The Reclamation of an Industrial Site and Design Impacts on Environmental, Social, and Economic Resilience

Brooke Shevela1, Jun-Hyun Kim2*, Wonmin Sohn3, and Noah Durst3

1Master of Environmental Design, School of Planning, Design and Construction, Michigan State University, East Lansing 48824, USA
2Associate Professor, School of Planning, Design and Construction, Michigan State University, East Lansing 48824, USA
3Assistant Professor, School of Planning, Design and Construction, Michigan State University, East Lansing 48824, USA

ABSTRACT

Background and objective: The industrial crisis in Michigan, USA calls for the redevelopment of abandoned industrial sites into functioning public spaces. Neglected spaces have negative impacts on the surrounding communities, promoting aesthetic, safety, economic, and environmental issues. The purpose of this study was to explore and discuss the possible redevelopment of an underused site, with particular focus on its industrial site elements; quantitative measures were then applied to determine redevelopment’s effects on the nearby community.

Methods: The Michigan Central Station in Detroit, Michigan, USA was selected as a case study. Landscape performance research methods were applied to quantitatively analyze the environmental, social, and economic benefits of reclaiming this abandoned industrial site and its various elements.

Results: The findings show that implementing the case study redesign would result in positive environmental impacts. These impacts include expanded areas of ecologically valuable land, a reduction in sulfur dioxide, and increases in carbon sequestration, retained stormwater, and the use of recycled contents. The case study redevelopment project would impact the surrounding economic context through savings on water treatment costs obtained from the use of retained stormwater, increased property values, and job creation. Furthermore, the redesign would also impact social aspects by increasing the available gathering spaces and public open areas and enhancing safety by adding sidewalks and bike lanes.

Conclusion: The findings of this study will help designers and planners recognize the value of reusing existing industrial sites instead of undertaking harmful demolition processes, eventually leading to more sustainable community designs.

Keywords: urban revitalization, landscape performance, urban design, urban regeneration, vacant land

Introduction

The UN (2012) has predicted that the urban population will double between 2011 and 2050, and cities will grow 2.5 times in area by 2030 (Angel et al., 2005). These trends project an immense quantity of urban expansion worldwide and intense demand for developable urban land on city outskirts, leaving inner cities dilapidated and a draw on public resources. Consequently, urban expansion could contribute to increased urban vacancies (Newman et al., 2016). Unoccupied urban areas have become a significant topic of interest in the United States, most notably in the Rust Belt, including Michigan, Illinois, Indiana, New Jersey, New York, Ohio, Pennsylvania, and West Virginia, all states with large industrial areas (Gu et al., 2019). According to Gabbianelli (2012), abandoned industrial structures, though previously useful, have become problematic due to their lack of social or economic function. Abandoned industrial areas may still...
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retain much of their past operating systems. These elements, once abandoned, can damage the natural environment. Such spaces generate aesthetic, safety, economic, and environmental issues for those living nearby (Gabbianelli, 2012). Property values near such abandoned spaces can also be negatively impacted, due to the perception of neglected spaces as being unsafe and undesirable.

Previous studies have documented the trend of declining cities and described how redeveloping these areas is one of the most effective ways to combat vacancy. Newman et al. (2016) explained that the severe depopulation of urban areas has become a popular topic recently, bringing into use the phrase "shrinking cities" (Newman et al., 2016). According to Oswalt and Rieniets (2007), cities such as Cleveland, Ohio and Detroit, Michigan are seen as prime examples of such shrinkage (Oswalt and Rieniets, 2007). Detroit is a widespread city with many abandoned lots at the outer edges of useable development. As a decaying city, Detroit faces ever-increasing issues related to urban vacancy. According to Bluestone (2013), the population loss is mostly due to the deindustrialization of the inner city, where factories used to be located. There are numerous social issues in Detroit, as well as many other cities around the world. These include population decline, crime, poverty, and an adverse economic climate.

To find solutions to urban vacancy issues, it is essential to develop comprehensive land use plans and redevelop declining cities. With regards to improving public spaces, Piemontese (2008) explained that redevelopment projects can generate design strength through the incorporation of past site materials, industrial features, and existing plants. This process connects the present to the past while changing the landscape in ways that mend the relationships among its various components (Piemontese, 2008). The redevelopment of brownfield sites can have a positive effect on public perceptions of crime, safety, and walkability. In describing green infrastructure, Garcia-Mayor et al. (2020) referred to "eco-corridors," which are ecological frameworks for environmental, social, and economic health (Garcia-Mayor et al., 2020).

Michigan's crisis demands the redevelopment and reuse of neglected industrial sites. Gaps in past research on this topic include a dearth of studies specific to Michigan that involve the quantitative analysis of social, environmental, and economic aspects of industrial redevelopment of abandoned areas. The purpose of the present research is first to examine the issues and challenges of urban vacancy, with a specific focus on abandoned industrial areas. There are a number of negative issues associated with urban vacancy, including decreased safety, a lack of education, vandalism, dissatisfaction, poor visual quality, and reduced health. Another purpose of this research is to develop a comprehensive master plan for a particular abandoned industrial site, which serves as a case study: Michigan Central Station and the adjacent Roosevelt Park in Detroit, MI, USA. Lastly, this research quantifies the design impact, based on the principle of landscape performance research (LPR). The ultimate goal is enhancement of the environmental, social, and economic benefits of the site in an effective manner. By quantifying the design benefits, this research provides a useful alternative design and planning guideline that will help reduce urban vacancy and industrial abandonment while creating safer and more unique public spaces for people of all ages.

Research Methods

Study area

The study area for this research is the Michigan Central Station in Detroit, Michigan, USA. Approximately 420 houses surround the project area within a quarter-mile radius (Fig. 1). The site serves as a connection to a lively stretch of waterfront along the Detroit River. After renovation, the site will link to existing bike lanes and trails, providing key access to surrounding neighborhoods that otherwise would lack connection to waterfront parks and activities. There are also many surrounding landmarks, including museums, casinos, and theatres.

The abandoned Michigan Central Station provides both opportunities and challenges for redesign as the study area of this research (Fig. 2). It features unused elevated railbeds and a single operating rail. The empty 15-story station building is 46,451 square meters in size and sits in front of the elevated rail beds. The site presently features a public greenspace called Roosevelt Park. Combining the station
Fig. 1. Area surrounding the study site.

(a) Station building (front)   (b) Roosevelt Park entrance (front of building)
(c) Single remaining operating railroad (back of building)   (d) Main road passing underneath the elevated rail beds

Fig. 2. Site photos.
with the attached Roosevelt Park, the design site is over 6.9 hectares in size. The elevated railbeds stretch above 16th Avenue at the southern end of the site. These are made up primarily of rail resting beds and one functioning rail, which is located furthest away from the core of site (Michigan Central Station, 2021). With so much onsite infrastructure and history, the site plan needed to consider the reuse of certain industrial elements. The slope is relatively insignificant, around 0.5%. Since the site is fairly flat, there were no major water issues to combat. Still, the site could benefit from water management by capturing the rainfall volume and recycling the water for onsite irrigation. Incorporation of this into the design would yield economic benefits because no additional irrigation would be required, thus reducing overall maintenance costs. The soil conditions, wildlife, and vegetation are typical of the Detroit region; sandy loam soil makes up the majority of the park space. Mixed urban concrete provides the remainder, due to the large elevated railbeds towards the south. The vegetation includes maple, black walnut, and oak trees. The historical elements already draw visitors, but the abandoned features make the area dangerous. Thus, when designing the study area, it was important to ensure that the new design benefited the general public by evaluating and responding to the social and economic needs of the surrounding area.

The proposed design focused on developing a plan to combat such social and economic issues and enhance the area's environmental quality. It also endeavored to integrate existing elements. For instance, in the design, the elevated railways serve as a raised pedestrian walkway to connect site elements. Also, the abandoned resting beds serve as a garden container for native Michigan plants and screens.

**Landscape performance research measurement**

LPR was applied in the present study, as it has been in numerous past works (Yang et al., 2020). LPR is a widely accepted analytical tool used to measure the impacts of landscape design and planning projects. It focuses on three main aspects: environmental, social, and economic benefits. The Landscape Architecture Foundation (LAF) provides LPR results for a number of past construction projects and the associated benefits, which can be used as evidence of possible future project success (LAF, 2021). LPR helps with examining specific design features of a project site and determining how they individually impact the local area. According to Yang et al. (2020), LPR is widely accepted as a means of demonstrating how aspects of a design can affect the nearby environment (Yang et al., 2020). To analyze the influence of the proposed design solution on the project area and surrounding environment, this study selected a series of landscape metrics focusing on three main categories: environmental, social, and economic benefits (Table 1) (LAF, 2021).

| Metric |
|---|
| Area of critical habitat or ecologically valuable land created |
| Carbon sequestered |
| Stormwater retained |
| Content recycled |
| Sulfur dioxide absorbed |

| Variable |
|---|
| Additional critical habitat or preserved ecological land created through design |
| Amount of carbon dioxide reduced as estimated from tree species, DBH (in centimeters), and land use and height |
| Percent of wet days retained |
| Abandoned elevated rail bed space reused |
| Amount of sulfur dioxide air pollution absorbed |

| Unit |
|---|
| Hectares |
| Tons per year |
| % |
| Centimeters per year |
| Kilograms |
| Kilograms per year |

| Metric |
|---|
| Annual cost saved from irrigating site with infiltrated water |
| Property values improved |
| Jobs created |

| Variable |
|---|
| Amount of water infiltrated converted on site into a monetary value using local city water bill rate |
| Property values increased |
| Number of jobs created per businesses proposed in the design |

| Unit |
|---|
| $ per cubic meter |
| $ per month |
| # of jobs created |
Results and Discussion

Design programs and master plan

The main design goals of this project were: 1) improving safety and social aspects, 2) fostering economic growth, and 3) enhancing environmental resilience. To achieve each goal, this study established detailed design programs (Fig. 3). For safety improvement, issues were resolved by redesigning the abandoned industrial elements. The design featured an extensive amount of open greenspace, providing areas for field sports, picnics, and other outdoor activities for children. The redesign also sectioned off forested areas to offer scenery, deliver environmental benefits, and provide habitat space. Changes would offer shade and climate mitigation for the southern end of the site. Gardens were placed throughout the redevelopment design as an aesthetic and environmental benefit. If adopted, many of the planted areas would also feature local artwork and bench seats. The old Detroit and Canada railroads were used as a concept for the sidewalk paths weaving through the site. A raingarden was added to the middle of the entrance drive lanes to help infiltrate water. The redesign of the abandoned elevated railbeds would provide the site with

Table 1. (continued)

| Metric                              | Variable                                                                 | Unit       |
|-------------------------------------|--------------------------------------------------------------------------|------------|
| Social benefits                     |                                                                          |            |
| Area of proposed gathering space    | Visitor capacity: Space for each guest (square meters per person)         | Maximum number of visitors |
| Safety enhanced                     | Number of pedestrian crosswalks added                                   | Each       |
| New sidewalks                       | Length of new sidewalks added                                           | Linear meters |
| New bike lanes                      | Length of new bike lanes added                                          | Linear meters |
| Event gathering space added         | Number of community event gathering spaces added                        | Square meters |
| Open recreational space added       | Amount of recreational space added                                      | Square meters |

Note. Sources: EPA National Stormwater Calculator; iTree Calculator; Pathfinder.
up to 30 new business locations designed to be beneath the railbed structure. This would act as an open marketplace for local commerce on the lower street section of the site. Using the old railbeds as a base concept, the elevated railbeds could be converted into a park space with moveable and unmovable planted components, play features, greenspaces, and event areas. Event locations could be created by reorganizing the moveable compartments to the west to provide extra space for a concert stage or other types of large gatherings. The elevated railbeds were designed to be ADA accessible through a ramp section underneath the center of the railbeds. In the redesign, ramps would stretch on both sides of a large tree serving as a focal point, planted such that the top half would be above the elevated railbeds.

The abandoned elevated railbeds would feature both moveable and non-moveable compartments. The individual compartments were designed to include moveable bench seating, patio table seating, adult and children play areas, and planted zones. The moveable elements are important because of the concert space alongside them. When a gathering or event would take place, they could be shifted to the west to provide space for stacked seating.

**Design impact and landscape performance results**

*Environmental Benefits:* Different variables were selected to test the environmental benefits, including: habitat creation, carbon sequestration, stormwater retention, waste recycling, and sulfur dioxide reduction (Table 2). By incorporating a number of plantings, the design proposal resulted in a significant increase in areas deemed ecologically valuable. There was a 624% increase in the planted valuable land; this was determined by comparing existing square meters (1,658 m²) to those proposed (12,002 m²). The new design predicted 4.9 tons of carbon sequestered on site. Compared to the .32 tons currently being sequestered, this would mean a 1,427% increase in carbon sequestered per year. Using the National Stormwater Calculator (EPA), estimations indicate that there would be a 37% increase in wet days retained, as well as a 14% decrease in the amount of average annual runoff volume. The proposed site design would retain 30,985,056 liters of water annually, largely due to the addition of the onsite rain garden in the middle of the north entrance lanes. The water retained would be used as irrigation for the site's landscape. The recycled content variable was also employed to evaluate the design's reuse of the elevated iron rail track. The Recycled Content Tool determined that 87,919.8 kilograms of recycled iron rail track would be used in the redesign (Fig. 4). Lastly, sulfur dioxide would be reduced by 1,400% through tree plantings, as shown by the iTree planting calculator.

**Economic Benefits:** This study investigated the economic benefits of the redesign of the station project site via selected variables, with a focus on the annual cost savings from the stormwater retained, improvement in property values, and creation of jobs (Table 3). The water volume retained onsite through plantings would be used as irrigation for the site landscaping. This would offer economic savings because the site would require less water for irrigation, and therefore lower overall maintenance and labor costs. In
studying the annual cost savings from using the stormwater retained on site, it was necessary to find Detroit's water volume rate. According to the City of Detroit Water and Sewage Department, the rate is $25.20 per 28.3 cubic meters. There are currently 30,985 cubic meters of water infiltrated on site annually through plantings, saving $27,574.49 each year from water that would otherwise need to be treated. When looking at how the surrounding area would be affected, it was important to understand how adding a park space can affect nearby property values. According to Caston (2018), parks at a similar scale to the Michigan Central Station site are known to greatly increase the property values of nearby homes, ranging from 8% to 20% (Caston, 2018). Thus, the redesign would help to increase overall property values of Corktown and Mexicantown and stimulate economic growth in the area.

In addition, the redevelopment of Michigan Central Station's elevated railbeds would yield 30 new businesses. In the design, these businesses were afforded 6 meters of storefront and 15.2 meters of store depth. This totaled 92.9 square meters for each of the new businesses. According to Kleiman (2012), stores employ an average of nine people, generally ranging from four to 36. Based on the size of the retail space proposed in this case study, the design would provide a minimum of four jobs per business. With 30 new businesses at four employees each, this would add a minimum of 120 new jobs to the community (Fig. 5).

Social Benefits: This study selected several variables to assess the social benefits of the redesign of the station project site, including the capacity and space for each guest, safety enhancements, new sidewalks, bike lane additions, public gathering spaces, and open recreational spaces (Table 4). In studying the proposed capacity space added, it was determined that there would be .92 square meters per person. The proposed site design allowed for a total capacity of 86,017 on site (Fig. 6). For safety enhancements, five crosswalks were added to the design to provide easy walking and biking access throughout. This would be a 43% increase, based on the existing linear meters of available sidewalk (1,981 m) and proposed 2,841 meters. There are no bike lanes on the existing site; the new site design adds 499 linear meters. The public gathering space would increase by 138%, from the 33,639 square meters existing to the 79,913 square meters proposed. Lastly, the open

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**Table 3. Economic benefits**

| Metric                                      | Unit         | Existing value                                      | Projected value                                      |
|---------------------------------------------|--------------|-----------------------------------------------------|------------------------------------------------------|
| Low impact development and annual cost savings from irrigating the site with infiltrating water | $ / cubic meters | $0.00 / year in cost savings because there is currently no maintenance of the abandoned site. | $27,574.49 / year in annual cost savings from stormwater retained on site. |
| Property values                             | $ / month    | N/A                                                 | 8% to 20% increase in nearby property values and 120 jobs created. |
| Job creation                                | Number of jobs created | 0 jobs                                           |                                                      |

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Fig. 4. Proposed rail track and open space.

Fig. 5. Redeveloped elevated railbeds and proposed storefronts.
recreational space would increase from the existing 33,639 square meters to the proposed 64,656 square meters, a 92% increase.

### Conclusion

Urban vacancies are increasing rapidly in cities such as Detroit. There are many reasons that such vacancies occur, including a decrease in available jobs, deindustrialization, and suburban sprawl (Kremer et al., 2013). Designers have easy access to a multitude of decaying sites, and it is crucial that they focus on the importance of their redevelopment to stop urban sprawl. It is essential to address these areas and provide case study examples that showcase the benefits of redeveloping outdoor environments while also preserving the history of such sites.

The goal of this study was to examine the redevelopment of an underused site, with a special focus on the site's industrial elements and the effects such redevelopment would have on the adjacent community. The proposed masterplan shows a balance of environmental improvements and social and economic benefits. Increasing the number of plantings, reusing materials, and improving stormwater retention will benefit the air quality and overall environment of the site. The addition of public art, games, open spaces, and safety features will benefit the local community by offering diverse outdoor opportunities. Bike lanes and sidewalks will improve accessibility to adjacent neighborhoods' existing bike networks and offer a connection to the downtown waterfront district. By adding storefronts under elevated railbeds, there will be new opportunities for local economic growth and job creation. Overall, the redevelopment of the currently abandoned urban site would feature Detroit's history, and the plan serves as an important case study showcasing the benefits of reuse versus demolition.

Based on the scientifically established conclusion that redevelopment of the abandoned industrial site will have a positive effect on the social, environmental, and economic conditions of nearby communities, this research ultimately reveals the value of redeveloping abandoned industrial sites. Focusing on these three aspects shows the wide range of benefits of reusing site elements versus turning directly to demolition. The use of LPR also underscores the benefits of stormwater management, improved air quality, and increased amount of ecologically valuable space. In terms of social aspects, this research determined that turning these abandoned areas into greenways, bike lanes, and pedestrian

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**Table 4. Social benefits**

| Metric                                | Unit                  | Existing Value                                                                 | Projected Value                                                                 |
|---------------------------------------|-----------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| Area of proposed gathering space      | maximum number of visitors | 36,208 total site capacity, based on .92 square meters per person | 86,017 total site capacity, based on .92 square meters per person |
| Safety enhancements                   | NA                    | 0 functioning crosswalks                                                       | 5 newly added crosswalks                                                        |
| New sidewalks                         | linear meters         | 1,981.8 linear meters of sidewalks                                             | 43% increase in sidewalk length and 2,841.6 linear meters of total sidewalks    |
| New bike lanes                        | linear meters         | 0 bike lanes                                                                   | Bike lanes increased by 499.5 linear meters                                     |
| Event gathering space                 | square meters         | 15,256.8 square meters of gathering space                                      | 64,656.3 square meters, a 138% increase in community event gathering spaces.   |
| Open recreational space               | square meters         | 23,882.1 square meters of open / recreational space                             | 88,538.5 square meters, a 92% increase in open / recreational space             |

**Fig. 6. Event spaces on elevated railbeds.**
paths will also provide a more positive perception of onsite safety. As stated above, relevant studies have supported the notion that the redevelopment of abandoned site elements increases the public’s perception of the area’s safety, and similar effects can be hypothesized for the current case study. Lastly, the economics of redevelopment were analyzed, starting with a map of the surrounding properties, illustrating the number of properties that would be positively impacted and allowing for a comparison of property values for similar properties in the context of accessibility to the new project. Past research regarding greenways, bike lanes and trails, and property values has shown that there is a beneficial effect on property values from adding comparable public parks. The research conducted here is an important step towards realizing the benefits of reusing abandoned sites.

The limitations of this research include the plantings chosen for the redeveloped site. Plants have to be individually analyzed due to differences in plant zones, characteristics, and local needs. For this study, the plantings selected were common to the plant zone of southeastern Michigan. Expense support that could not be obtained for this research may be another limitation. It is important to note that every abandoned urban industrial site will have different needs and unique attributes to consider. The results of this study are subject to site-specific conditions. Therefore, the generalization of this research’s findings to other projects should be limited. Finally, although this study has adopted diverse landscape metrics to evaluate benefits of the final design proposal, the results from landscape performance were still hypothetical values without implementing the design proposal to the real-world setting.

This study will potentially impact future design projects for abandoned industrial sites in urban settings. It provides important insights useful in designers’ decision-making related to redevelopment versus demolition. There may also be a cost incentive for local governments resulting from increased property values and decreased environmental hazards such as flooding. This research also promotes the quantification of design impacts in future research. This redeveloped site can also provide inspiration for similar projects and act as a malleable guidebook. Increasing this type of redevelopment will contribute to building better urban communities and an outdoor lifestyle.

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