best return on investment in terms of households gaining 15-minute walking access, which validates the common refrain in UA scaling literature framing vacant land parcels as key sites of opportunity.

The implementation of sustainability and resilience plans currently being developed by cities will reshape the map of urban agriculture through the programs and partnerships catalyzed by their development, and through the public engagement, participation, and collaboration opportunities with communities that these planning efforts engender. To advance the democratization of access to gardens, we seek to establish a blueprint that democratizes access to information about UA – where it is, who has access to it, and where it might be able to go in the future. To accomplish this aim, this paper outlines a novel process for the strategic spatial planning of community gardens which can be replicated in other cities where planning staff want to strategically plan for urban agriculture and the multiple benefits it can bring the communities they serve.

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Supplemental Information

Table S1. Supplemental map overlays for remote sensing garden search

Layer	Justification	Source
MAP NYC Inventory	Highlights community gardens listed by an NYU survey project	*Mapping Agricultural Production in New York City (M.A.P. NYC), 2022*
GreenThumb Inventory	Highlights community gardens registered with the city of New York	*GreenThumb Garden Info, 2022*
NYCHA Properties and NYCHA 2017 garden inventory	Highlights NYCHA properties, where several governmental and non-governmental projects have supported gardening	Personal communication, not publicly available
Church and school properties	Highlights schools and churches, community hubs which have often been linked to gardens in NYC and across the country	*MapPLUTO Release 22v3, 2023*

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Table S2. Factors assessed for regression

Grouped Category	**Socio-demographic factor**	**Spatial Resolution**	**Year**	**Source**
Neighborhood trajectory	Vacancy, 2013-17	Parcel	2013-17	HUD Aggregated USPS Administrative Data On Address Vacancies
Urban decline	Demolition	Parcel	2014-17	NYC Department of City Planning's (DCP) Housing Database
Built Form	Building Density	Census tract	2018	Computer Generated Building Footprints for the United States
Built Form	Median Building Age	Census tract	2016-2020	American Community Survey (ACS)
Built Form	% Owner-occupied	Census tract	2016-2020	American Community Survey (ACS)
Race and ethnicity	% residents, Black	Census tract	2016-2020	American Community Survey (ACS)
Race and ethnicity	% residents, White	Census tract	2016-2020	American Community Survey (ACS)
Race and ethnicity	% US Citizens or nativity	Census tract	2016-2020	American Community Survey (ACS)
Affluence	Home Value	Census tract	2016-2020	American Community Survey (ACS)
Affluence	Income	Census tract	2016-2020	American Community Survey (ACS)
Affluence	Unemployment	Census tract	2016-2020	American Community Survey (ACS)
Education	% College educated	Census tract	2016-2020	American Community Survey (ACS)
Education	% No high school diploma	Census tract	2016-2020	American Community Survey (ACS)
Household composition	# children	Census tract	2016-2020	American Community Survey (ACS)
Household composition	median age	Census tract	2016-2020	American Community Survey (ACS)

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Table S3. Factors included in raster-based biophysical suitability analysis

Criterion	**Qualifying condition**	**Source**
Land Use	Meets scenario conditions	*MapPLUTO Release 22v3, 2023*
Ownership	Meets scenario conditions	*MapPLUTO Release 22v3, 2023*
Slope	Less than 15 degree slope	*NYC Topobathymetric Data, 2017*
Land Cover	Not covered by building or other structure	*Land Cover Raster Data (2017) – 6in Resolution, 2017*
Sunlight Availability	At least partial sun (greater than 4 hours sunlight per day on average during growing season)	*NYC Topobathymetric Data, 2017*

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Table S4. Community Boards Districts with clusters of garden assignments in our modeling

Neighborhood(s)	Borough, Community Board District	Number of scenarios (out of 5) where CD was assigned 2 or more gardens	Average gardens assigned across all scenarios
Bensonhurst-Bath Beach	Brooklyn 11	5	4
Long Island City-Sunnyside-Woodside	Queens 2	5	2.8
Sheepshead Bay-Gravesend (East)	Brooklyn 15	5	2.6
Borough Park-Kensington	Brooklyn 12	4	3.3
East Midtown-Murray Hill	Manhattan 6	4	2.8
Forest Hills-Rego Park	Queens 6	4	2
East Flatbush	Brooklyn 17	4	2
Upper East Side-Roosevelt Island	Manhattan 8	3	4.3
Upper West Side	Manhattan 7	3	2.3
Midtown-Flatiron-Union Square	Manhattan 5	3	2.3
Soundview-Parkchester	Bronx 9	3	2
Coney Island-Brighton Beach	Brooklyn 13	3	2
Elmhurst-Corona	Queens 4	3	2
Jackson Heights-East Elmhurst	Queens 3	2	2

Table S5. Community Board Districts with > 90% access

Neighborhood(s)	Borough, Community Board District	Percentage of households with 15-minute access
Morningside Heights-Hamilton Heights	Manhattan 9	98.8%
Bedford-Stuyvesant	Brooklyn 3	98.6%
Ocean Hill-Brownsville	Brooklyn 16	97.6%
Harlem	Manhattan 10	97.4%
Crown Heights (North)	Brooklyn 8	96.0%
Tremont-Belmont-West Farms	Bronx 6	95.9%
Morrisania-Crotona Park East	Bronx 3	93.3%
Park Slope-Carroll Gardens	Brooklyn 6	93.1%
Bushwick	Brooklyn 4	92.0%
Melrose-Mott Haven-Port Morris	Bronx 1	90.7%

Table S6. Community Board Districts with < 20% access

Neighborhood(s)	Borough, Community Board District	Percentage of households with 15-minute access
South Shore	Staten Island 3	0.0%
South Ozone Park-Howard Beach	Queens 10	5.9%
Kew Gardens-Richmond Hill-Woodhaven	Queens 9	7.1%
Queens Village-Bellerose-Rosedale	Queens 13	12.9%
Bensonhurst-Bath Beach	Brooklyn 11	13.1%
Mid-Island	Staten Island 2	15.1%
Borough Park-Kensington	Brooklyn 12	17.0%
Upper East Side-Roosevelt Island	Manhattan 8	17.2%
Midtown-Flatiron-Union Square	Manhattan 5	19.3%
Fresh Meadows-Hillcrest-Briarwood	Queens 8	19.4%