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Reimagining New York City's Underutilized Building Stock and Infrastructure

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Abstract: During World War II, parts of New York City were largely industrial zones, collections of industrial buildings and a few scattered pockets of residents. Today much of that industry has moved out, leaving behind underutilized building stock. The city hosts some significant abandoned infrastructure as well: closed rail-road and subway stations, non-functioning aqueducts, and retired sewer lines among them. These facilities offer opportunities for conversion to new housing and public recreational and cultural spaces. In some cases transformation has already occurred, proof of concept that transformation is possible. This paper reviews some of those successful revitalizations and identifies still-untapped significant opportunities for similar reinvention within the city's urban landscape, covering outlines of the history of such sites and the dynamics of redevelopment through retrofitting and proposing potential repurposing of selected underutilized resources.

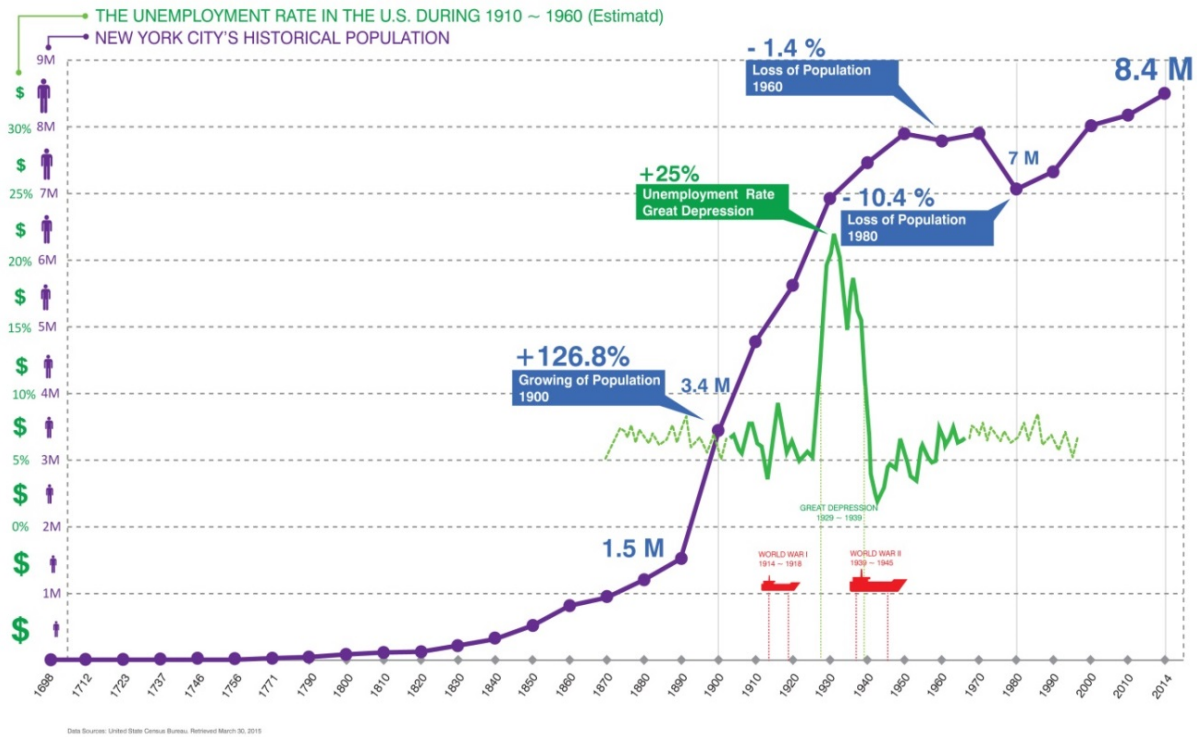
Keywords: reimagining; New York City; underutilized building stock; mega city; infrastructure; retrofitting; industrial revolution; re-development; repurposing; Queensway

1. Introduction

From the first third of the nineteenth century on, New York City was a major United States point of entry for goods from all over world, and over the years the city housed a significant industrial presence which endured and expanded for nearly a century-and-a-half. During World War II, this long-developed capacity enabled the city to supply and maintain, among other things, ships for the military effort in the European theater.

Consequently, New York, a city of five boroughs, had mega infrastructure built to serve both the industries that comprised the backbone of the city's economy and its teeming population, which swelled in large part as result of a massive influx of immigrants during the latter part of the nineteenth century and the first two decades of the twentieth. This infrastructure served the city and its industry well until the second half of the twentieth century, when social and economic trends turned against the city, and both people and industry began to abandon urban environments and to move to suburbia and beyond. Industrial areas and part of the city's infrastructure languished and in more than a few instances were abandoned. People sought what appeared to them to be better ways of living, moving first into close-in suburbs and eventually beyond. During the 1950s through the 1980s, New York City's population decreased, as the population in nearby suburbs (e.g., Long Island's Levittown) grew [13,32]. Now, however, suburban development (typically based on a 50'x100' lot for one family) has slowed [13]. Enchantment with the open spaces of suburbia has diminished for many, as the children and grandchildren of those who initially fed the urban exodus realized that it was harder to access public service in the suburbs than in the city, and movement within the suburbs themselves and between the suburbs and the city became increasingly difficult, as roadways and freeways clogged. Coincidentally, the suburban lifestyle increased the output of greenhouse gases such as CO^2 [13]. The American dream of one house for one family faltered, and interest in urban living began a slow but steady rise. The collapse of the housing market bubble at the end of the first decade of the twenty-first century hit suburbs especially hard.

Figure 1. New York City's Historical Population. With the increased immigration and growing industrialization in the 1900s, population increased about 126% between 1890 and 1910 [3]. Between World War I and World War II came the Great Depression, which pushed the unemployment rate over 20% in the United States. New York City's population decreased after the 1960s, reflecting migration to suburbia [3,13,33].



By the end of the twentieth century, New York City's population began to increase again as both some of the suburban population embraced urban life and new immigrants arrived [2,3]. The City expanded once again, requiring more housing stock and public space. Today about 8.5 million people (the high-water mark of the city's population) call New York City home. They comprise 40% of the New York State population [3,34].

The clamor for additional housing has revitalized some faltering parts of the city, and reutilizing existing buildings has become not only attractive but also economically advantageous. Repurposing structures not only avoids the greater cost of erecting new ones from scratch as it creates new space for the heavily populated city, but it also preserves unique features of those existing structures. Thus, the contextual aspect of such buildings fuses with the practical needs of New Yorkers. This approach preserves contextual meaning and returns everyday utility to these unused structures as people begin to put them to new uses by various means.

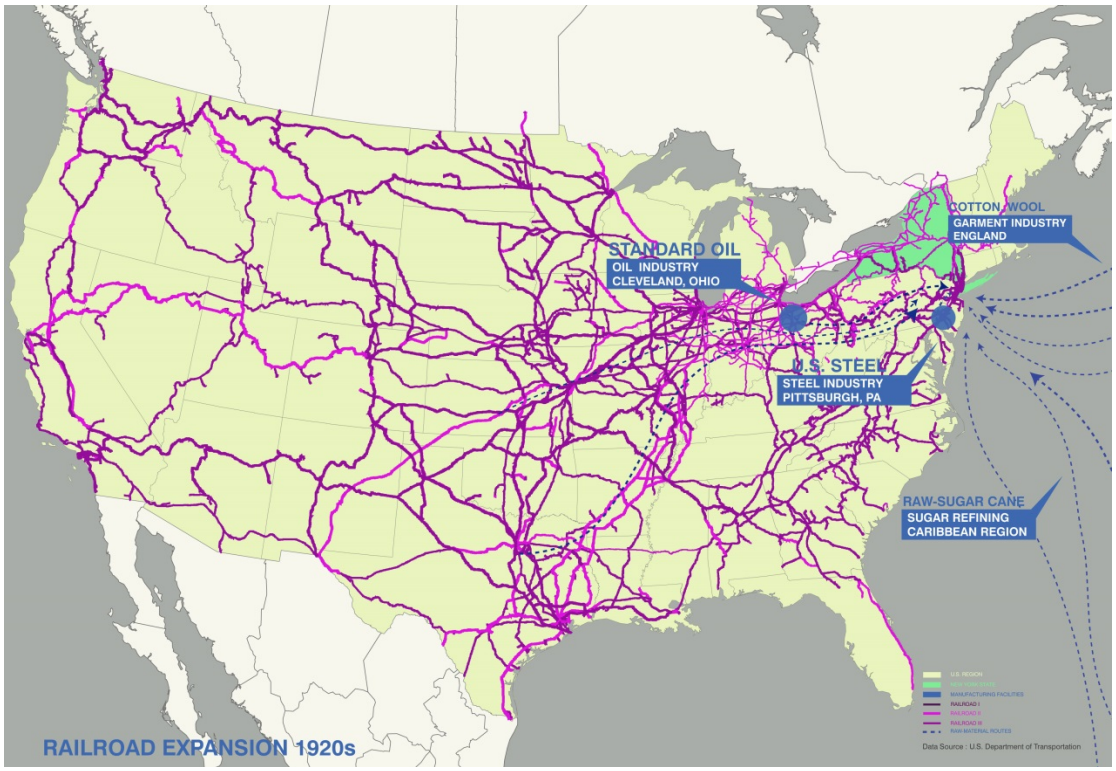
As the architect Renzo Piano noted in another but analogous context, "it's crucial, that Italians not build any more peripheries, because stretching services and public transportation further outward is unsustainable. Peripheries must be developed not by expansion, but by implosion; by transforming what's already available including what's known as brownfields. They are sometimes industrial places – railways, military spaces – and all those places can be transformed to intensify the city without necessarily making the city physically bigger and bigger and bigger and bigger, [1]"

2. Mega-City needs Mega-Infrastructure

Prior to the Civil War the United States saw rapid railway expansion and the extension of many short, dis-jointed lines into important rail routes [36,37]. Railways developed especially intensely in the country's north-eastern region, home to a large percentage of the country's manufacturing facilities. An argument can be made that this phenomenon, along with well-developed communication capabilities, was a major factor in the Unionist North's ultimate victory in the Civil War [2]. The map below shows the density of rail capabilities in the United States at the outbreak of that country's Civil War in 1861 [40].

The eight decades following the Civil War through approximately 1940 saw the well-developed railroad system play a major role in the explosive growth of American commerce. Manufacturers depended on the rails to deliver the raw goods that they needed and for the shipping to their customers of the final products that they sold. By the end of the nineteenth century, railroads played a significant part in the growth of major companies such as Andrew Carnegie's U.S. Steel, based in Pittsburgh, Pennsylvania, and John D. Rockefeller's Standard Oil-Company [18], located in Cleveland, Ohio [36]. The former provided the steel for the frameworks of the high rise building that allowed New York City to grow quickly and densely, while the latter helped provide the power that fueled the City's industries [17]. This fast-developing infrastructure helped transform New York into a mega-city, fostering, among others, three large industries [2,39].

Figure 2. Railroad Expansion 1920s [40].



These three great industries (i.e., the garment trade, sugar refining, and publishing) flourished in nineteenth century New York City and made the city and its port into a transport hub for both national and international trade [2]. The garment industry, the largest of the three, found a natural home in New York City as a result of the abundance of imported wool, cotton, and silk goods which came into the country through the City's harbor. England sent textiles into America through New York, and these materials were the basis of the ready-to-wear products of the garment industry [2]. The confluence of the textiles and the inexpensive labor from the increasing immigrant populations made New York City the center of the American garment industry.

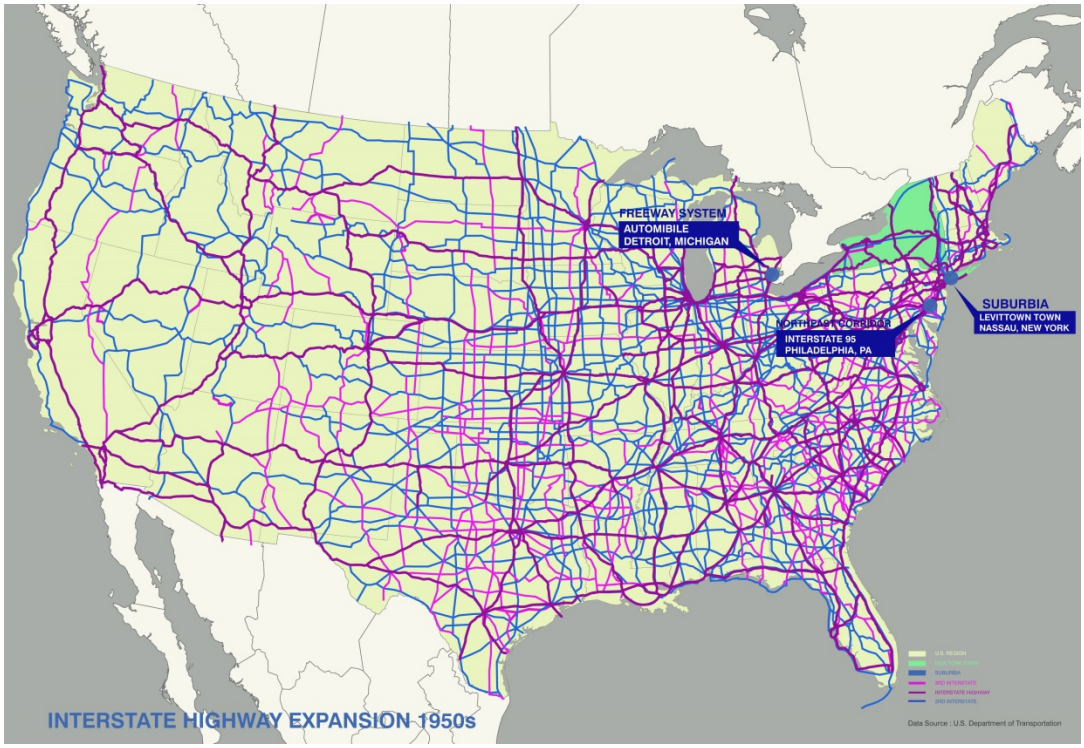
New York City's Domino Sugar processing complex, now abandoned, was the largest factory in Brooklyn and the largest sugar refining complex in the country. In 1900, sugar was the second-largest industry in New York City. The strength of the sugar industry in New York owed everything to the city's role as a shipping hub connecting Caribbean ports both with the American hinterland and with consumers in Europe [2,35].

New York's third-largest industry was printing and publishing, ensuring that an important part of the city centered on the transfer of ideas [2]. This business of managing ideas and disseminating them rapidly turned print publishing and, later on, non-print media businesses into a growth industry for the City. Today, many of those businesses still reside in the City (e.g., CBS, ABC, NBC, Time-Warner, *The New York Times*). Information about the other businesses substantially centered in New York (the New York stock market, private equity companies, banking, and part of the insurance industry) helped both those businesses and the media enterprises to grow.

As the city's immigrant influx subsided as a result of restrictive federal laws established in the early 1920s, other factors began to affect the city's evolution after World War II. As already noted, as people became more prosperous through the post-war economic boom, many moved to the suburbs,

car-based communities built at far lower density levels than the city [38,5]. The creation of a national system of interstate highways made shipping by truck easier and more attractive than it had been [2]. No longer dependent on railroad shipping, manufacturing no longer needed to cluster around a port or a train depot. As the population moved out of New York and other American cities as well (e.g., Philadelphia, Detroit, and Pittsburgh), so did some of the industries that employed them. This led to the loss of population mentioned above in the 1960s and in the decades that followed [13]. The blight that affected other American cities did not leave New York unscathed, but the city survived these problems. It became increasingly oriented around finance and corporate management. Despite weathering economic shocks that also affected much of the rest of the United States, New York continues to prosper because of finance and business services.

Figure 3. Interstate Highway Expansion 1950s to 1970s [5].

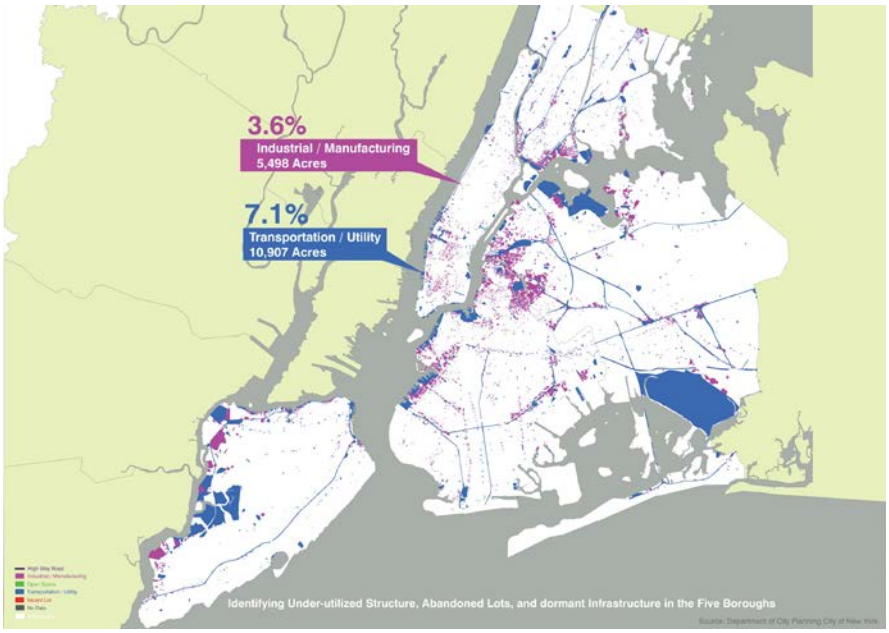


3. Identifying Under-utilized Structures, Abandoned Lots, and Dormant Infrastructure in the Five Boroughs.

3.1. Industrial Zoning

Despite the changes in its economic make up, New York still contains significant structures from its earlier years. According to The New York Department of City Planning, industrial zoning covers 3.6% (5,498 acres) of the City's Lot Area, which totals 153,605 acres [4]. The most populous borough, Brooklyn, has industrial zones which cover 4.6% (1,770 acres) of the borough's 38,194 total acreage, making it the borough with the largest percentage of industrial coverage [4]. The industrial zoning stems in large part from industry that was located on the Dutch Kill stream and Gowanus Canal, points of water access that attracted the most industrial activity.

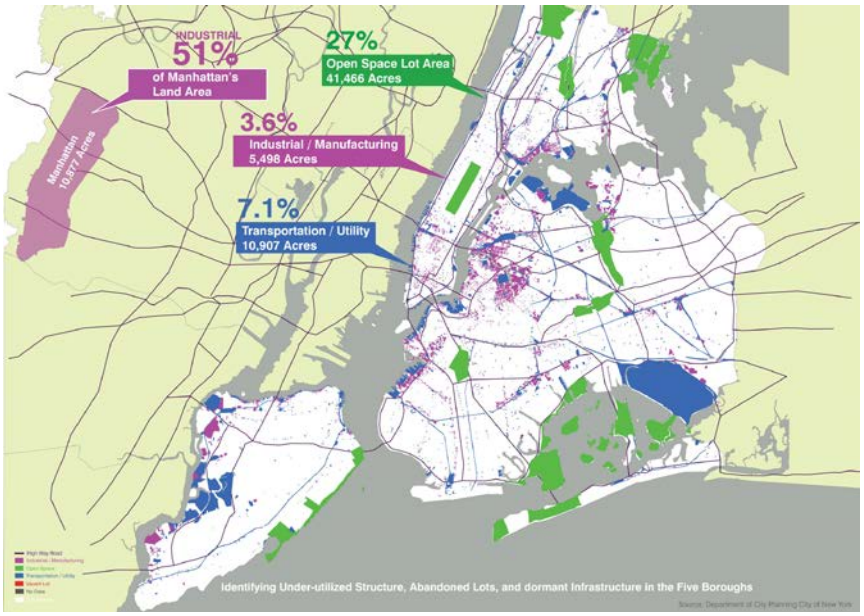
Figure 4. New York City's Industrial and Infrastructure zoning map [4].



3.2. Infrastructure

The infrastructure of the City covers an area equivalent to 7.1% (10,907 acres) of the city's total surface and includes ports, railroads, and local roads. The largest proportion of a borough's area given over to infrastructure is in Queens, physically the largest of the City's boroughs, which has 11.7% of its total land area of 53,170 acres devoted to infrastructure [4,16]. Apart from the rail systems, Queens's large proportion of industrial land area is due to its two major airports, LaGuardia and JFK. The second largest proportionate infrastructure usage is in Manhattan, where of 6.5% of the land area, 702 acres, is assigned to such purposes [4]. This stems from the presence of linked interstate railroads (Grand Central Terminal, and Penn Station) and the dense subway system [4].

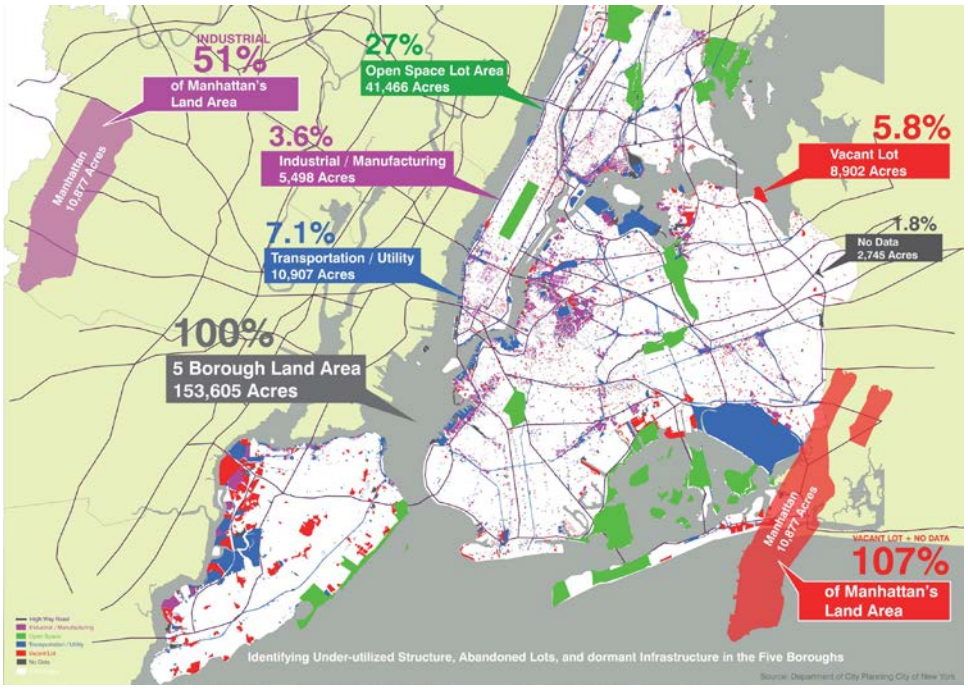
Figure 5. Interstate Highway in the Five Boroughs [4].



3.3. Vacant Lots

The 5,498 acres zoned industrial in New York City pale in comparison to the combined area of the vacant lots it contains, 8,902 acres [12], a total about 161% greater in size than the acreage given over to industrial uses [4,16]. The entire City's vacant land comprises an area that would cover up to 81% of Manhattan. Considering that this includes only the ground level area, the City therefore has a huge amount of underutilized space. Furthermore, there are no data on some lots in New York City. If this admittedly unspecified area is taken into account, the amount of vacant space rises to the equivalent of 107% of Manhattan's land area. Thus, New York City has many potential opportunities for new housing and public space in an aggregated area that is bigger than Manhattan. The challenge is finding good uses for this considerable amount space. Making repurposing easier is the status of these spaces. Most are soft-lots, meaning that they do not already have developed buildings on them. This flexibility will allow projects that can go in many directions. Several redevelopment projects around New York City demonstrate ways in which we can resourcefully put such vacant spaces to practical use.

Figure 6. Five Boroughs Vacant and No Data Lots Calculation [4].



4. The City's Successful Projects through the Retrofitting Re-development

As shown above, New York City has underutilized building stock and infrastructure ripe for repurposing. I found three successfully completed and ongoing projects and one still in the earlier stages of the re-development process in New York City that demonstrate the possibilities of re-use. The size of re-development, involving community-based projects, includes a balance of affordable housing, community accessibility, and places for local small businesses to grow. The Domino Sugar factory is a new development in progress whose plan has been approved by city. The project consists of creating multi-use and community accessible buildings by developing the existing industrial site. Another redevelopment project, the Brooklyn Navy Yard, is more focused on small business growth. It offers below-market rents for small and local business owners. The tenants currently are light industry

concerns, artists' spaces, and sustainable businesses. The third successful project is the High Line Park, and the fourth is its reflection, the Low Line Park, which is much earlier in the development process. These are good examples of re-purposed abandoned infrastructure, providing large public access spaces.

4.1. The Domino Sugar Factory

The Domino Sugar factory, built in 1856, is located in the Williamsburg section of Brooklyn on the East River. By 1871 this factory produced 50% of the sugar consumed in the United States and was in active use for 148 years processing raw sugar cane from the Caribbean region [2]. The refinery closed in 2004, resulting in the lay-off of over 225 workers. The closing affected related businesses (i.e., shippers, handlers, suppliers, servicing companies, distributors, and other similar enterprises), and thus the effects of the closure included further job losses. This factory moved to the suburbs, as the company sought affordable land, lower cost labor, and outsourcing overseas.

In 2007, the site's buildings were given landmark status by the Landmarks Preservation Commission. After this, developers, including the original frontrunner, CPC Resources, sought to convert the site into mixed-use buildings. However, because CPC planned only 660 affordable housing, a 34-story building, and no public open space, the CPC plan was ultimately rejected in favor of the proposal by the developer Two Trees in 2012 [15]. Two Tree's plan will provide 700 affordable housing units and open space covering 60% of the site [15]. This mixed-use building plan meant that the redevelopment received an additional benefit from an expanded FAR (Floor allowance ratio) [44], because of its provision for more affordable housing units and open public space. In contrast to the CPC's proposed building, Two Tree's structure will be a 50-story tower including the bonus FAR, and the project will include a 400-meter long Water Front Park, open, of course, to the public. The Two Trees proposal shows the value of retrofitting industrial building structure, preserving the contextual aspect of the Domino Sugar factory, while creating programs that increase publicly-accessible space as well as shared office for start-ups and other small enterprises open around the clock.

The sugar factory plan has used the adaptive reuse approach to the main building while redesigning the whole area, also creating new buildings around this historic area. In effect, the Domino Sugar Factory is becoming a mixed-use building with offices, retail, and commercial use, in a publicly-accessible space open 24 hours a day. The city, in turn, has provided Two Trees, a private company, with the built additional FAR. All in all, this project shows how government and private developers have created better opportunities for everyone.

Figure 7. (a) Before demolition Sugar Factory (Photo by Paul, Raphaelson) [19]. **(b)** Two Tree's Plan (Rendering by Shop Architects) [20].

4.2. High and Low Line Parks

The High Line elevated rail spur opened up Manhattan's largest industrial district in 1934 [14]. The High Line viaduct, connected directly to factories and warehouses, allowed trains to load and unload their cargo inside buildings. Milk, meat, and raw and manufactured goods could be transferred and unloaded without impeding street traffic. As noted above, in this period much of the expansion of the U.S. economy was largely the result of the railroad services between the east and west, allowing shipments to other states. With the creation of the Interstate Highway system in the 1950s and 1960s, trucking became the dominant mode of transportation, and the southwestern section of this Manhattan rail line was demolished. The last trains ran in the 1980s [14]. As structure stands today, it has become the High Line Park, a very successful retrofitting project.

Figure 8. (a) Prior to Park Construction High Line Park from North view (Photo by Miru Kim) [22]. **(b)** After Construction High Line Park from South view (Photo by David Giral) [21].

When what became the park project was first being discussed, two plans were under consideration, a plan to demolish the elevated rail line and a plan to preserve it. In 1999, an organization called Friends of the High Line was created by the local community. These activists worked to preserve the line's natural features, and reuse them. The movement started when the fashion designer Diane Von Furstenberg moved to the Meatpacking District, where the remnant of the elevated rail line structure ends, in 1997. She organized fund-raising events for the High Line in her own building. This campaign also had important supporters such as the New York City mayor, Michael Bloomberg, and two successive city council speakers, Gifford Miller and Christine C. Quinn [14]. The New York City government committed $50 million to this project. Ultimately, the fund's supporters raised more than $150 million [14].

Construction on the repurposing of the unused elevated rail-road began in 2006. The first phase opened in 2009; the third and final phase opened in September 2014. Now, the Park gets about five million visitors annually. Physically, the High Line Park is a narrow, 1.45-mile-long, elevated [14], open, landscaped public space extending on the city's West Side from Gansevoort Street in Greenwich Village to 34th Street, near the Javits Convention Center and the Hudson Yards, the new development being constructed over the rail lines that feed into Penn Station from the west. The elevated park passes through the Chelsea market, connecting the viaduct to the former National Biscuit Company building. More than 30 projects such as new housing and offices have completed construction in the surrounding neighborhoods on the ground since the first section of the High Line Park opened in 2009

[14]. The retrofitting approach revitalized west Chelsea, which was in poor condition in the late twentieth century. However, since it opened, the park has become a "tourist-clogged catwalk," and gentrification began bringing new businesses and, housing. Among the positive aspects of the redevelopment, the City has required that new development include a set-aside of 20% [44] of the housing units for low-and middle-income tenants. The presence of the Park has also given new businesses a chance to prosper and broadened the cultural mix of businesses located in the area.

Regrettably for those already situated in the neighborhood, construction of the High Line Park has led to some negative changes as well. Rising rents have caused some existing neighborhood population and small business owners to look for more affordable spaces elsewhere, leaving for other places (e.g., Brooklyn). Many long-established businesses in west Chelsea have closed due to the loss of neighborhood customers or rent increases. In addition, many artists who had been attracted by the area's relatively low rents relocated as new development crowded out spaces that the artists had used. Nonetheless, although some businesses have closed, others such as Chelsea Market that are related to the new enterprises in the area have stayed. These changes have brought many positives for the local community. After the High Line's second section opened in 2011, *The New York Times* reported that there were no reports of major crimes such as assaults or robberies in the area [6]. Surrounding communities have more lighting, which takes away opportunities for crimes that might occur in the darkness of night, and communities see less littering, keeping them cleaner [6].

Culturally, the High Line Park provides outdoor videos, live performances, and temporary site-specific artwork. Now, Chelsea Market (which hosts local food businesses), a flea market (local artists), galleries, hotels, fashion, and hi-tech businesses (including a building occupied by Google) have found homes, along the High Line [10,14]. The High Line Park's influence has extended beyond its district's borders, in effect promoting the Low Line Park on the city's Lower East Side neighborhood as an underground park. Traditional parks are located at ground level. The High and Low Line Parks are contrastingly located above the ground and underground, by re-using abandoned existing infrastructure.

The Low Line will ultimately become an underground park covering about one acre. Formerly a trolley terminal just below Delancey Street that connected to the Williamsburg Bridge, the existing structure opened in 1908 and fell into dis-use in 1948, becoming a hidden historic site [23]. Being underground, the new park will be unusual in that it will avoid the usual inconveniences posed by inclement weather [23,24]. The park will provide daylight through the use of solar collection dishes. In this technology, solar light is collected from outside and reflected through a tracking mechanism, through a helio tube, and finally through the dome which will reflect and distribute the sunlight in the underground space. This mechanism provides sufficient sunlight for underground green space with plants, trees, and grass. James Ramsey, an architect of Raad Studio, designed the space in 2009, and fund-raising campaigns have been in progress since 2012 [23]. The Low Line Park will open in 2018 in accordance with negotiations with the region's Metropolitan Transit Authority and the City [23]. Small community-based movements have worked to develop vibrant programs such as those associated with the High Line. Because the goal is to create the Low Line Park analogous to the High Line, the Low Line communities are studying the historical aspects of the space and its physical structure to determine how the structure that remains will be re-used, thus creating a re-purposing plan that is custom-designed for its community. This park and the High Line are two good examples of multi-layered parks that have developed out of retrofitting existing structures to create public space while preserving cultural aspects of the structures from which they are or will be built.

Figure 9. (a) Existing condition at Underground Space [23]. **(b)** Rendering Low Line Park (Rendering from Raad Studio) [24].

4.3. Brooklyn Navy Yard

Located in New York City's borough of Brooklyn, the Brooklyn Navy Yard stretches for 1.7 miles. It extends over 200 acres, which is about 25% the size of Central Park's 778-acre site. First built in 1801 by federal authorities, the Navy Yard was in use from 1806 to 1966. During World War II, it employed 70,000 people 24 hours a day. In 1967, Seatrain Lines leased the Yard and housed container ships, eight barges, and one ice-breaker barge there. Until 1976 the Yard provided jobs for 6,000 workers. In 1987, the Brooklyn Navy Yard Development Corporation (BNYDC) failed in attempts to lease it, and so the site was abandoned [45].

Today the Navy Yard provides space for private manufacturing and commercial activity including more than 200 businesses employing 5,000 people. One tenant, Steiner Studios, is one of the largest film and video production studios outside of Los Angeles. In November 2011, the Yard opened "A Program of the Brooklyn Navy Yard Development Corporation," which offers exhibits, public tours, education programs, archival resources, and workforce development services [45]. The BNYDC has driven the Yard's largest expansion since World War II. Current tenants are many artists, designers, furniture companies, contractors, studios, and light industry businesses. Adaptive reuse of historic buildings is on-going. The area known as Admiral's Row, Building 77, and the Steiner Media Campus are examples. These developments will have created 6,050 new jobs as of 2017. Total investment is about $442 million from private and public funding. The site is home to some green industry operations as well, among which are Brooklyn Grange Farms, operating on a 65,000 ft² (600M²) commercial farm on top of one building. Other current green tenants are the Capsys Corp (modular homes, re-useable homes), a furniture company (less harmful material use), and a printing company (100% co-generated power, recyclable materials) [45,10].

The Brooklyn Navy Yard is a prime example of reusing existing structures. Once virtually abandoned and employing no one, the Yard has now not only opened up sustainable jobs for the local population in sustainable settings but has also opened up many job opportunities for others. It has created an environment in which small businesses can collaborate to create other projects. The Navy Yard has resulted from a retrofitting approach by using older buildings to create sustainable ones that use solar panels and urban farming [26]. The Navy Yard is a successful example of reused buildings which, while preserving its historical context, has created opportunity for something new.

Figure 10. (a) Before Re-development (Photo by Harrison, Boyce) [25]. **(b)** Urban Farm, Brooklyn Grange [26].

4.4. Gowanus Canal

As the successful projects above demonstrate, local communities can revitalize disused sites. The Gowanus Canal has been a highly contaminated waterway since World War I. Located in Brooklyn in the neighborhood of Red Hook, the canal is 1.8 miles long with seven bridges over it [27]. Gowanus Canal was one of the busiest cargo transportation hubs during the First World War [27,28]. The Canal saw 6 million tons of cargo pass though it after the First World War came to an end. That made it the nation's busiest commercial canal but also the most polluted. Though it is still used today for domestic waterborne transportation of goods, notably fuel oil, scrap metal, and aggregates, it remains one of the most polluted bodies of water in the United States [27,30]. Recently, the local community realized the need to restore its environment. Under the 1972 federal Clean Water Act [30] and with the more recent Gowanus Canal Community Development Corporation (GCCDC), the federal Environmental Protection Agency selected the canal as a "Superfund Site" in an effort to create a clean-up plan [30].

Restoration of this site means that several changes are in the works, but there are several problems. One problem is the Flood District. The site is often flooded during and after heavy rains because of the combined sewer overflow (CSO) [42] that occurs. Whenever a hurricane hits the site, the area around the canal becomes flooded. A second problem facing the restoration of the canal is the presence of active polluting activities. For example, as noted above, fuel oil, scrap metal, and aggregates are still transported via the canal.

Figure 11. (a) Old Central Power Station [9]. **(b)** Gowanus' Brownfield Locations [27].

The Gowanus Canal and its surrounding area have abandoned factories, contaminated water, and repeated flooding. There are several design competitions for the Gowanus Canal. One idea is called Sponge Park. This project proposes floating remediation for contaminated wetlands, living sponges

that can absorb and break down organic toxins [11]. This would provide a wet-land park along the Canal, which would help prevent flooding from heavy rains and hurricanes [7,31]. Another idea is Oyster-Tecture. This concept proposes an active oyster culture to improve water quality [28], as oysters can remove pollutants from water [28]. Oyster-Tecture proposes to nurture an active oyster culture that engages issues of water quality, rising tides, and community based development around Red Hook and the Gowanus Canal [28]. This living oyster field will support oyster and mussel growth, as mussels are another shellfish that can tolerate polluted waters [28]. The reef attenuates waves and cleans millions of gallons harbor water through harnessing the biotic process of oysters, mussels, and eelgrass [28]. Current plans for the re-development of Gowanus Bay will provide space for revived forms of marine habitat [28,7]. The above two projects will use soft-infrastructure to provide the means to prevent natural disasters like flooding and reduce pollution contamination from previous and ongoing industrial activity. The revitalization will affect the local community's culture and provide opportunities for sustainable growth. This new way to approach to infrastructure will create public space and link separated communities to each other. The Gowanus Canal is still in the earliest phases of the cleaning stage but zoning shows the existing land use plan for its surrounding areas. Vacant lots and abandoned factories provide opportunities for community rain gardens, roof gardens, a water detention tank for a parking lot, and co-working spaces of existing factory building. The first phase is the remediation of this water infrastructure spurred by the local community and employing the government's designation of the Canal as a clean-up site. The second phase calls for specific zoning that applies only to this site. Because the site has a special character that renders it prone to flooding, development will require a 40-foot set-back from the canal's edge to prevent inundation. The City can compensate for this requirement by granting bonus FAR to developers, resulting in more buildable space. The City could also recommend grey water re-use and CSO modification [30,42] for preventing flooding in addition to specifying the 40-foot set-back rule [43].

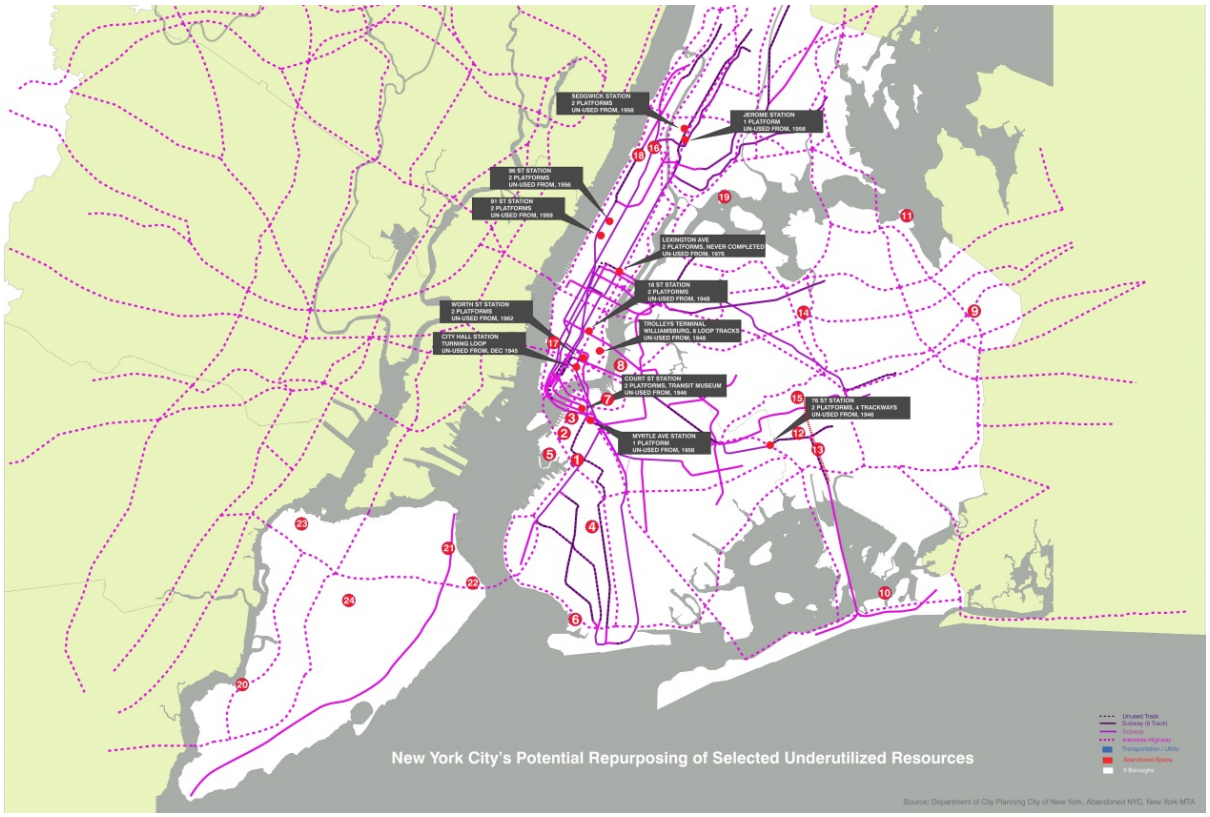
All five of New York City's boroughs need more working space and affordable housing. The Gowanus local community needs co-working space for artists and light industry at below-market prices. Usually, when new development starts, local small businesses face gentrification in short order, leading to higher rents. Truly sustainable urban design means not only appealing design but also design adapted for the growth of the local economy. While the Canal previously found use only for shipping raw materials, a balanced mixture of housing and working spaces makes a more sustainable infrastructure.

Figure 12. (a) Sponge Park (Rendering by DLand Studio) [11]. **(b)** Oyster-Tecture (Rendering by Scape Studio) [28].

5. New York City's Potential Repurposing of Selected Underutilized Resources

New York City possesses a trove of under and above ground space such as retired subway and railroad stations. The High and Low Line Park are good examples of the reuse of underutilized or abandoned infrastructure, and Manhattan has a dense subway system that has run for 110 years but is not without under-utilized spaces, which could be very useful, as the Low Line Park demonstrates. Among the currently abandoned subway stations are the City Hall Loop and the Worth Street, 18th Street, 91st Street, and Cortlandt Street stops [8]. There is also an old trolley station located at 38th Street and Park Avenue and unused subway platforms at Lexington Avenue and 63rd Street, Canal Street, Chambers Street, and 59th Street at Columbus Circle [8].

Figure 13. Unused Subway System [8].

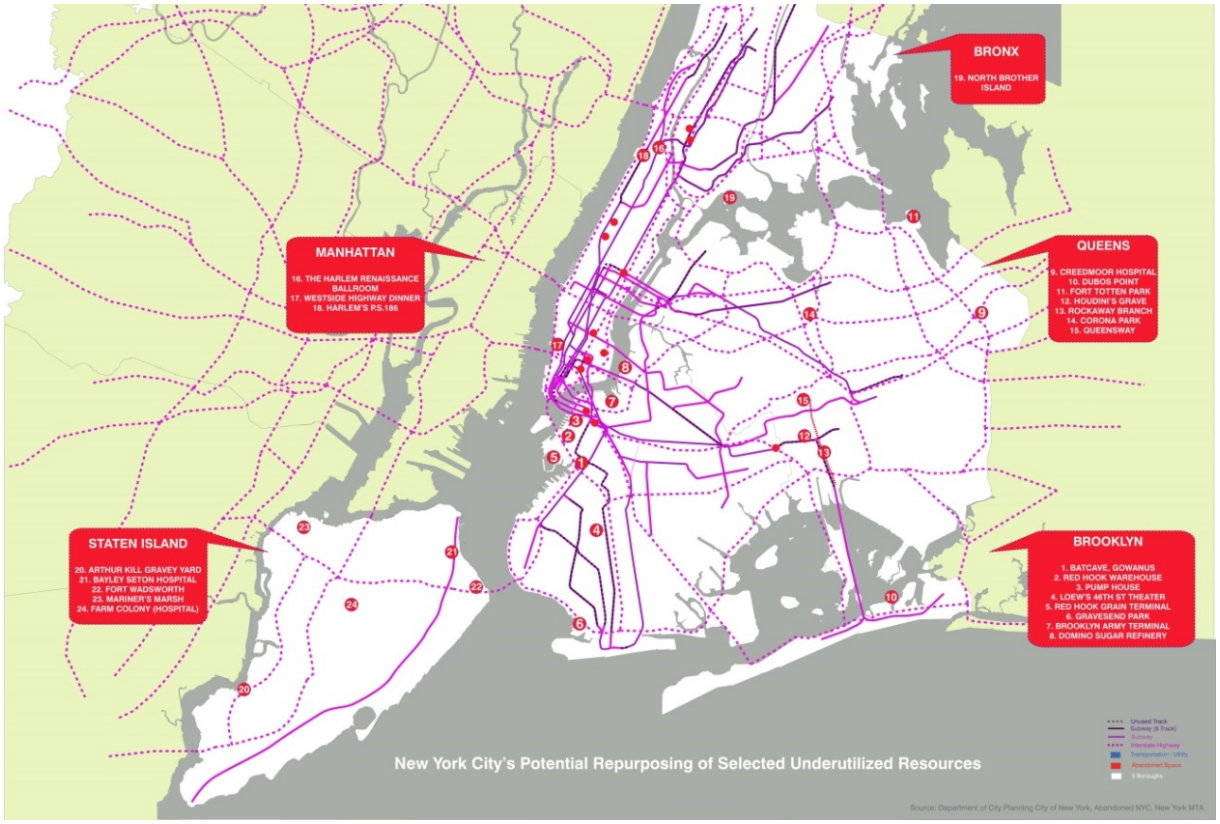


Another abandoned rail line, originally part of the Long Island Railroad's system but unused since 1962, is located in Queens. Called the Queensway, it starts at Queens Boulevard; it then runs near Jamaica Avenue and Liberty Avenue, passing through the borough north to south over 3.5 miles [29]. Currently, 70% of the 900,000 annual visitors to Queens's Forest Park, an ecological restoration project, come by car, as access to it requires crossing dangerous major roads, including Woodhaven Boulevard, the most dangerous street in the borough [29]. With a mixture of grade level and elevated sections, Queensway will make access to this park far more friendly to pedestrians and bicyclists. The Queensway will preserve many of the substantial trees that have grown up around its path during its abandonment. Like the High Line, Queensway has a local community advocacy group called Friends of the Queensway. Like the Low Line, Queensway is scheduled to open in 2018 [29]. These three

projects show the same pattern of local community-based redevelopment. The High Line, Low Line, and Queensway all will provide an economic benefit to local businesses and retail establishments and create recreational opportunities. The City can create multi-layered public space from unused infrastructure including over-and underground and at grade spaces and reactivate underutilized resources. New York City's High Line syndrome can and will happen in other mega-cities, as well.

Other borough's underutilized resources include the Loew's 46th Street Theater and the Red Hook Grain Terminal, both located in Brooklyn. Unused port locations include the Arthur Kill Boat Grave Yard and Fort Wadsworth located in Staten Island. An abandoned island, North Brother Island, is located a few miles from LaGuardia Airport in Bronx County [9]. The location of hospital starting in 1885, it was abandoned in the 1960s. Today, opportunistic ivy floods the old lawns and races up the corners of the dormitories [9]. As most of New York City's abandoned space is near existing infrastructure, because these spaces often had industrial and thus made use of those facilities, their proximity to such facilities could prove a boon for any reutilized purposes, as that usually means that they are relatively accessible. These underutilized spaces, which have had negative effects on their local communities, can now be repurposed to revitalize their local environs. Each New York City borough contains unused buildings, land, and infrastructure. These all have a certain kind of beauty and reflect the history of their locales. The question for each of them is how the city and the communities around them will make new uses for them. They offer opportunities for soft-infrastructure, co-working space, and affordable housing and in some cases such as the wetlands that the border the Gowanus Canal, new or restored wildlife habitats and protection from unfortunate natural events.

Figure 14. New York City's Underutilized Resources



6. Conclusions

Today, 50% of the world's population lives in cities. It has been estimated that by 2050 that figure will be 75% [41]. Some governments have at times instituted policies that encourage movement to suburban areas, but history has shown (as Renzo Piano has indicated in the quote given earlier) that this is not a viable way to reduce over-crowding in urban environments. Instead, cities need to make plans for repurposing underutilized factory spaces, vacant land, and retired infrastructure into affordable housing and public space. In New York City, successful projects that do exactly that have already been completed, and considerable space and infrastructure remain as opportunities for further similar efforts.

The four successful projects outlined above make it clear that, underutilized area can effect big changes for the future of the mega-city. The High, Low Line, Queensway parks utilize elevated, at grade, and underground public space that would not have been included in any earlier calculation of space available for repurposing or development, so future redevelopment and repurposing projects must not overlook the possibilities of unconventional spaces.

In other mega-cities such as Beijing, Seoul, Tokyo, London, and Paris, city development has always started with an industrial revolution, though the timing and period have, of course, been different for each city. These mega-cities' urbanizing pattern has been similar. An industrial revolution needs manufacturing based on mega-infrastructure. During times of mass production, cities need considerable labor resources, and inward migration of local population occurs and, in a least some cases, that also comes with increased immigration.

In many cases throughout the world much underutilized space rests on contaminated sites. Thus, the sequencing for redevelopment starts with remediating any such proposed re-purposed sites. Next, the local community should spearhead the planning for the optimal use of the space. This often includes fundraising and application for and acquisition of government funding for the project. City government must take the next step and make a contextual zoning analysis. Each private developer (or, in the case of government-owned property, the local authorities) needs plans that accommodate public space and affordable housing. Redevelopment works best when issues of environmentally prudent policies for sustainability are included, as seen in the renewable energy use, green infrastructure [30], and flood prevention plans in the New York City projects discussed above.

New York City provides a good template for putting historically underutilized resources to work to create vibrant new spaces. There, many of the underutilized buildings, infrastructure base, and spaces had begun to fall into dis-use or under-use after the decades following the 1950s and 1960s. Often they remained virtually abandoned for long periods, contaminated and contributing to increases in crime and having a negative effect on the local economy. Their rejuvenation began with creative ideas that saw the possibility of new types of space. Other cities would do well to examine their own underutilized areas. By doing so, mega-cities can create a better quality of life for each of their respective communities.

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Conflict of Interest

The authors declare that they have no conflicts of interest.

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