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Spatial Decision Support Systems for Sustainable Urban Redevelopment

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SPATIAL DECISION SUPPORT SYSTEMS FOR SUSTAINABLE URBAN
REDEVELOPMENT

A DISSERTATION

Submitted to the Faculty of
Montclair State University in partial fulfillment
of the requirements
for the degree of Doctor of Philosophy

by

AMY V. JOHNSON-FERDINAND

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2015

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MONTCLAIR STATE UNIVERSITY

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SPATIAL DECISION SUPPORT SYSTEMS FOR
SUSTAINABLE URBAN REDEVELOPMENT

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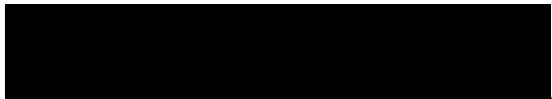
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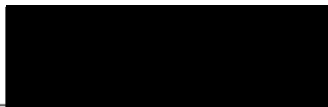
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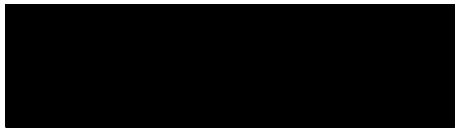
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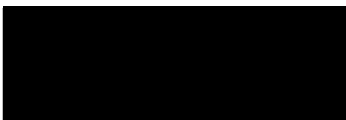
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ABSTRACT

SPATIAL DECISION SUPPORT SYSTEMS FOR SUSTAINABLE URBAN
REDEVELOPMENT

by Amy V. Johnson-Ferdinand

A recent United Nations study concludes that worldwide population will grow from approximately 7 billion today to 9.3 billion in 2050 and 10.1 billion in 2100. Nowhere is this population growth more evident than in the major cities of the world. For the first time in history, a majority of the world's people lived in cities. In 1950, by comparison, less than 30% of the world's population dwelled in cities. This rapid growth of population, coupled with an aging infrastructure, and the abandoning of urban manufacturing sites, creates an urgent need for inner city revitalization. There are several urban areas especially at risk. They include cities with high concentrations of derelict properties and vulnerable populations that are located within the urban core. Others include sites that are in proximity to urban industrial riverfronts. These sites are collectively known as Brownfields. Also included are sites, including Public Complexes (e.g. large publicly owned campuses such as colleges, universities, prisons, and hospital centers), with an expansive campus footprint, "where storm water runoff occurs instead of soaking into the ground" (Rutgers, 2014). As global population continues to increase in these areas, researchers are investigating new techniques that promote economic growth and sustainable development, while minimizing the environmental, social, and economic impacts of urban sprawl. One such technique is building green buildings on

these Brownfield Sites. The present study investigates whether a prescriptive approach to urban development, the third party rating system, coupled with a Business Intelligence Dashboard, as a data visualization tool to display the status of redevelopment, can provide feasible and intuitive integration of data in which to prioritize redevelopment. The study presents a new framework and key sustainability indicators, based on existing third party rating systems, to prioritize redevelopment. It introduces these assessments into a Spatial Decision Support System, utilizing a dashboard as an interactive tool to gather and consolidate data and to present an evaluative means for decision-makers. The tool allows identification of the highest priority sites for long-term and short-term redevelopment of distressed properties. The aim of the research is to advance knowledge for new concepts for sustainable urban redevelopment projects using decision frameworks for selection among alternative Brownfield redevelopment projects. The study indicates that the third party rating system, coupled with dashboards, is an effective decision support tool that facilitates efficient decision-making.

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ABBREVIATIONS

GIS	Geographic Information System/Science
LEED	Leadership in Energy and Environmental Design
LEED-ND	Leadership in Energy and Environmental Design for Neighborhood Development
PV	Photovoltaic/Solar Panels
RS	Remote Sensing imaging
SLL	Smart Location & Linkage LEED criteria
USGBC	United State Green Building Council

CHAPTER 1

1. Introduction

The prioritization of urban redevelopment to achieve sustainable neighborhood revitalization has received considerable attention. Due to an aging infrastructure, an abandoning of inner city manufacturing sites, and increasing population growth, our cities are at risk and are in need of redevelopment (Sardinha, Craveiro, & Milheiras, 2013; Suzuki, Cervero, & Iuchi, 2013) (Gough & Accordino, 2013) (Blanc, 2013; Rohloff, 2013). There are several areas especially at risk. The first areas at risk are cities with high concentrations of derelict properties that are located within the urban core (Doyle, 2013). The second areas at risk are Public Complexes and sites located on known Historic Fill, abandoned mills, quarries, and landfills (Bilodeau, Podger, & Abd-El-Aziz, 2014). The third are sites that are in proximity to urban industrial riverfronts (Meadows, Meadows, Randers, & Behrens III, 1972; Wrenn, 1983), or as they are collectively called by the United States Department of Environmental Protection Agency (USEPA): Brownfields (USEPA, 2013).

Brownfields, under the Brownfields Act of 1998, (USEPA, 2013) are real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant. Cleaning up and reinvesting in these properties protects the environment, reduces blight, and takes development pressures off greenspaces and working lands. The Superfund (i.e., Superfund Act) (USEPA, 2014) is the name given to the environmental program

established to address abandoned hazardous waste sites (Superfund sites). According to the Environmental Protection Agency, (USEPA, 2003), “Brownfields differ from Superfund sites in the degree of contamination. Superfund sites pose a real threat to human health and/or the environment. Brownfields are not enough of a serious health or environmental threat to warrant cleanup under the Federal Superfund program. Instead, they represent a local economic or social threat, since they prevent development and therefore, stifle local economies”. As global population continues to increase in these affected areas, researchers are investigating new techniques that promote economic growth and sustainable development, while minimizing the environmental, social, and economic impacts of urban sprawl. One such technique is building green buildings on Brownfield Sites utilizing third party assessments to prioritize redevelopment.

Many well-known third party assessment tool sets were developed internationally such as the International Initiative for a Sustainable Built Environmental Rating System and Sustainable Building Tool (iiSBE, SBTool 07) in Canada, the Building Research Establishment Environmental Assessment Method (BREEAM) Communities in England, and the Comprehensive Assessment System for Built Environment Efficiency (CASBEE) in Japan. Several of these organizations and professional groups offer sustainable development solutions to builders and developers. One such group, the U.S. Green Building Council (USGBC), now includes Green Infrastructure in its latest neighborhood revitalization system, which is sure to affect the future of sustainable development.

This paper focuses on the USGBC Leadership in Energy and Environmental Design,

(LEED) process, which involves tracking projects from design through construction to final certification of occupancy. It also reviews strategies used to determine the feasibility of implementing these standards. The goal of the study was to identify those real estate parcels that met all five of LEED-ND Smart Location and Linkage Prerequisite (SLLp) points and are, therefore, eligible for development under the remaining LEED- ND standards for urban design and green construction. LEED-ND Smart Location and Linkage encourages communities to consider location, transportation alternatives, and preservation of sensitive lands, while also discouraging sprawl (Talen et al., 2013).

The study investigates whether a prescriptive approach to urban development, the third party rating system, coupled with a Business Intelligence Dashboard, as a data visualization tool to display the status of redevelopment, can provide feasible and intuitive integration of data in which to prioritize redevelopment (Dempsey, Bramley, Power, & Brown, 2011; Sweet et al., 2014). A new framework and new key sustainability indicators are presented, based on existing third party rating systems to prioritize redevelopment (Alyami & Rezgui, 2012; Ayala, Hauge, Conradi, Franch, & Li, 2011).

The modeling tool used in the study is similar to ones adapted to model urban residential development (Balmori & Benoit, 2007), and introduces these assessments into a Spatial Decision Support System, utilizing a dashboard as an interactive tool to gather and consolidate data and to present an evaluative means for decision-makers. The tool allows identification of the highest priority sites for long-term and short-term redevelopment of properties. The results of the study indicate that the third party rating

system, when coupled with dashboards, is an effective decision support tool that facilitates efficient decision-making. Online dashboards are used effectively as interactive tools to gather and consolidate information in the business arena (Dagan, 2007). These tools include charts and graphs, which provide stakeholders with a means to visualize and prioritize business and economic decisions (Adam & Pomerol, 2008; Cloutier, Turmel, & Lavoie-Boulianne, 2000; Erickcek, 2012).

Development indicators and indices used to evaluate urban redevelopment in these and other studies include a decrease in the crime rate (Carroll & Eger III, 2006), with a subsequent increase in “quality of life” measures (Williams, Galster, & Verma, 2014). Indicators also include an increase in construction activities (new homes, businesses, or mixed use) and new jobs created (especially for current occupants); an increase in property values with limited displacement of current occupants (non-gentrification environmental justice issues) (Lorenc et al., 2013; Myhre et al., 2013; Petrov, Shahumyan, Williams, & Convery, 2013; Tatham, Eisenberg, & Linkov, 2014).

Other indicators identified by Bacot and O’Dell (2006) include changes in property values associated with Brownfield redevelopment, public investments associated with increased brownfield redevelopment, private investments associated with increased brownfield redevelopment, environmental improvements associated with increased property values,; public investments associated with environmental improvements; and private investments associated with environmental improvements.

A case study is included of sustainability and sustainable development indicators

designed for institutions of higher education (Djordjevic & Cotton, 2011; Lozano, Lukman, Lozano, Huisingh, & Lambrechts, 2013; Stewart, 2010; Wright, 2010; Yuan & Zuo, 2013)

1.1 Research Objectives

The problem of deciding how to prioritize urban redevelopment projects, and Brownfields in particular, to achieve holistic and sustainable urban redevelopment has received considerable attention in recent years. The aim of the research is to develop a framework for a spatial decision support system for sustainable development, allowing key decision makers (e.g. federal and state government agencies as well as local community development leaders) to prioritize the allocation of scarce resources.

Set against the background of Brownfields and sustainable urban redevelopment, the central research question is how can social, environmental, and economic assessments of Brownfield properties be analyzed and visualized via dashboards designed to inform sustainable neighborhood redevelopment and urban planning in terms of prioritization? How can the application of third party rating systems such as LEED for Neighbor Development **reduce urban sprawl? Is a** decision support tool such as an Executive Dashboard capable of assessing Brownfield redevelop via third party rating systems? Can and executive dashboard bridge the gap between best environmental management practice and science? These questions are explored using a case study approach applying third party rating systems as well as dashboards.

The first objective of the study was to investigate whether the outcomes from one

prescriptive approach to redevelopment, the third party rating system, coupled with the expected outcomes and priorities of the Brownfields Act, can be used to prioritize Brownfield redevelopment. Spatial analysis is used to determine if LEED for Neighborhood Development, or a similar process, is a viable strategy for holistic and sustainable urban and industrial riverfront neighborhood redevelopment. The study presents a site allocation and selection model within a suitable framework to facilitate the decisions for accessing and choosing between redevelopment alternatives. It includes an improved urban Brownfield redevelopment assessment, via multiple rating systems, simulation, visualization, and spatial analysis, to facilitate the decision-making process. The study utilizes an online dashboard, designed as an interactive tool, to gather and consolidate information on environmental, social, economic, and political data. The study questions the relationship between indicators used to evaluate third party rating systems and Brownfields redevelopment. It asks if third party rating systems, coupled with the expected outcomes and priorities of the Brownfields Act, as well as Spatial Analysis, can be used to prioritize Brownfields Development issues and enable decision-makers to make informed assessments at the national, regional, and local level.

1.2 Organization of Thesis

- **Chapter 2**, titled “Sustainable Urban Redevelopment: Assessing the Impact of Third Party Rating Systems”, presents a case study that investigates whether third party rating systems, together with a Business Intelligence Dashboards, can provide feasible and intuitive integration of data with which to prioritize redevelopment at the municipal level. The study introduces key sustainability

indicators based on existing third party rating systems to prioritize redevelopment. These assessments are introduced into a Spatial Decision Support System, utilizing a dashboard as an interactive tool to gather and consolidate data and to identify the highest priority sites for long-term and short-term redevelopment of properties in Paterson, New Jersey.

- **Chapter 3**, titled “Assessing the Impact of Third Party Rating Systems on Sustainable Development at the County Scale”, expands the Spatial Decision Support tool to prioritize redevelopment at the county (e.g. regional) level. The dashboard was designed as an interactive tool, to gather and consolidate information on environmental, social, economic, and political data, in simple graphical formats such as charts, graphs, and maps, and provide stakeholders with a means to visualize and prioritize Brownfields redevelopment, from initial assessment and identification, to its beneficial reuse. The result of this endeavor provides an analysis of what different strategies mean for Passaic County, New Jersey’s ability to prioritize the Brownfield redevelopment that occurs in their area, and how third party rating systems aid in such an undertaking. This model can be scaled up, or down, to enable decision-makers to make informed assessments at the national, regional, or local level.
- **Chapter 4**, titled “Decision-Support Models and Tools for More Sustainable Societies: Prioritizing Sustainable Development Projects for Public Complexes”, presents factors that support the development of tools for the prioritization of redevelopment projects at the campus level. We present a Return on Investment

(ROI) type example of a solar installation project to illustrate how a GIS/Remote Sensing based Executive Dashboard could improve a decision support model informed by third party rating systems, stakeholder input, and spatial data analysis. These are important elements of the tool-kit for implementing assessment for more sustainable societies.

- **Chapter 5** presents the Environmental Management implications of the study. It also discusses the limitations and constraints of the work presented. Appendix A gives an overview of project reports that document the implementation of the research work into spatial decision support systems for sustainable urban redevelopment.

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CHAPTER 2

Sustainable Urban Redevelopment: Assessing the Impact of Third Party Rating Systems at the Municipal Level

[A portion of the chapter was submitted to the Journal of Urban Planning & Development
(2014)]

Abstract

The prioritization of urban redevelopment to achieve sustainable neighborhood revitalization has received considerable attention. This study investigates whether a prescriptive approach to urban development, the third party rating system, coupled with a Business Intelligence Dashboard, as a data visualization tool to display the status of redevelopment, can provide feasible and intuitive integration of data in which to prioritize redevelopment. The study presents a new framework and key sustainability indicators based on existing third party rating systems to prioritize redevelopment. It introduces these assessments into a Spatial Decision Support System, utilizing a dashboard as an interactive tool to gather and consolidate data and to present an evaluative means for decision-makers. The tool allows identification of the highest priority sites for long-term and short-term redevelopment of properties in Paterson, New Jersey. The study shows that Paterson is losing two hundred fifteen million dollars a year in potential tax revenue, due to Brownfields and abandoned properties. Our study indicates that the third party rating system, coupled with dashboards, is an effective decision support tool that facilitates efficient decision-making.

2. Introduction

The United Nations estimates that worldwide population will grow from approximately 7 billion today to 9.3 billion in 2050 and 10.1 billion in 2100 (Lee, 2011). Nowhere is this population growth more evident than in the major cities of the world. According to Jack Goldstone (2010), in 2010, for the first time in history a majority of the world's people lived in cities. In 1950, by comparison, less than 30% of the world's population dwelled in cities.

This rapid growth of population, coupled with aging infrastructure, and the abandoning of urban manufacturing sites, generates a dire need for urban redevelopment. Several areas are especially at risk. The first are cities with high concentrations of derelict properties that are located within the urban core. The second areas at risk are sites in suburban areas located on known Historic Fill. The third are sites that are in proximity to urban industrial river fronts (Meadows, Meadows, Randers, & Behrens III, 1972; Wrenn, 1983), or as they are collectively called - Brownfield Sites (USEPA, 2013). As global population continues to increase in their areas, researchers are investigating new techniques that promote economic growth and sustainable development, while minimizing the environmental, social, and economic impacts of urban sprawl. One such technique is building green buildings on Brownfield Sites.

Brownfields are abandoned or underutilized industrial and commercial properties where redevelopment or expansion may be complicated by possible environmental contamination, whether real or perceived (NJDEP, 2013; USEPA, 2013). Research

estimates that there are between five hundred thousand and one million Brownfields in the United States (M. R. Greenberg & Issa, 2005; Simons, 1998). Locating green buildings on those sites seems to be a sustainable and welcoming approach to both revitalize the cities and cope with increasing demands for land and properties. To accomplish this goal, the EPA (2013), “empowers states, communities, and other stakeholders in economic development to work together in a timely manner to prevent, assess, safely clean-up, and sustainably reuse Brownfields”.

Research indicates that successful Brownfield remediation has a positive effect on neighborhood redevelopment by job creation, housing (Adams & Watkins, 2002; M. Greenberg, Craighill, Mayer, Zukin, & Wells, 2001) and improved transportation and infrastructure (Amekudzi & Fomunung, 2004; Brennan et al., 2012). According to Litt, Tran, and Burke (2002), once a Brownfield’s environmental, health, and safety hazards have been identified and remediated the challenge becomes how to galvanize action across the public and private sectors to return them to productive use, curb sprawling development outside urban areas, and reinvigorate urban communities.

When the Brownfields Act was enacted, however, there were no uniform standards for measuring its positive impact. Therefore, there is a lack of research on redevelopment of Brownfields as a key to sustainable neighborhood redevelopment. Moreover, what are lacking for sustainable urban Brownfield redevelopment are tools that can incorporate the positive effects of Brownfield remediation and facilitate strategic decision-making.

In this regard, the study attempts to investigate whether a prescriptive approach

to redevelopment, the third party rating system, such as the U.S. Green Building Council (USGBC) Leadership in Energy and Environmental Design for Neighborhood Development (LEED-ND), can provide essential information for urban Brownfield redevelopment prioritization and spur urban Brownfield redevelopment in the most effective and possibly most sustainable way.

Prioritizing *Urban Brownfield Redevelopment*

The third party rating system for urban communities has become an increasingly popular decision support tool in recent years. Many well-known third party assessment tool sets were developed internationally (see Table 2.1), such as the International Initiative for a Sustainable Built Environmental Rating System and Sustainable Building Tool (iiSBE, SBTool 07) in Canada, the Building Research Establishment Environmental Assessment Method (BREEAM) Communities in England, and the Comprehensive Assessment System for Built Environment Efficiency (CASBEE) in Japan.

Table 2.1: Third party rating systems list (not exhaustive)

Assessment Tools	Developer	Date Established
LEED for Neighbor Development (LEED-ND)	United States Green Building Council	2009
Sustainable Sites Initiative™	American Society of Landscape Architects (ASLA) and the Lady Bird Johnson Wildflower Center.	2005
New Jersey's Brownfields Development Area (BDA) Initiative	New Jersey Department of Environmental Protection (NJDEP)	2003
Leadership in Energy and Environmental Design (LEED)	United States Green Building Council	1998
U.S. Green Building Council (USGBC)	USGBC	1993

Assessment Tools	Developer	Date Established
Greening of the White House	President Bill Clinton	1993
Environmental Resource Guide	American Institute of Architecture	1992
Energy Star Program	EPA and the U.S. Department of Energy	1992
First local green building	City of Austin, TX	1992

National, regional, and municipal sustainable development initiatives include the United States Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED); the Sustainable Sites Initiative™; which includes a set of arguments - economic, environmental, and social - for the adoption of sustainable land practices; the New Jersey Brownfields Development Area (BDA) Initiative, and the Sustainable Jersey rating systems.

Third party assessment tools, according to Simão, (2009), offer great support “through enhanced access to information, increased public participation in decision-making, and support for distributed collaboration between planners, stakeholders, and the public”. These tools often integrate the principles of smart growth, new urbanism, and green building into a system for sustainable neighborhood redevelopment (Kellogg, 2014; Morgia & Vicino, 2013). They emphasize the creation of compact, walkable, vibrant, mixed-use neighborhoods, with good connections to nearby communities (Farr, 2007; M. Greenberg, Lowrie, Mayer, Miller, & Solitare, 2001).

Researchers attempting to tackle the urban development problem with third party

rating systems have done so from a variety of aspects. For instance, several studies focus on Brownfield risk assessments, with some addressing Brownfields remediation's relationship to sustainable development (Davis, 2002; De Sousa, 2000). De Sousa's research (2000) studied development in the Greater Toronto Area (Ontario, Canada) and assessed the potential effectiveness of different policies and programs designed to attenuate associated costs and risks from a private sector perspective. In addition, scholars have also examined various factors associated with the unique challenges associated with sustainable Brownfield redevelopment. For example, it was found that the redevelopment of Brownfield sites has been slow due largely to the lack of a framework for cooperation between public and private sector stakeholders (Beauchamp & Adamowski, 2013).

While most of those studies focus on evaluating and certifying Brownfield redevelopment, little research has been undertaken that addresses the ability of these third party rating systems to prioritize redevelopment of Brownfields. There are few tools that enable the comparison of different sites for the purpose of prioritizing them for redevelopment or facilitating the assessment of large areas (Chrysochoou et al., 2011). Yet, in our course of investigation, the study found that USGBC's most recent rating system, LEED for Neighborhood Development (LEED-ND), has the potential to integrate urban sustainable development and Brownfield redevelopment (Brown, 2010; D. A. Lange & McNeil, 2004b; Talen et al., 2013), and could potentially provide essential means for Brownfield redevelopment prioritization. Apart from integrating third party rating systems to facilitate Brownfield redevelopment prioritization, the key to success is

access to data and the development of an effective means to evaluate redevelopment progress. Such access and evaluation rest upon agency-generated (e.g. federal, regional, and local level) information and effective use of this information by stakeholders. This information will enable stakeholders to make the most optimal decisions possible with the information available. It will help to map-out the likely consequences of decisions, to balance different factors, and choose the best courses of action to take. Executive Dashboards, which are popular tools in recent Building Information (BI) decision support studies, seem to suit the task well. Dashboards are Business Intelligence (BI) tools used by corporations to aid in performance management and monitoring (Dagan, 2007). Dashboards are also interactive tools. Adapted to Brownfields redevelopment, they enable the user to “drill down” to gather and consolidate information on environmental, social, economic, and political data that facilitate decision-making and prioritize redevelopment.

Set against the background of Brownfields and sustainable urban redevelopment, the central question with the application of the dashboard system is how can social, environmental, and economic assessments of Brownfield properties be analyzed and visualized via dashboards to inform sustainable neighborhood redevelopment and urban planning in terms of prioritization? How can the application of third party rating systems such as LEED for Neighbor Development reduce urban sprawl? Is a decision support tool such as an Executive Dashboard capable of assessing Brownfield redevelopment via third party rating systems? Can stakeholders design dashboards that bridge the gap between best environmental management practice and science? These questions are explored

using Paterson, NJ as a case study applying third party rating systems as well as dashboards.

2.1 **Materials and Methods**

2.1.1 **Study area: Paterson, New Jersey**

Paterson, New Jersey, shown in Fig. 2.1, has a long and storied past. It was chosen as our local study area because of the city's socioeconomic status and the proximity of its Brownfields to the Passaic River, one of the most contaminated rivers in the country (Moran, 2009). According to the US Census (2012), Paterson, with a population of 146,199, is New Jersey's third-largest city by area, with a population density of 17,279.15 people per square mile. Between 2007 and 2011 Paterson's median household income was \$34,302, with 27.1% of its population below the poverty line (Census, 2012).

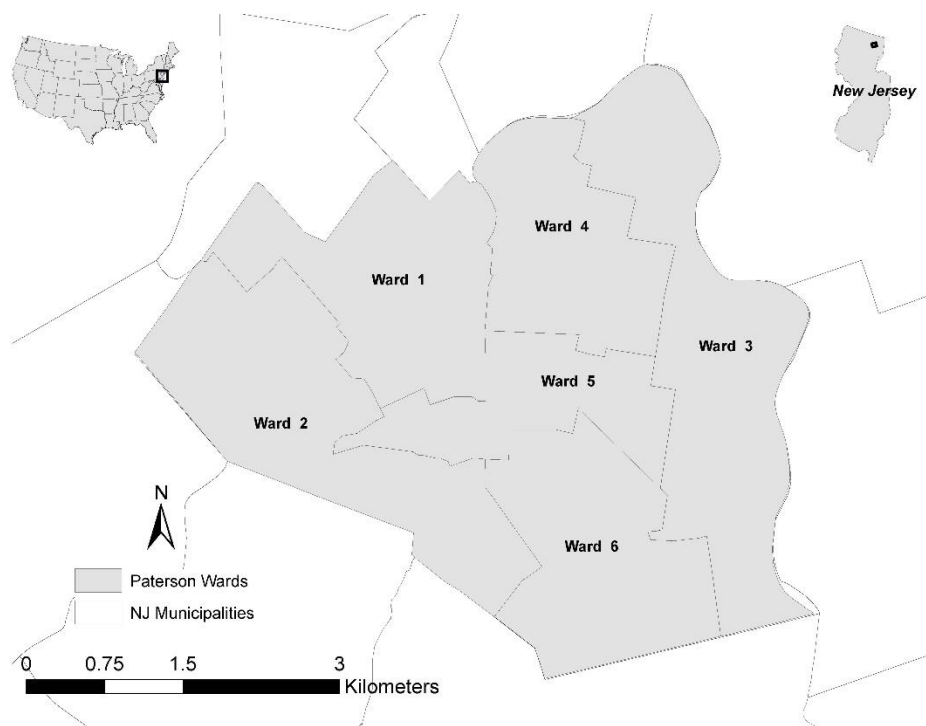


Figure 2.1: Study Area of Paterson, New Jersey

Paterson was established in 1791 by Alexander Hamilton as “the Society for Establishing Useful Manufactures (S.U.M.). Hamilton’s intent was to harness the power of the Passaic River’s Great Falls” (Falls, 2013). It was America’s first systematically planned industrial site and one of the major contributors to America’s Industrial Revolution (Archer, 2010). From the last quarter of the 19th century until the mid-20th century, Paterson was known as the “Silk City of the World” (Lind, 2012). However, when industry left Paterson, what remained were abandoned and derelict properties, which became known as Brownfields and Superfund sites.

Fortunately, for Paterson, in response to the growing Brownfields concerns, EPA

initiated the Brownfields Assessment Grant program to provide funding for Brownfield inventories, planning, environmental assessments, and community outreach. In 1998, Paterson received one of the first EPA Pilot Grants, which enabled the initial survey and assessment of six Brownfield properties. Included among the sites were Paterson Paperboard, Kaysam, Leader Dye, 69-83 Straight Street, 95 Cliff Street, and 62 Garfield Avenue (Institute, 2007). Since that time, subsequent grants have enabled Paterson to establish the Paterson Environmental Revitalization Committee (PERC) to address public health issues as part of Brownfields redevelopment, and to increase the development of the Brownfields inventory (USEPA, 2013).

Despite its numerous blighted sites, Paterson is doing much to reverse its Brownfield legacy and establish itself as a sustainable city. In addition to several privately owned LEED certified sites (Barringer, 2008; NJCEP, 2006), Paterson is actively pursuing designation as a certified Sustainable Jersey municipality (S. N. Jersey, 2011). To register with Sustainable Jersey, Paterson was required to pass a resolution that states its intent to pursue the certification and designate an entity to take charge of the process. After registering, Paterson must accumulate, and maintain, a certain number of points (e.g. 150 points for bronze and 350 points for silver), based on the sought after certification level (S. Jersey, 2014).

The *study* identifies methods for public and private stakeholders to prioritize *Brownfield redevelopment* options in Paterson, *within* the context of previously defined third party rating systems. The goal of the study was to present a Decision Support

System (DSS) that incorporates indicators for three dimensions: social, economic, and environmental, as defined by Leadership in Energy and Environmental Design for Neighborhood Development (LEED-ND) rankings to determine the highest priority sites for long-term and short-term redevelopment of properties in each of Paterson's six wards. The study introduces these assessments into an interactive dashboard to gather and consolidate the data and to present means for Paterson's decision-makers to redevelop Brownfield properties and to register successfully with Sustainable Jersey with the least investment but the most output (Goldstein-Chairperson et al.).

2.1.2 LEED and GIS

The study utilized a Geographic Information System (GIS) methodology to develop an Executive Dashboard that supports Brownfield redevelopment decision-making. The Executive Dashboard is based on third party rating systems, which, for Paterson, NJ, included the United States Green Building Council's Leadership in Energy and Environmental Design for Neighborhood Redevelopment (LEED-ND) (USGBC, 2009), and Sustainable Jersey (Goldstein-Chairperson et al.; Mills, 2010).

The goal of the study was to identify those parcels in Paterson that met all five of the LEED-ND Smart Location and Linkage Prerequisite (SLLp) points and are, therefore, eligible for development under the remaining LEED-ND standards for urban design and green construction (Table 2.2). LEED-ND Smart Location and Linkage encourages communities to consider location, transportation alternatives, and preservation of sensitive lands, while also discouraging sprawl (Talen et al., 2013).

The study's Brownfield redevelopment prioritization method builds upon an

application developed by Criterion Planners, consisting of seven parcel-level steps identifying and prioritizing LEED-ND eligible locations (Planners, 2011, 2012; Talen et al., 2013). The steps enable city and county planners to determine which parts of their jurisdictions are qualified for LEED-ND certification. These steps include defining water and wastewater service areas, identifying vacant and underbuilt parcels and their current zone designations, and identifying redevelopable parcels and their zone designations.

The steps also include the performance of LEED Smart Location and Linkage - Prerequisite 1 (SLL p1) option tests as well as the application of Prerequisite 2 (SLL p2) through Prerequisite 5 (SLLp5) constraints (see Table 2.2) (Talen et al., 2013; USGBC, 2011). Per LEED/LEED-ND requirements, the selected parcels were buffered with radii of $\frac{1}{4}$, $\frac{1}{2}$, and 1- mile, to group eligible parcels into unconstrained and constrained groups. Prioritized sites were identified by current plan/zone designation, and minimum densities (Planners, 2011; Talen et al., 2013). The intent was to measure the data based on the LEED/LEED-ND definitions and indicators.

Table 2.2: Summary of USGBC LEED-ND “Smart Location & Linkage” criteria used to develop sustainability indicators

Smart location (SLLp1)	Eligible parcel is one served by an existing water and wastewater infrastructure, or within a legally adopted, publicly owned, planned water and wastewater service area, and provide new water and wastewater infrastructure for the project, and, an existing infill site.
Imperiled species and ecological communities conservation (SLLp2)	No imperiled species or ecological communities have been found or have a high likelihood of occurring at the site.
Wetland and water body conservation (SLLp3)	Eligible parcel limits development effects on wetlands, water bodies, and surrounding buffer land according to the requirements that sites have no wetlands, water bodies, land within 50 feet of wetlands, or land within 100 feet of water bodies.
Agricultural land conservation (SLLp4)	Eligible parcel is a site that is not within a state or locally designated agricultural preservation district; does not disturb prime soils, unique soils, or soils of state significance as identified in a state Natural Resources Conservation Service soil survey.
Floodplain avoidance (SLLp5)	Eligible parcels do not contain any land within a 100-year high- or moderate-risk floodplain as defined and mapped by the Federal Emergency Management Agency (FEMA), or state or local floodplain management agency.
Preferred locations (SLLc1)	Eligible parcel is in one of the following locations: A previously developed site that is not an adjacent site or infill site; an adjacent site that is also a previously developed site; an infill site that is not a previously developed site; an infill site that is also a previously developed site
Brownfields redevelopment (SLLc2)	Preference is toward a site that is documented as a Brownfield by a local, state, or federal government agency.
Locations with reduced automobile dependence (SLLc3)	Preference is toward a site with existing transit service with at least 50% of dwelling units and nonresidential building entrances (inclusive of existing buildings) are within a 1/4-mile walk distance of bus or streetcar stops, or within a 1/2-mile walk distance of bus rapid transit stops.
Bicycle network and storage (SLLc4)	Project is to design bicycle network and storage on site
Housing and jobs proximity (SLLc5)	Eligible site is one with an affordable residential component, residential component; or infill project with nonresidential component in proximity to existing transportation and existing dwelling units whose number is equal to or greater than 50% of the number of new full-time-equivalent jobs created as part of the project.
Steep slope protection (SLLc6)	Project must minimize erosion to protect habitat and reduce stress on natural water systems by preserving steep slopes in a natural, vegetated state.
Site design for habitat or wetland and water body conservation (SLLc7)	Project must conserve native plants, wildlife habitat, wetlands, and water bodies.
Restoration of habitat or wetlands and water bodies (SLLc8)	Project must restore native plants, wildlife habitat, wetlands, and water bodies that have been harmed by previous human activities.
Long-term conservation management of habitat or wetlands and water bodies (SLLc9)	Project must conserve native plants, wildlife habitat, wetlands, and water bodies.

Utilizing the Environmental Systems Research Institute (ESRI) Executive Dashboard (ESRI, 2012), several GIS layers were created or used to compute the variables of interest for the study. As shown in Table 2.3, property value layers were derived from the 2010 New Jersey Property Tax System (MOD-IV) database. A Socio-economic Index and a population density layer were derived from United States Census data. Unemployment rate data was acquired from ESRI and an Environmental Index was developed, based on past use of the sites.

To determine which sites could be defined as previously-developed impervious surfaces, (e.g. a Smart Location and Linkage Prerequisite 1 (SLLp1) and Neighborhood Pattern & Design (NDP) requirement), the study used Remote Sensing (RS) image analysis utilizing New Jersey's 2012 - 2013 High Resolution Orthophotography (Banzhaf & Netzband, 2004; Talen et al., 2013). The features necessary to calculate measurements and map design elements were imported into the GIS, and then evaluated for the potential use of these procedures for selected Brownfield Properties.

To complete the analysis, a supervised classification of aerial photographs and a subset of the Landsat scene were used. The divided data spaces were classified into discrete regions in an attempt to evaluate previous use. In the case of making a Paterson Land Cover map, these regions corresponded to land cover types. ESRI's Maximum-Likelihood Classification tool was used to recognize the patterns of Brownfields in Paterson. This required us to supply signatures composed of training data. The parametric signatures contained the pixel values from the bands of a Remotely Sensed image.

Statistics were extracted and used to define decision boundaries. The RS data set

was then divided into those discrete regions. The computer was instructed to identify pixels with similar characteristics such as roof, streets, parking lots, ball fields, urban parks, and Greenfields.

The software packages used in the study were ArcGIS for Desktop 10.1, ArcGIS for Server 10.1, ESRI Code for Executive Dashboard 10.1, and Clark Labs, Clark University IDRISI 17. The data were input into ESRI's ArcGIS for Local Government Information Model (Geodatabase) for GIS processing and spatial analysis.

This study evaluated subsets of real estate parcels in Paterson. The data used to build the dashboard were from publically available documents from the USEPA, NJDEP, New Jersey New Jersey Department of Transportation, New Jersey Transit, Passaic County, the city of Paterson, and the US Census. The datasets listed in Table 2.3 and 2.4 are comprised of Paterson's real estate parcels obtained from the Paterson, NJ Office of Community Development, Paterson Habitat for Humanity, New Jersey Department of Environmental Protection, and State of New Jersey Division of Taxation 2010 (MOD-IV) database.

Table 2.3: Dataset Sample and Analysis Procedures

Analysis	Procedure
GIS analysis	The value of property is based on proximity to Brownfields or other Vacant and Abandoned properties.
Socio-economic index	The Socio-economic index is derived using the technique recently developed by the Bureau of the Census. This combines scores for education, occupation and family income to derive a composite numerical index (Myriantopoulos & French, 1968).
Property value	Property values, at the parcel level, derived from the New Jersey County Tax Boards Association, database
Population Density	Population density data is derived from the US Census Bureau, and the New Jersey DEP (Shen et al., 2009)
Unemployment Rate	An ESRI map service was used to illustrate the unemployment rate in Paterson for 2012. Data on unemployment is obtained from the U. S Census
Environmental Index	An Environmental Index derived from the New Jersey DEP Known Contaminated Site List, and the Passaic County and Paterson Offices of Economic Development which include past use of site, proximity to surface water and groundwater, soil permeability, zoning of the site, proximity to sensitive receptors (protected habitats, parks, protected open space) and characterization as floodplain or wetland

Table 2.4: Real Estate Parcels and Target Area Datasets

Data	Count	Source/Format	Use in LEED Analysis
Tax Assessment Records	25,533	New Jersey Tax Search Database (Excel Spreadsheet – geocoded)	Candidate identification
Parcels	24,672	New Jersey Geographic Information Network (NJGIN) (GIS Shapefile: New Jersey State Plane NAD83)	Candidate identification SLLp1 (option 1a-d, 2, 3, and 4) - SLL p2 - SLL p3 - SLL p4 - SLL p5
Paterson Habitat for Humanity parcels	1,535	Paterson Habitat for Humanity (Excel Spreadsheet – geocoded)	Candidate identification
Vacant & Abandoned Properties	536	Paterson Office of Community Development (Excel Spreadsheet – geocoded)	Candidate identification
NJDEP Known Contaminated Sites (KLS)	218	New Jersey Department of Environmental Protection (NJDEP) Known Contaminated Sites List (GIS Shapefile: New Jersey State Plane NAD83)	Candidate identification
Impervious Service		NJGIN (Orthoimagery through WMS via ArcGIS) (New Jersey 2012 - 2013 High Resolution Orthophotography, NAD83 NJ State Plane Feet, MrSID Tiles)	Candidate identification - Development intensity - Wetlands base map (SLLp3)
Roads		New Jersey Department of Transportation (Paterson) Shapefile	Intersection density -Pedestrian routes
Rivers & Streams		NJDEP Hydrography (Paterson) Shapefile	SLL p3 SLL p5
Urban Enterprise Zones		NJGIN Shapefile	Candidate identification

2.1.3 Dashboards for Decision Support

To support the decision-making process, one of the critical elements, other than the information itself, is the ease of access to and the evaluation of, the information. Researchers have found that the data needed to evaluate Brownfields redevelopment are not readily accessible (Rall & Haase, 2011; Solitare & Lowrie, 2012) or in a format that allowed for the simple adaptation of existing sustainability metrics and management frameworks to produce an adequate set of decision-making tools (Edwards & Thomas, 2005; Mississauga, 2009). Recent studies show that a particularly powerful online toolset, such as the study's Executive Dashboard, can gather information on complex business and economic issues, and consolidate valuable information to assemble, integrate, and disseminate data, thus facilitating decision-making.

Several Dashboards of Sustainability have been developed to show progress towards municipal and regional sustainability goals. On the municipal level, dashboards have been developed for the cities of Padua (Italy) and Atlanta, Georgia (USA) (Edwards & Thomas, 2005; Scipioni, Mazzi, Mason, & Manzardo, 2009). On a regional level, the Hartford–Springfield Economic Partnership, a consortium of central Connecticut and western Massachusetts stakeholders, developed a dashboard that tracks indicators in several areas of environmental, economic, and social sustainability. According to the developer, Timothy Brennan, (HSEP, 2012), "...the dashboard was established to provide information to the community, the indicators are important for guiding the plan policies and implementation."

If the performance measures show progress towards a goal, then planners can assume the strategy is working. Although it seems that dashboards are an effective decision support tool for Business Intelligence (BI) and most recently for regional and municipal administration, similar ideas are ideally suited for sustainable Brownfield redevelopment at the local or municipal level. This research attempts to tackle this task via the development of a Brownfield Redevelopment Dashboard for prioritization purposes. In particular, the study develops the Third Party Rating Dashboard based on ESRI's Executive Dashboard, which was developed in November 2012, as a business management tool to be used by local government leaders who need to make decisions with geographic information analysis capability. The dashboard allows stakeholders to answer not only questions of 'what needs to be done', but 'where to ... start first' (ESRI, 2012). Answering the latter question provides a perfect chance for prioritization of Brownfield redevelopment via coupling this particular Executive Dashboard with indicators from the third party rating systems (ESRI, 2012).

To fit the purpose of our study, the ESRI Executive Dashboard was modified to use site-specific data, including real estate parcel information (location, size, ownership), socioeconomic data (property values, and employment rates), and environmental factors (i.e. inclusion on the USEPA and New Jersey Department of Environmental Protection (NJDEP) Known Contaminated Sites List) to prioritize Brownfields redevelopment projects. The goal was to present a Decision Support System (DSS) utilizing a web-based, online dashboard that incorporates indicators for three dimensions: socioeconomic, environmental, and livability, as defined by LEED for Neighborhood

Development rankings. The study aims to show that the dashboard will enable stakeholders to identify the Brownfields with the highest potential for redevelopment to their highest and best uses.

2.1.4 Redevelopment prioritization –Key Performance Indicators

Key Performance Indicators (KPIs) are a measure of performance used to help an organization, and in our case, a municipality, define and evaluate how successful it is in making progress towards its long-term goals (Epstein & Roy, 2001; Shah, Manaugh, Badami, & El-Geneidy, 2013). This study presents a new framework and a new set of Key (Sustainability) Performance Indicators based on Third Party Ratings and assessments, through a comprehensive literature review, and tested them at the municipal level to prioritize Brownfield redevelopment in Paterson, New Jersey.

The indicators used in the study (Table 2.5) are developed based upon select LEED Green Building Rating Systems, LEED-ND, and the Sustainable Jersey ratings systems criteria. The performance indicators use targets to monitor progress toward development goals (Segnestam, 2003). While not all the indicators were used, due to data availability issues, we believe KPI dashboards advance visualization information and the data presented is sufficient to inform Brownfield redevelopment prioritization at the neighborhood and municipal levels.

Table 2.5: Key Performance Indicators for Sustainable Development: Neighborhood and Municipal levels

Performances Measured – Sustainable Development		
Goal - Design new Paterson owned buildings to comply with LEED, and./or Sustainable Jersey standards with the goal of achieving certification for all municipal buildings		
<i>Key Performance Indicators</i>	<i>Sustainable Development</i>	<i>Paterson's Initiatives</i>
Indicator #1	Maintain commitment, at the municipal level, to build and/or support sustainable development at the Public/Private level.	Paterson has two commercial LEED Certified sites: TD Bank (Gold) and PSE&G (Silver), and seven LEED registered homes.
Indicator #2	Identification of candidate parcels with the potential for development to LEED standard	
Indicator #3	Design and Construction of Municipal owned sites built LEED standard	
Indicator #4	Development of incentives such as zoning, property tax abatements, and fee waivers to increase in the number of planned LEED certified sites	Long Term – Increase number of third party certified sites
Performances Measured - Municipal Green Building		
Goal – Establish and maintain a Green Building Program at the municipal level		
<i>Key Performance Indicators</i>	<i>Municipal Green Building</i>	<i>Paterson's Initiatives</i>
Indicator #1	Creation of a Green Team and identification of requisite Priority Action Items (6 of the following priority actions: energy audits for municipal buildings, a municipal carbon footprint, a sustainable land use pledge, a natural resource inventory, a water conservation ordinance, and/or a fleet inventory	Short Term Maintain Sustainable Jersey Bronze Rating
Indicator #2	Based on Sustainable Jersey rating: select two of the above to maintain bronze level score	Continued Monitoring and Assessment of programs and projects
Indicator #3	Increase Rating: Commitment at the municipal level to select three of the above for a silver level	Long Term Increase Sustainable Jersey rating from Bronze to Silver
Performances Measured – Brownfields redevelopment.		
Goal – Develop and maintain a Brownfields redevelopment program		
<i>Key Performance Indicators</i>	<i>Brownfields redevelopment</i>	<i>Paterson's Initiatives</i>
Indicator #1	Develop and maintain Brownfields inventory, commit to redevelopment of sites	Appointed a Brownfields Coordinator in the Community Development Department.

2.2 Results

The study began with the 24,672 real estate parcels, within Paterson's six Wards. These data were joined with publically available information from the US Census, Land Use/Zoning data, and property tax records from the New Jersey Tax Record Database. From these parcels (Fig. 2.2) the study evaluated the 218 sites listed on the NJDEP Known Contaminated Sites List and the 531 Vacant and Abandoned Properties that Paterson identified under a New Jersey statute. The statute provides municipalities with certain powers to address the issue of dilapidated and unused properties (Mayors, 2008). These vacant sites met the Agency for Toxic Substances and Disease Registry's (ATSDR) criteria for Land Reuse sites. A land reuse site is defined as "...any site formally utilized for commercial and industrial purposes complicated by real or perceived contamination,," that has not received funding from EPA's Brownfield Program for redevelopment (ATSDR, 2013).

While the vacant properties in Paterson were not designated as Brownfields, based on EPA or NJDEP classification, according to the U.S. Conference of Mayors (2008), "the state ordinance permitted the City to file a notice of determination, encumber an offending property, and prompt owners to take action to clean up the sites. Following a brief appeal period, the City could file a lawsuit to gain entry and start rehabilitation and could designate a rehabilitation entity to do the necessary work. Upon completion of the remediation, the City could sell the property and compensate the offending owner, to the extent that any money remained after deducting costs associated with the rehabilitation".

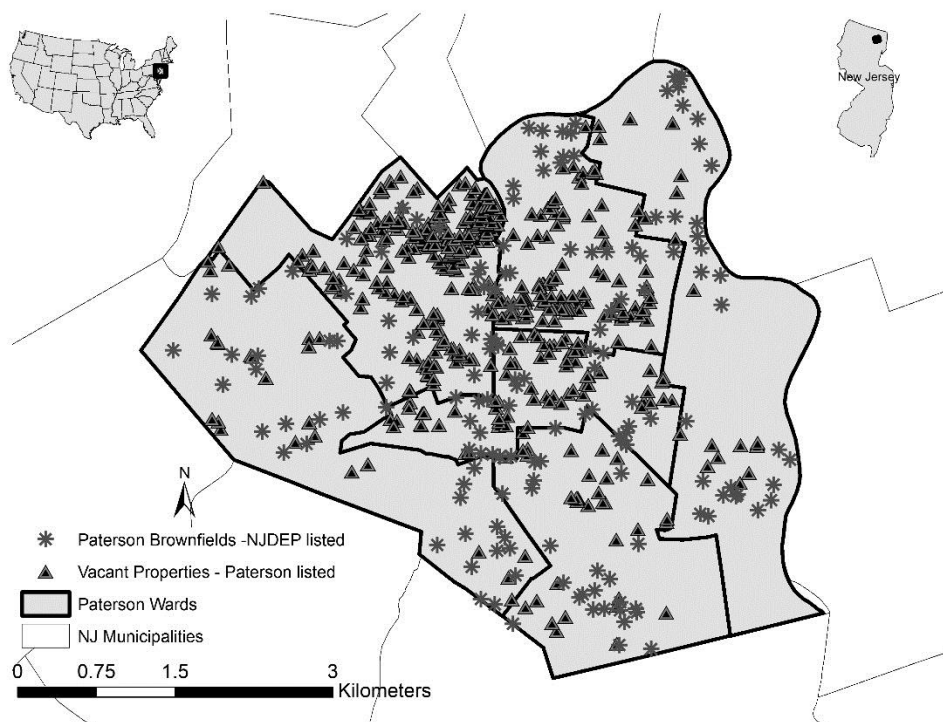


Figure 2.2: Sites selected based identification of all vacant & underbuilt parcels, current plan, and zones

From this select group of parcels, GIS is used to compare properties, adjacent to Brownfields sites, which, based on the proposed indicators, we expect to have the potential to achieve LEED-ND certification. Using key economic, social, and environmental indicators of property value from tax assessments, parcel size, environmental status, census, and neighborhood demographics, we associated a sustainability measure with each indicator and introduced it into the dashboard to give a comprehensive sustainability evaluation (Bleicher & Gross, 2010; Stone, 2009).

To identify and prioritize the sites in Paterson that meet the LEED-ND Smart Location & Linkage criteria, we applied Criterion Planners (2011) seven parcel-level steps, within the dashboard, to identify LEED-ND eligible locations (Fig. 2.3).

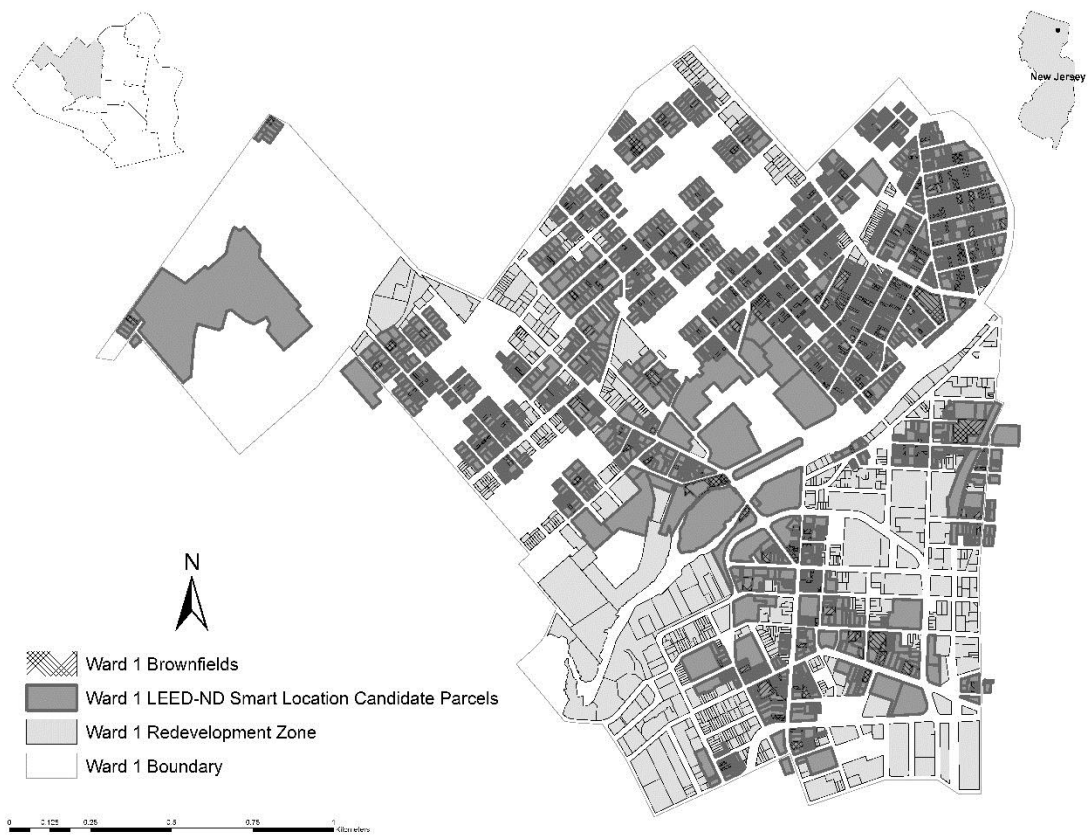


Figure 2.3: Smart Location & Linkage (SLL) qualifying parcels

All of Paterson's 24,672 parcels (100%) were within the municipality's water and wastewater service areas. Of those sites, 536 (2%) were identified as vacant & underbuilt parcels and 1% (218) are Brownfield sites. Potential re-developable parcels and their plan/zone designations were based on the performance of nine SLLp1 option tests. Due to density, we were limited in the application of SLLp2-p5 constraints. We determined under LEED/LEED-ND's ½ and 1-mile buffering requirement that 18,591 parcels (75%) were within 1000 feet of a Brownfield and over 90% of eligible sites were within ½ mile of an affected Brownfield site. However, due to the density of the neighborhoods, a large portion of Paterson's population was also close to amenities such as restaurants, retail, banks, parks, schools, or grocery stores (Figure 2.4).

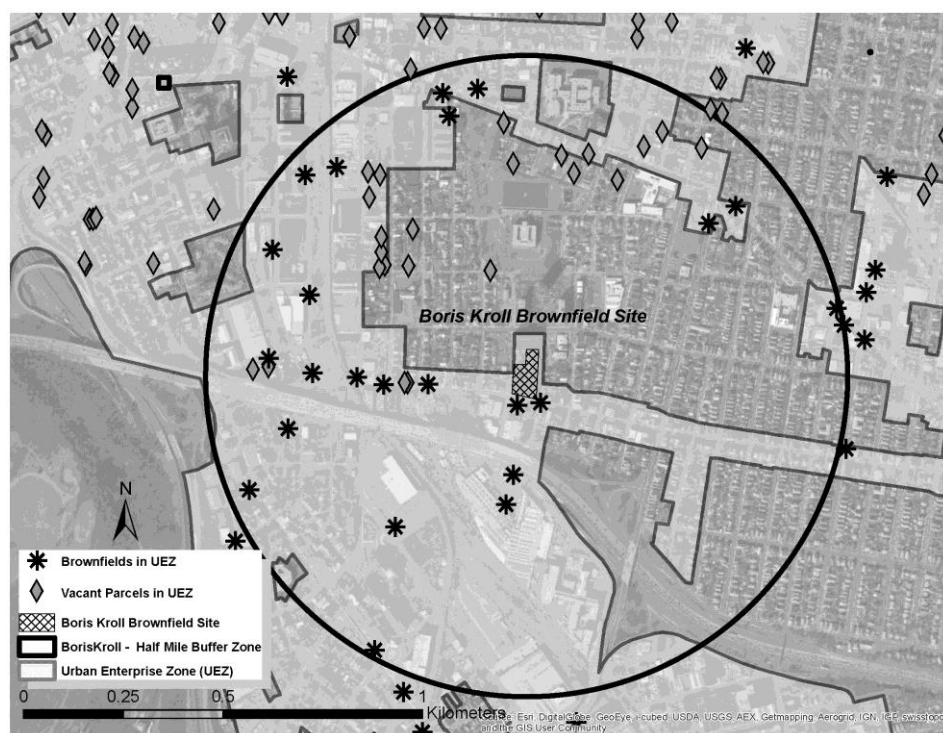


Figure 2.4 “Smart Location & Linkage”, LEED-NC “Development Footprint”, and Sustainable Jersey sites

In Figure 2.5, we depict the status of the 218 Brownfield sites on the New Jersey Department of Environmental Protection's Known Contaminated Sites list at Paterson's ward level. These "Active Sites" were those with one or more active cases, or with pending and/or closed cases. The sites with "No Further Actions", and "Response Action Outcomes" had obtained final remediation documents indicating that there were no contaminants present, or that any discharged contaminants that were present had been remediated to applicable standards or remediation regulations (with Restrictions) (NJDEP, 2013). Of the 218 Known Contaminated Sites, Ward 1 contained 20 Brownfields (13% of total sites), Ward 2 had 31 sites (19%), Ward 3 had 30 sites (19%), Ward 4 contained 27 sites (17%), Ward 5 had 24 sites (15%), and Ward 6 had 27 developable Brownfield sites (17%).

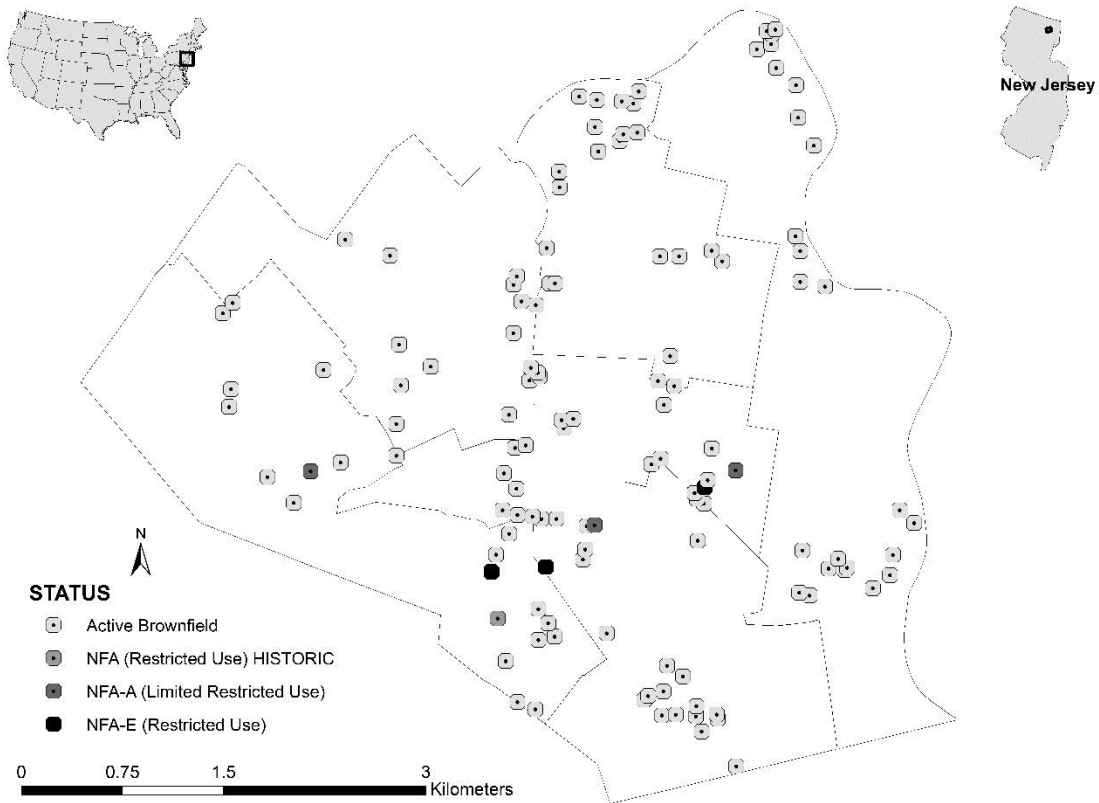


Figure 2.5: Highest priority redevelopment sites selected for long-term and short-term redevelopment based on current plan/zone designations and densities

Figure 2.6, is a map of the City of Paterson showing the results of the Sustainability Assessment of the Paterson Brownfield Redevelopment Sites, by Ward, as visualized by the dashboard. The eleven candidate sites shown were selected subject to the following conditions. The map displays the Priority Brownfield sites that had received “No Further Action” letters, and were cleared for redevelopment. The assessment illustrates several major aspects of sustainable Brownfield revitalization. Each high-priority site identified fits a number of the select LEED-ND criteria. These criteria include a discernible center, housing within a five-minute walk of the center, a variety of dwelling types, and a variety of stores and commercial activity. It also includes flexible backyard buildings for working or living, a school within walking distance, playgrounds near dwellings, connected streets, and narrow, shaded streets conducive to pedestrians and cyclists. Buildings close to the street at a pedestrian scale are needed, as well as parking or garages placed behind buildings and away from street frontages, civic and public buildings, and a community decision process for maintenance, security, and neighborhood development (NRDC, 2011; USGBC, 2009)

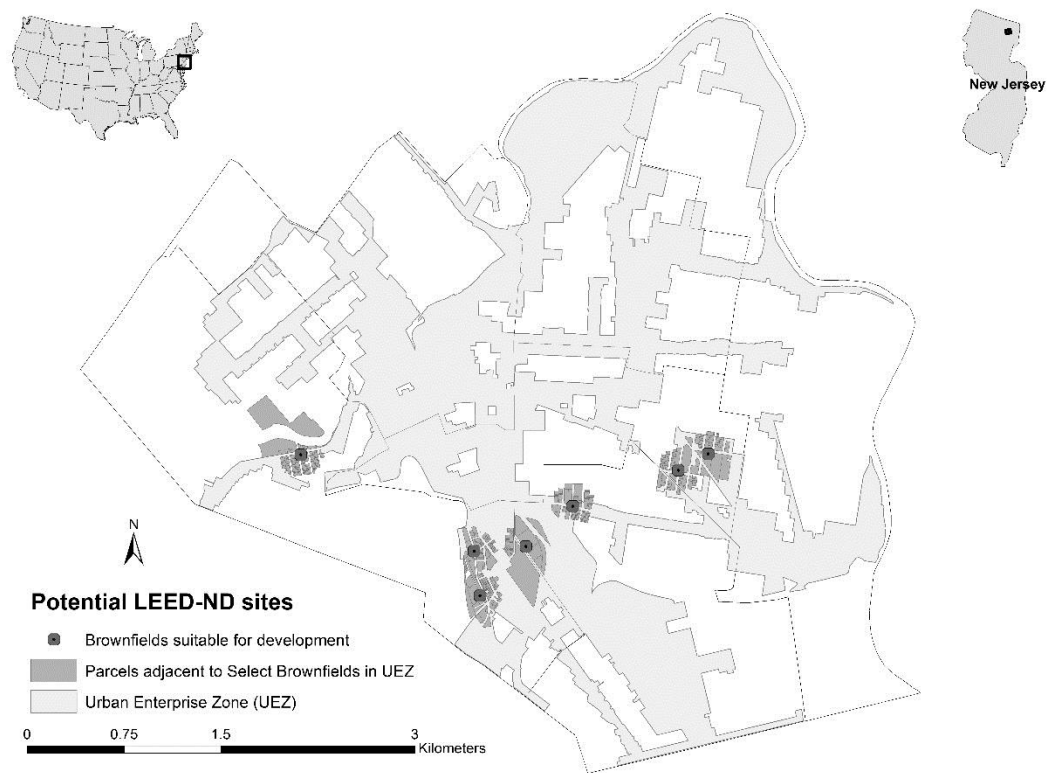


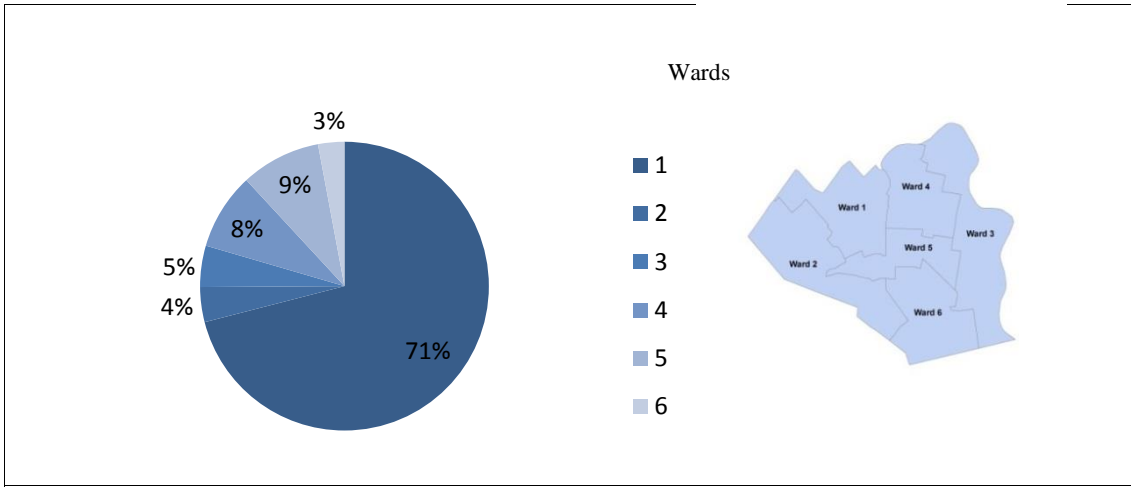
Figure 2.6: High Priority Brownfield Redevelopment Sites - No Further Action Status

Table 2.6: Assessed Property Values of Highest Priority Brownfield Redevelopment Sites in Paterson, NJ

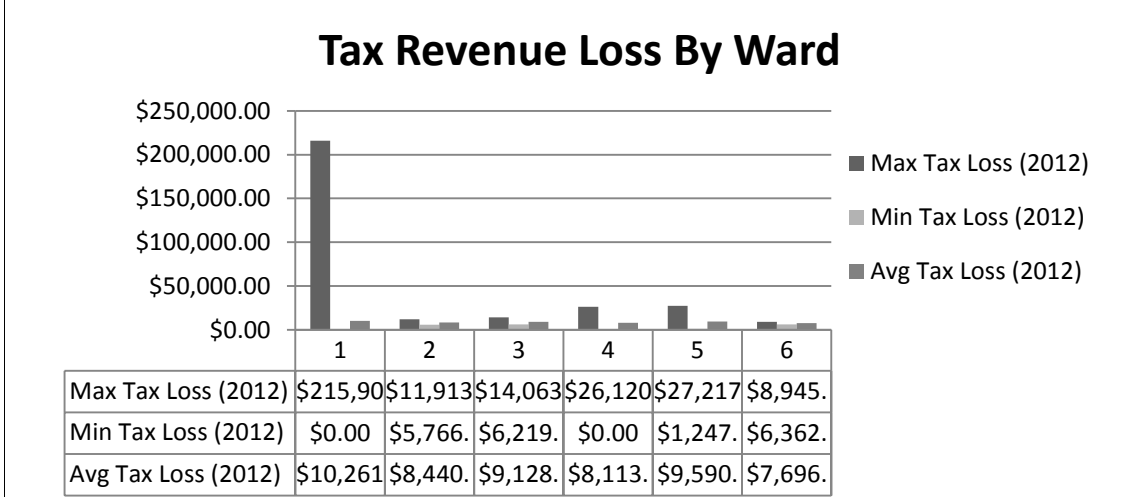
Address	Acreage	Tax 2012	Land (Assessed Value)	Improvement (Assessed Value)	Total (Assessed Value)
39 Getty Ave	4.2	\$0.00	\$2,310,000.00	\$8,728,800.00	\$11,038,800.00
169-191 Lafayette St	0.6428	\$59,009.45	\$257,200.00	\$2,089,100.00	\$2,346,300.00
834-864 E 25th St	1.1249	\$52,815.00	\$618,800.00	\$1,481,200.00	\$2,100,000.00
50-72 Gray St	1.6	\$47,274.46	\$880,000.00	\$999,700.00	\$1,879,700.00
58-73 Canal St	2.8	\$27,672.55	\$781,000.00	\$319,300.00	\$1,100,300.00
252-278 Marshall St	1.3788	\$23,100.28	\$522,500.00	\$396,000.00	\$918,500.00
245-259 McBride Ave	0.4591	\$22,607.34	\$630,000.00	\$268,900.00	\$898,900.00
144-158 18th Ave	0.4959	\$21,377.50	\$283,300.00	\$566,700.00	\$850,000.00
398 McBride Ave	0.2066	\$8,837.71	\$271,300.00	\$80,100.00	\$351,400.00
145-147 Alabama Ave	0.1722	\$10,869.83	\$196,000.00	\$136,200.00	\$332,200.00
226-242 E 29th St	0.5165	\$7,894.59	\$258,000.00	\$55,900.00	\$313,900.00

2.3 Discussion

Integration of the Executive Dashboards, with the data management and visualization capabilities of GIS, revealed an effective tool in which stakeholders can gather and consolidate environmental, social, and economic data from LEED-ND. Our findings confirm that Third Party assessments, when integrated with dashboards, enable stakeholders to identify Brownfields with the highest potential for redevelopment. The outcome of the study identified the priority sites chosen for sustainable redevelopment, as identified by the stakeholders and extracted from the data presented in the dashboard as illustrated in Fig. 2.7.



a. Percent Property Tax Revenue Loss to Vacant Properties - By Ward



b. Tax Revenue Loss of Vacant & Abandoned Properties - By Ward (Min, Max, Avg) (n=531)

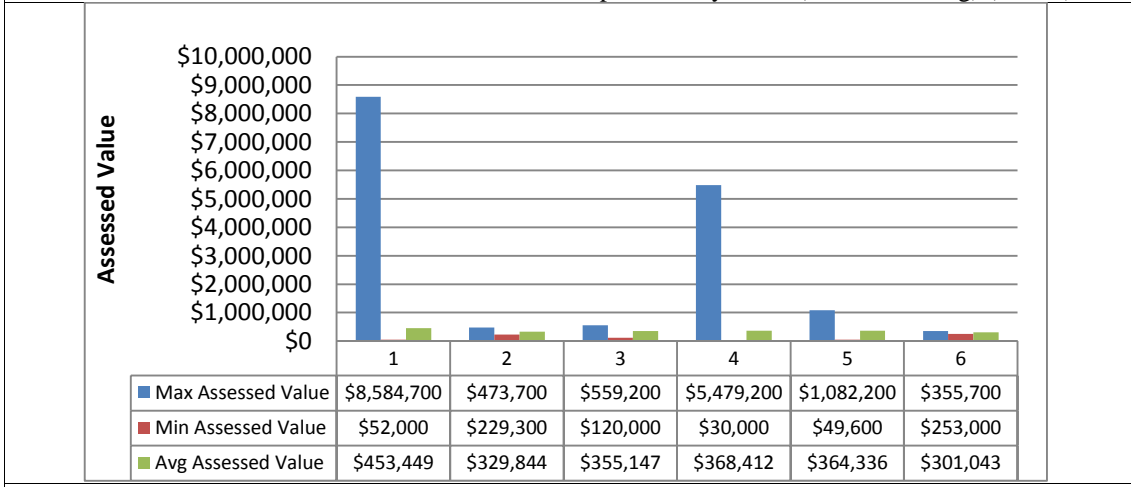


Figure 2.7: Assessed Value of Vacant & Abandoned Properties

The basic premise of the Brownfield site prioritization process is that each property has characteristics that are either suitable or not suitable for the redevelopment activities that are being planned for the site. Site suitability is determined through a systematic examination of the different aspect of the site. Inputs into the dashboard model include a variety of environmental, social, and economic factors, which could inform each stakeholder's decisions (Morio, Schädler, & Finkel, 2013). We conducted a Multi Criteria Evaluation (MCE) in ArcGIS 10.1 to produce a "Site Suitability/Priority Analysis." The results are displayed on GIS maps that highlight suitable or unsuitable sites, to ensure properties are cleaned to a standard of their highest and best use (Berardi, 2013; Berke & Conroy, 2000; Farr, 2007)

The dashboard was developed to enable public and private stakeholders to prioritize *Brownfield redevelopment* in Paterson, New Jersey *within* the context of third party rating systems. The goal was to identify the highest priority sites for long-term and short-term redevelopment in a subset of properties in each of Paterson's wards. These assessments were introduced into an interactive decision support tool to gather and consolidate environmental, social, and economic data. The assessment was also intended to present a tool for Paterson's decision-makers to redevelop Brownfield properties and to register with Sustainable Jersey with the least investment but most output.

2.4 Conclusions

On a national level, according to the USEPA (2013), Brownfield redevelopment creates many benefits for local communities. The agency asserts that Brownfields

revitalization leveraged \$17.79 per each dollar that EPA expends and leveraged 85,883 jobs nationwide. Redevelopment can increase residential property values 2 to 3 percent when nearby Brownfields are addressed, and promotes area-wide planning. In New Jersey, the Brownfields redevelopment program has had some successes (Michael Greenberg, Lowrie, Solitare, & Duncan, 2000; D. Lange & McNeil, 2004a), and some blatant misses (Barnett, 2006; Masilamani, 2010). Our study shows that Paterson is losing over two hundred fifteen million dollars a year in potential tax revenue due to Brownfields and abandoned properties. This has indicated a need for methods to inform the Brownfields decision support system that enables the prioritization of Brownfield redevelopment to achieve sustainable neighborhood revitalization.

This study was designed to inform Brownfields decision support efforts in Paterson, New Jersey. The study includes such principals as sustainability, renewable energy, and smart growth, and adds to the lessons learned from the experience of Brownfield redevelopment. The prioritization of Brownfields redevelopment projects using a multi-criteria decision model is informed by third party rating systems, stakeholder input, and spatial data analysis. The findings presented suggest that, on a local level, our Sustainable Brownfields Decision Support Dashboard shows that components of LEED for neighborhood Development and Sustainable Jersey are rating systems capable of evaluating multiple components of a sustainable community.

This is important because, unlike other LEED programs, LEED-ND does not rate individual buildings. It takes a rather holistic approach by addressing the entire

community. Smart Location and Linkages encourages the community to address transportation and preserve sensitive lands and discourages sprawl. Neighborhood Pattern and Design encourages communities that are healthy, diverse, and walkable. Green Infrastructure and Buildings bring into play the remediation of Brownfields and prioritizes infill site redevelopment.

With numerous redevelopment projects and limited funds, we anticipate that these third party rating systems will play an important role in sustainable redevelopment. Third party rating systems provide a monitoring and recordkeeping system that ensures properties are cleaned to a standard of their highest and best use. Dashboards provide decision support by providing tools that enable stakeholders to analyze and visualize key performance indicators. Coupled with GIS, these tools provide interactive spatial models that correlate environmental, social, and economic data and make it easier for users to peruse data and identify trends and make informed decisions.

Our study confirms that in the case of Paterson, New Jersey, Brownfield redevelopment in higher socioeconomic areas realize a greater potential for redevelopment than properties in neighborhoods of lower value or those on the fringe (Brasington & Hite, 2005). However, such studies have often involved goals that are in direct conflict with sustainable development, since the latter encompasses a much wider social responsibility than pure economic performance. This study focuses on employing the third party rating systems, using them to prioritize various projects, and comparing the outcomes from these rating systems to determine which projects have the higher

potential for redevelopment. The Dashboard operationalizes Morio's, (2013), "multi-criteria genetic algorithm framework for Brownfield reuse optimization, which improves redevelopment options based on stakeholder preferences". This facilitates the user to make tradeoffs among eligible options.

The study demonstrates that dashboards are effective tools that can be used to prioritize Brownfield redevelopment. We found that effective Brownfields redevelopment must consider the entire neighborhood and policy makers must consider the results of multiple scenarios in developing remediation strategies. This web-based dashboard will act as a decisional support system, which can be used for Brownfields Redevelopment planning by decision makers at local and regional levels alike.

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CHAPTER 3

Assessing the Impact of Third Party Rating Systems on Sustainable Development at the County Scale

Abstract

The context for this paper is research supporting the development of spatial support tools for prioritizing Green Infrastructure and other sustainability projects, which are important elements of the tool-kit for implementing assessments for more sustainable societies. There are several organizations and professional groups offering sustainable development solutions to builders and developers. One such group, the U.S. Green Building Council (USGBC) has included Green Infrastructure into its neighborhood revitalization system, which is sure to affect the future of sustainable development. The prioritization of redevelopment, to achieve sustainable revitalization at the county or regional scale, has received considerable attention. This study investigates whether a GIS based business intelligence dashboard, as a data visualization tool, can provide feasible and intuitive integration of data in which to prioritize Green Infrastructure projects. It presents a new framework and new key sustainability indicators based on GIS and Remote Sensing, to prioritize development. These assessments are introduced into a Spatial Decision Support System, utilizing a dashboard as an interactive tool to gather and consolidate data and to present an evaluative means for decision-makers. The tool

allows for the identification of the highest priority sites for long-term and short-term revitalization of properties along the rivers and streams of Passaic County, in Northern, New Jersey. The study shows that Passaic County has over 712 Brownfields and abandoned properties. Of that number, 235 are within 500 feet of a river or navigable waterway and, due to Climate Change, are potentially subject to repeated flooding. Our study indicates that dashboards for Decision Support, coupled with GIS, are an effective tool to facilitate Regional Revitalization.

3 Introduction

Due to an aging infrastructure, an abandoning of manufacturing sites in the northern New Jersey Regional area, and increasing urban population growth, our cities are in need of redevelopment. Especially at risk are cities that are in proximity to urban industrial river fronts (Meadows, Meadows, Randers, & Behrens III, 1972; Wrenn, 1983). From the Passaic River in New Jersey, to the Pasig River in the Philippines, to the Yellow River in China, rivers like these, all over the world, bear a tremendous burden. They not only provide much of the world's drinking water, but food, recreation and a means of transportation, in most countries as well (Bridges & Gustavson, 2014; Clarke, 2013).

Unfortunately, the contamination of river sediments by inorganic elements has been an increasing eco-toxicological problem, because rivers often receive anthropogenic and industrial wastes from these abandoned sites. The Passaic River, located in Northern New Jersey, is one such river. It has the distinction of being one of the most contaminated rivers in the country (Jones, Feng, Stern, Lodge, & Clesceri, 2001; Walker, McNutt, & Maslanka, 1999). Ironically, throughout its history, the factories and industries along the industrial rivers brought wealth to the very businesses that polluted, and then abandoned them, as industries closed, relocated overseas, or expanded from the urban core out to the hinterlands (Conzen, 2014).

When industry left what remained were abandoned and derelict properties known as Brownfields and Superfund sites (USEPA, 2013, 2014). According to the United

States Environmental Protection Agency (USEPA, 2003), “Brownfields differ from Superfund sites in the degree of contamination. Superfund sites pose a real threat to human health and/or the environment. Brownfields, on the other hand, do not pose enough of a serious health or environmental threat to warrant cleanup under the Superfund program. Instead, they represent an economic or social threat, since they prevent development and, therefore, stifle local economies”.

The problem of deciding how to prioritize the remediation of Brownfield and Superfund projects, to achieve holistic and sustainable urban redevelopment, is receiving considerable attention with third party rating systems. These include the U. S. Green Building Council’s Leadership in Energy and Environmental Design for Neighborhood Development (LEED-ND) rating System, Yale University's Land and Natural Development Code, and the United States Environmental Protection Agency (USEPA) Criteria for Land Revitalization.

The United Nations estimates that worldwide population will grow from approximately 7 billion today to 9.3 billion in 2050 and 10.1 billion in 2100 (Lee, 2011). Nowhere is this population growth more evident than in the major cities of the world. According to Jack Goldstone (2010), in 2010, for the first time in history a majority of the world’s people lived in cities. In 1950, by comparison, less than 30% of the world’s population dwelled in cities.

This rapid growth of population, coupled with aging infrastructure and the abandoning of urban manufacturing sites, generates a need for urban redevelopment. At

risk are cities with high concentrations of derelict properties that are located within the urban core. Second areas at risk are sites in suburban areas located on known Historic Fill. Third areas at risk are sites that are in proximity to urban industrial river fronts (Meadows et al., 1972; Wrenn, 1983), or as they are collectively called, Brownfield Sites (USEPA, 2013). As global population continues to increase in these areas, researchers are investigating new techniques that promote economic growth and sustainable development, while minimizing the environmental, social, and economic impacts of urban sprawl. One such technique is building green buildings on Brownfield Sites.

Brownfields are defined by the United States Environmental Protection Agency (USEPA) as abandoned or underutilized industrial and commercial properties, where redevelopment or expansion may be complicated by possible environmental contamination, whether real or perceived. Research estimates that there are between five hundred thousand and one million Brownfields in the United States (M. R. Greenberg & Issa, 2005; Simons, 1998). Locating green buildings on those is a sustainable and welcoming approach to both revitalize the cities and cope with increasing demands for land and properties. To accomplish this goal, the EPA (2013), “empowers states, communities, and other stakeholders in economic development to work together in a timely manner to prevent, assess, safely clean-up, and sustainably reuse Brownfields”.

Research indicates that successful Brownfield remediation has a positive effect on neighborhood redevelopment by job creation, housing (Adams & Watkins, 2002; M. Greenberg, Craighill, Mayer, Zukin, & Wells, 2001) and improved transportation and infrastructure (Amekudzi & Fomunung, 2004; Brennan et al., 2012). According to Litt,

Tran, and Burke (2002), once a Brownfield's environmental, health, and safety hazards have been identified and remediated, the challenge becomes how to galvanize action across the public and private sectors to return them to productive use, curb sprawling development outside urban areas, and reinvigorate inner-city communities.

When the Brownfields Act was enacted, however, there were no uniform standards for measuring its positive impact. Therefore, there is a lack of research on redevelopment of Brownfields as a key to sustainable neighborhood revitalization. Moreover, sustainable urban revitalization tools that can incorporate the positive effects of Brownfield remediation and facilitate strategic decision-making are also lacking.

To this regard, we attempt to investigate whether a prescriptive approach to redevelopment, the third party rating system, such as the U.S. Green Building Council (USGBC) Leadership in Energy and Environmental Design for Neighborhood Development (LEED-ND), can provide essential information for urban Brownfield redevelopment prioritization and spur urban revitalization in the most effective and possibly most sustainable way.

Prioritizing Urban Revitalization Projects

The third party rating system for urban communities has become an increasingly popular decision support tool, in recent years. Many well-known third party assessment tool sets were developed internationally (see Table 3.1), such as the International Initiative for a Sustainable Built Environmental Rating System and Sustainable Building Tool (iiSBE, SBTool 07) in Canada, the Building Research Establishment Environmental

Assessment Method (BREEAM) Communities in England, and the Comprehensive Assessment System for Built Environment Efficiency (CASBEE) in Japan.

Table 3.1: List of third party rating systems (not exhaustive)

Assessment Tools	Developer	Date Established
LEED for Neighbor Development (LEED-ND)	United States Green Building Council	2009
Sustainable Sites Initiative™	American Society of Landscape Architects (ASLA) and the Lady Bird Johnson Wildflower Center	2005
New Jersey's Brownfields Development Area (BDA) Initiative	New Jersey Department of Environmental Protection (NJDEP)	2003
Leadership in Energy and Environmental Design (LEED)	United States Green Building Council	1998
U.S. Green Building Council (USGBC)	USGBC	1993
Greening of the White House	President Bill Clinton	1993
Environmental Resource Guide	American Institute of Architecture	1992
Energy Star Program	EPA and the U.S. Department of Energy	1992
First local green building	City of Austin, TX	1992

National, regional, and municipal sustainable development initiatives include the United States Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED); the Sustainable Sites Initiative™, which includes a set of arguments, economic, environmental, and social, for the adoption of sustainable land

practices, the New Jersey Brownfields Development Area (BDA) Initiative, and the Sustainable Jersey rating systems.

These assessment tools, according to Simão, (2009) offer great support “through enhanced access to information, increased public participation in decision-making, and support for distributed collaboration between planners, stakeholders, and the public”. These tools often integrate the principles of smart growth, new urbanism, and green building into a system for sustainable neighborhood redevelopment. They emphasize the creation of compact, walkable, vibrant, and mixed-use neighborhoods, with good connections to nearby communities (Farr, 2007; M. Greenberg, Lowrie, Mayer, Miller, & Solitare, 2001).

Researchers attempting to tackle the urban development problem with third party rating systems have done so from a variety of approaches. For instance, several studies focus on Brownfield risk assessments, with some addressing Brownfield remediation’s relationship to sustainable development (Davis, 2002; De Sousa, 2000). De Sousa’s (2000) research studied development in the Greater Toronto Area (Ontario, Canada) and assessed the potential effectiveness of different policies and programs designed to attenuate associated costs and risks from a private sector perspective. In addition, scholars have also examined various factors associated with the unique challenges associated with sustainable Brownfield redevelopment. For example, it was found that the redevelopment of Brownfield sites has been slow, due largely to the lack of a framework for cooperation between public and private sector stakeholders (Beauchamp & Adamowski, 2013).

While most of those studies focus on evaluating and certifying Brownfield redevelopment, little research has been undertaken that addresses the ability of these third party rating systems to prioritize revitalization of Brownfields. There are few tools that enable the comparison of different sites for the purpose of prioritizing them for redevelopment or facilitating the assessment of large areas (Chrysochoou, Dahal, et al., 2011). Yet, in the course of this investigation, the study found that USGBC's most recent rating system, LEED for Neighborhood Development (LEED-ND), has the potential to integrate urban sustainable development and Brownfield redevelopment (Brown, 2010; D. A. Lange & McNeil, 2004b; Talen et al., 2013), and could potentially provide essential means for Brownfield redevelopment prioritization.

Apart from integrating third party rating systems to facilitate Brownfield redevelopment prioritization, the key to success is access to data and the development of an effective means to evaluate redevelopment progress. Such access and evaluation rest upon agency-generated (e.g. federal, regional, and local level) information and effective use of this information by stakeholders. This information will enable stakeholders to make the most optimal decisions possible with the information available. It will help to map-out the likely consequences of decisions, to balance different factors, and choose the best courses of action to take. Executive Dashboards, which are popular tools in recent Building Information (BI) decision support studies, seem to suit the task well. Dashboards are Business Intelligence (BI) tools used by corporations to aid in performance management and monitoring (Dagan, 2007). Dashboards are also interactive tools. Adapted to Brownfields redevelopment, they enable the user to "drill down" to

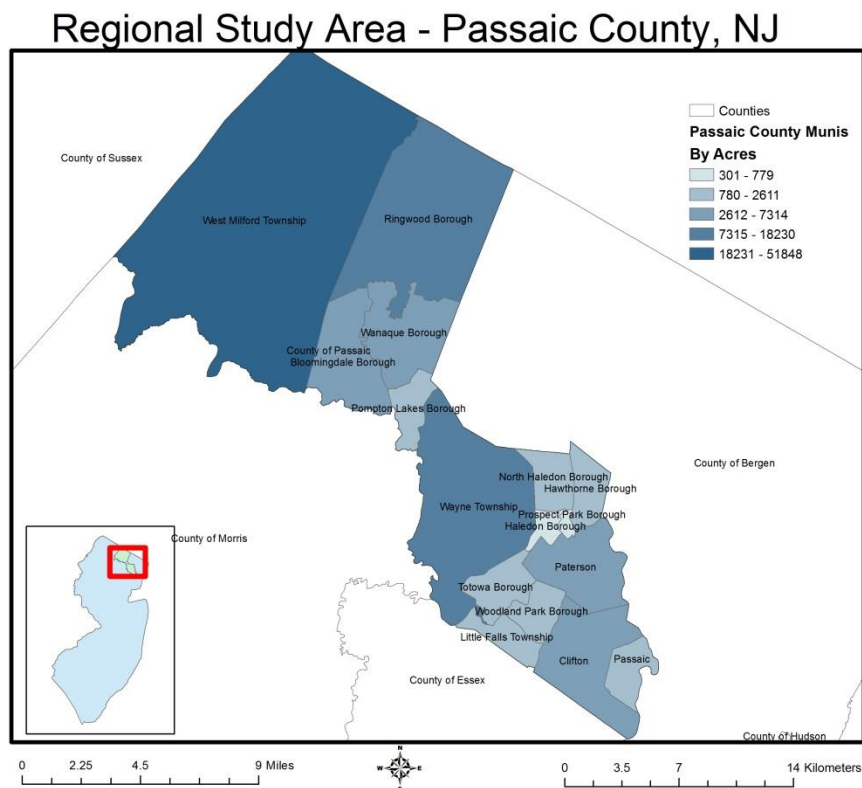
gather and consolidate information on environmental, social, economic, and political data that facilitate decision-making and prioritize redevelopment.

Set against the background of Brownfields and sustainable urban redevelopment, the central question with the application of the dashboard system is how can social, environmental, and economic assessments of Brownfield properties be analyzed and visualized via dashboards to inform sustainable neighborhood redevelopment and urban planning, in terms of prioritization? How can the application of third party rating systems, such as LEED for Neighbor Development, reduce urban sprawl? Is a decision support tool, such as an Executive Dashboard, capable of assessing Brownfield redevelopment via third party rating systems? Can stakeholders design dashboards that bridge the gap between best environmental management practice and science? These questions are explored using Passaic County, NJ as a case study applying third party rating systems, as well as dashboards.

3.1 Materials and Methods

3.1.1 Study area: Passaic County, New Jersey

Passaic County, New Jersey, shown in Figure 3.1, was chosen as our local study area because of the city's socioeconomic status, and the proximity of its Brownfields to the Passaic River, one of the most contaminated rivers in the country (Moran, 2009).



According to a recent proposal for the Passaic County Office of Economic

Development EPA Assessment Grant:

Passaic County has a population of 497,093 and is ethnically diverse with 34% of the population classified as Hispanic (over twice the national percentage of 15%), 60% white, 12% African American, and 23% of another race. The percentage of foreign-born persons is high, totaling 28% of the population, an increase from the 2000 number of 26.6% of the population. The percentage of foreign born in the US was only 13% in 2006. Fifteen of the sixteen Passaic County municipalities have populations under 100,000 excluding the City of Paterson (148,708), and 11 of the municipalities have populations under 20,000. The median age of the County's population is 36 years, below the national figure of 36.4 years and that of the State of New Jersey at 38.2. Twenty-six percent of

the County's population in 2006 was under the age of eighteen, higher than the State of New Jersey at 24%, and the national average of 25%.

According to the 2006 American Community Survey Estimate, US Census Bureau, 15% of the residents of Passaic County were in poverty as compared to 9% in New Jersey and 13% for the United States. Children, all persons under 18 years of age, had an even higher incidence of poverty, at 23% for Passaic County, compared dramatically to 12%, for the State of New Jersey, and 18% for the United States. The residents of Passaic County households also demonstrated a significantly lower median income for 2006, \$49,940, as compared to \$64,470 in the State of New Jersey. Three of the County's 16 municipalities, the cities of Clifton, Paterson, and Passaic, are designated as State of New Jersey Urban Aid Communities. According to the US Department of Labor, Bureau of Labor Statistics, the Passaic County annual average unemployment rate for 2006 is 5.6%, with the cities of Passaic at 7.1 % and the City of Paterson reaching 8.6%. The cities of Paterson and Passaic are also designated as State of New Jersey Urban Enterprise Zones, which should make them attractive sites for urban development.

According to the 2006 American Community Survey Estimate, US Census Bureau, Passaic County has a higher percentage of disabled individuals between the ages of 16 and 64, 10.3%, as compared to the State of New Jersey at 9.3%. In addition, according to a recent report by the American Lung Association, "Estimated Prevalence, and Incidence of Lung Disease", September 2004, 10,918 residents of Passaic County have been diagnosed with pediatric asthma, 28,088 with adult asthma, 16,093 with chronic bronchitis and 5,503 with emphysema. In each of these situations, as Brownfield properties in Passaic County are abandoned, or in the process of a costly multi-year environmental remediation, no economic activity has occurred on these sites for decades. The impacted municipalities and the County have lost potential tax revenue, the potential for employment opportunities for local residents, and a loss of capital investment. (D. Hoffman, personal communication, May 7, 2010)

The study identifies methods for public and private stakeholders to prioritize Brownfield redevelopment options in the demographically, socially, and economically diverse County of Passaic, within the context of previously defined third party rating systems. The goal of the study was to present a Decision Support System (DSS) that

incorporates indicators for three dimensions, including social, economic, and environmental (e.g. livability), as defined by LEED for Neighborhood Development rankings to determine the highest priority sites for long-term and short-term redevelopment of properties, in each of Passaic County's municipalities. These assessments are introduced into an interactive dashboard to gather and consolidate the data and to present means for Passaic County's decision-makers to redevelop Brownfield properties and to register successfully with Sustainable Jersey with the least investment but most output.

The study utilized a Geographic Information System (GIS) methodology to develop an Executive Dashboard that supports the County's Brownfield redevelopment decision-making. The Executive Dashboard is based on third party rating systems, which, for Passaic County, NJ, included the United States Green Building Council's LEED for Neighborhood Redevelopment (LEED-ND) (USGBC, 2009).

The goal of the study was to identify those parcels in Passaic County that met all five of LEED-ND Smart Location and Linkage Prerequisite (SLLp) points and are, therefore, eligible for development under the remaining LEED-ND standards for urban design and green construction (Table 3.2). LEED-ND Smart Location and Linkage encourages communities to consider location, transportation alternatives, and preservation of sensitive lands, while also discouraging sprawl (Talen et al., 2013).

The study's Brownfield redevelopment prioritization method builds upon an application developed by Criterion Planners, consisting of seven parcel-level steps identifying and prioritizing LEED-ND eligible locations (Planners, 2011, 2012; Talen et

al., 2013). The steps enable city and county planners to determine which parts of their jurisdictions are qualified for LEED-ND certification. These steps include defining water and wastewater service areas; identifying vacant and underbuilt parcels and their current zone designations; and identifying redevelopable parcels and their zone designations.

The steps also include the performance of LEED Smart Location and Linkage - Prerequisite 1 (SLL p1) option tests as well as the application of Prerequisite 2 (SLL p2) through Prerequisite 5 (SLLp5) constraints (see Table 3.2) (Talen et al., 2013; USGBC, 2011). Per LEED/LEED-ND requirements, the selected parcels were buffered with radii of ¼, ½, and 1 mile, to group eligible parcels into unconstrained and constrained groups. Prioritized sites were identified by current plan/zone designation, and minimum densities (Planners, 2011; Talen et al., 2013). The intent was to measure the data based on the LEED/LEED-ND definitions and indicators.

Table 3.2: Summary of USGBC LEED-ND “*Smart Location & Linkage*” criteria used to develop sustainability indicators at the county level

SLLP	Criteria
Smart location (SLLp1)	Eligible parcel is one served by an existing water and wastewater infrastructure, or within a legally adopted, publicly owned, planned water and wastewater service area, and provide new water and wastewater infrastructure for the project, and, an existing infill site.
Imperiled species and ecological communities conservation (SLLp2)	No imperiled species or ecological communities have been found or have a high likelihood of occurring at the site.
Wetland and water body conservation	Eligible parcel limits development effects on wetlands, water bodies, and surrounding buffer land according to the requirements that sites have no wetlands,

SLLP	Criteria
(SLLp3)	water bodies, land within 50 feet of wetlands, or land within 100 feet of water bodies.
Agricultural land conservation (SLLp4)	Eligible parcel is a site that is not within a state or locally designated agricultural preservation district; does not disturb prime soils, unique soils, or soils of state significance as identified in a state Natural Resources Conservation Service soil survey.
Floodplain avoidance (SLLp5)	Eligible parcels do not contain any land within a 100-year high- or moderate-risk floodplain as defined and mapped by the Federal Emergency Management Agency (FEMA), or state or local floodplain management agency.
Preferred locations (SLLc1)	Eligible parcel is in one of the following locations: A previously developed site that is not an adjacent site or infill site; an adjacent site that is also a previously developed site; an infill site that is not a previously developed site; an infill site that is also a previously developed site
Brownfields redevelopment (SLLc2)	Preference is toward a site that is documented as a Brownfield by a local, state, or federal government agency.
Locations with reduced automobile dependence (SLLc3)	Preference is toward a site with existing transit service with at least 50% of dwelling units and nonresidential building entrances (inclusive of existing buildings) are within a 1/4-mile walk distance of bus or streetcar stops, or within a 1/2-mile walk distance of bus rapid transit stops.
Bicycle network and storage (SLLc4)	Project is to design bicycle network and storage on site
Housing and jobs proximity (SLLc5)	Eligible site is one with an affordable residential component, residential component; or infill project with nonresidential component in proximity to existing transportation and existing dwelling units whose number is equal to or greater than 50% of the number of new full-time-equivalent jobs created as part of the project.

SLLP	Criteria
Steep slope protection (SLLc6)	Project must minimize erosion to protect habitat and reduce stress on natural water systems by preserving steep slopes in a natural, vegetated state
Site design for habitat or wetland and water body conservation (SLLc7)	Project must conserve native plants, wildlife habitat, wetlands, and water bodies.
Restoration of habitat or wetlands and water bodies (SLLc8)	Project must restore native plants, wildlife habitat, wetlands, and water bodies that have been harmed by previous human activities.
Long-term conservation management of habitat or wetlands and water bodies (SLLc9)	Project must conserve native plants, wildlife habitat, wetlands, and water bodies.
Source: (USGBC, 2011)	

Data

Utilizing the Environmental Systems Research Institute (ESRI) Executive Dashboard (ESRI, 2012), several GIS layers were created or used to compute the variables of interest for the study. As shown in Table 3.3, property value layers were derived from the State of New Jersey Division of Taxation 2010 (MOD-IV) database. A Socioeconomic Index and a population density layer were derived from United States Census data. Unemployment Rate data were acquired from ESRI and an Environmental

Index was developed based on past use of the sites.

To determine which sites could be defined as previously developed impervious surfaces, which are Smart Location and Linkage Prerequisite 1 (SLLp1), and Neighborhood Pattern & Design (NDP) requirements, the study used Remote Sensing (RS) image analysis utilizing New Jersey's 2012 - 2013 High Resolution Orthophotography (Banzhaf & Netzband, 2004; Talen et al., 2013). The features necessary to calculate measurements and map design elements were imported into the GIS, and subsequently evaluated for the potential use of these procedures for selected Brownfield Properties. To complete the analysis, a supervised classification of aerial photographs and a subset of the Landsat scene were performed, to classify the divided data spaces into discrete regions.

In the case of making a Passaic County Land Cover map, these regions corresponded to land cover types. A classification using the Maximum-Likelihood algorithm was performed, which required training the computer to recognize the patterns of Brownfields in Passaic County being sought after. This required supplying signatures composed of training data. The parametric signatures contained the pixel values from the bands of a Remotely Sensed image. Statistics were extracted and used to define decision boundaries. The RS data set was then divided into those discrete regions. The computer was programmed to identify pixels with similar characteristics such as roof, streets, parking lots, ball fields, and urban parks.

The software packages used in the study were ArcGIS for Desktop 10.1, ArcGIS for Server 10.1, ESRI Code for Executive Dashboard 10.1, and Clark Labs, Clark

University IDRISI 17. The data were input into ESRI's ArcGIS for Local Government Information Model (Geodatabase) for GIS processing and spatial analysis.

This study evaluated subsets of real estate parcels in Passaic County. The data used to build the dashboard were from publically available documents from the USEPA, NJDEP, New Jersey New Jersey Department of Transportation, New Jersey Transit, Passaic County, and the US Census. The datasets listed in Table 3.3 and 3.4 are comprised of Passaic County's real estate parcels obtained from the Passaic County Office of Economic Development, New Jersey Department of Environmental Protection, and State of New Jersey Division of Taxation 2010 MOD-IV database.

Table 3.3: Dataset Sample and Analysis Procedures

Analysis	Use
GIS analysis	The value of property is based on proximity to Brownfields or other Vacant and Abandoned properties.
Socioeconomic index	The Socioeconomic index is derived using the technique recently developed by the Bureau of the Census. This combines scores for education, occupation and family income to derive a composite numerical index (Myriantopoulos & French, 1968).
Property value	Property values, at the parcel level, was derived from the New Jersey County Tax Boards Association, database
Population Density	Population density data is derived from the US Census Bureau, and the New Jersey DEP (Shen et al., 2009)
Unemployment Rate	An ESRI map service was used to illustrate the unemployment rate in Passaic County for 2012. Data on unemployment is obtained from the U. S Census
Environmental Index	An Environmental Index derived from the New Jersey DEP Known Contaminated Site List, and the Passaic County Office of Economic Development which

Analysis	Use
	include past use of site, proximity to surface water and groundwater, soil permeability, zoning of the site, proximity to sensitive receptors (protected habitats, parks, protected open space) and characterization as floodplain or wetland (Chrysochoou, Garrick, et al., 2011).

Table 3.4: Real Estate Parcels and Target Area Datasets

Data	Count	Source/Format	Use
Tax Assessment Records	25,533	New Jersey Tax Search Database (Excel Spreadsheet – geocoded)	Candidate identification
Parcels	24,672	New Jersey Geographic Information Network (NJGIN) (GIS Shapefile - New Jersey State Plane NAD83)	Candidate identification SLLp1 (option 1a-d, 2, 3, and 4) SLL p2 SLL p3 SLL p4 SLL p5
NJDEP Known Contaminated Sites (KLS)	218	New Jersey Department of Environmental Protection Known Contaminated Sites List (Shapefile)	Candidate identification
Impervious Service		NJGIN (Orthoimagery through WMS via ArcGIS) (New Jersey 2012 - 2013 High Resolution Orthophotography, NAD83 NJ State Plane Feet, MrSID Tiles)	Candidate identification Development intensity Wetlands base map (SLLp3)
Roads		New Jersey Department of Transportation (Shapefile)	Intersection density Pedestrian routes

Data	Count	Source/Format	Use
Rivers & Streams		NJDEP Hydrography (Shapefile)	SLL p3 SLL p5
Urban Enterprise Zones		NJGIN – (https://njgin.state.nj.us/NJ_NJGINExplorer/DataDownloads.jsp) Shapefile	Candidate identification

3.1.2 Dashboards for Decision Support

To support the decision-making process, one of the critical elements, other than the information itself, is the ease of access to and the evaluation of, the information. Often it was found that the data needed to evaluate Brownfields redevelopment were not readily accessible (Rall & Haase, 2011; Solitare & Lowrie, 2012) or in a format that allowed for the simple adaptation of existing sustainability metrics and management frameworks, to produce an adequate set of decision-making tools (Edwards & Thomas, 2005; Mississauga, 2009). Recent studies show that a particularly powerful online toolset, such as the study's Executive Dashboard, can gather information on complex business and economic issues, and consolidate valuable information to assemble, integrate, and disseminate data, thus facilitating decision-making.

Several dashboards of sustainability have been developed to show progress towards municipal and regional sustainability goals. On the municipal level, dashboards have been developed for the cities of Padua (Italy) and Atlanta, Georgia (USA) (Edwards & Thomas, 2005; Scipioni, Mazzi, Mason, & Manzardo, 2009). On a regional level, the

Hartford–Springfield Economic Partnership, a consortium of central Connecticut and western Massachusetts stakeholders, developed a dashboard that tracks indicators in several areas of environmental, economic, and social sustainability. According to the developer Timothy Brennan, (HSEP, 2012), “...the dashboard was established to provide information to the community, the indicators are important for guiding the plans policies and implementation.”

If the performance measures show progress towards a goal, then planners can assume the strategy is working. Although it seems that dashboards are an effective decision support tool for Business Intelligence (BI) and most recently for regional and municipal administration. Similar ideas are ideally suited for sustainable Brownfield redevelopment at the local or municipal level. This research attempts to tackle this task via the development of a Brownfield Redevelopment Dashboard for prioritization purposes. In particular, we will develop our Third Party Rating Dashboard, based on ESRI’s Executive Dashboard.

ESRI’s Executive Dashboard was developed in November 2012, as a business management tool, to be used by local government leaders who need to make decisions with geographic information analysis capability. The dashboard allows stakeholders to view critical metrics, to answer not only questions of ‘what needs to be done’, but ‘where to start first’ (ESRI, 2012). Answering the latter question provides a perfect chance for prioritization of Brownfield redevelopment via coupling this particular Executive Dashboard with indicators from the third party rating systems (ESRI, 2012).

To fit the purpose of our study, the dashboard was modified to use site-specific data, including real estate parcel information (location, size, ownership), socioeconomic data (property values and employment rates), and environmental factors (i.e. inclusion on the USEPA and the New Jersey Department of Environmental Protection (NJDEP) Known Contaminated Sites List) to prioritize Brownfields redevelopment projects. The goal was to present a Decision Support System (DSS) utilizing a web-based, online dashboard that incorporates indicators for three dimensions: socioeconomic, environmental, and livability, as defined by LEED for Neighborhood Development rankings. We aim to show that the dashboard will enable stakeholders to identify the Brownfields with the highest potential for redevelopment to their highest and best uses.

3.1.3 Redevelopment prioritization –Key (Sustainability) Performance Indicators

Key Performance Indicators (KPIs) are a measure of performance used to help an organization and, in our case a municipality, define and evaluate how successful it is in making progress towards its long-term goals (Epstein & Roy, 2001; Shah, Manaugh, Badami, & El-Geneidy, 2013). This study presents a new framework and a new set of Key (Sustainability) Performance Indicators, based on Third Party Ratings and assessments, through a comprehensive literature review, and tested them at the municipal level to prioritize Brownfield redevelopment in Passaic County, New Jersey.

The indicators used in the study (Table 3.5) are developed, based upon select LEED Green Building Rating Systems, LEED-ND, and Sustainable Jersey ratings systems criteria. The performance indicators use targets to monitor progress toward development goals (Segnestam, 2003). While not all the indicators were used, due to data

availability issues, it is believed that KPI dashboards advance visualization information and the data presented is sufficient to inform Brownfield redevelopment prioritization at the neighborhood and municipal levels.

Table 3.5: **Key Performance Indicators for Sustainable Development at the county level**

Performance Measured Sustainable Development		
Goal - Design new government owned buildings to LEED, and/or Sustainable Jersey standards with the goal of achieving certification for all municipal buildings.		
Key Performance Indicators	Sustainable Development	Passaic County's Initiatives
Indicator #1	Maintain commitment, at the municipal level, to build and/or support sustainable development at the Public/Private Partnership level.	Current initiatives - Paterson has two commercial LEED Certified sites: TD Bank (Gold) and PSE&G (Silver).
Indicator #2	Identification of candidate parcels with the potential for development to LEED standard	
Indicator #3	Design and Construction of Municipal owned sites built LEED standard	
Indicator #4	Development of incentives such as zoning, property tax abatements, and fee waivers to increase in the number of planned LEED certified sites	Long Term – Increase number of third party certified sites
Performances Measured: Municipality owned green building		
Goal – Establish and maintain a Green Building Program at the municipal level		
Key Performance Indicators	Municipal Green Building	Passaic County's Initiatives
Indicator #1	Creation of a Green Team and identification of requisite Priority Action Items from the following six priority actions: <ol style="list-style-type: none"> 1. energy audits for municipal buildings 2. a municipal carbon footprint 3. a sustainable land use pledge 	Short Term Maintain Sustainable Jersey Bronze Rating

	4. a natural resource inventory	
	5. a water conservation ordinance	
	6. and/or a fleet inventory	
Indicator #2	Based on Sustainable Jersey rating: must select two of the above to maintain bronze level score	Continued Monitoring and Assessment of programs and projects
Performances Measured: Municipality owned green building (cont.)		
Indicator #3	Increase Rating: Commitment at the municipal level to select three of the above for a silver level score	Long Term Increase Sustainable Jersey rating from Bronze to Silver
Performances Measured: Brownfield redevelopment		
Goal – Develop and maintain a Brownfields redevelopment program		
Indicator #1	Develop and maintain Brownfields inventory, commit to redevelopment of sites	Passaic County’s Director of Economic Development is the Brownfields. Coordinator

3.2 Results

The study began with the 126,620 real estate parcels within Passaic County’s sixteen municipalities. These data were joined with publically available information from the US Census, Land Use/Zoning data, and property tax records from the New Jersey Tax Record Database. From these parcels, we evaluated the 721 sites that were listed on the NJDEP Known Contaminated Sites List (Figure 3.2).

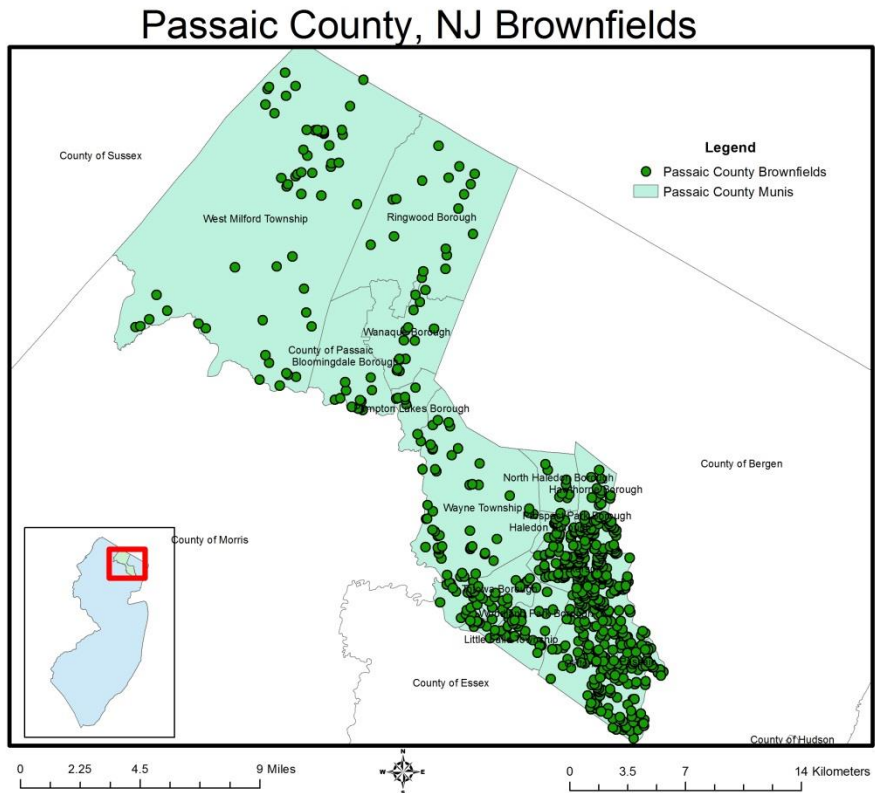


Figure 3.2: Map of Passaic County, NJ Brownfields

From this select group of parcels, we use GIS to compare properties, adjacent to Brownfields sites, which, based on the proposed indicators, we expect to have the potential to achieve LEED-ND certification. Using key economic, social, and environmental indicators of property value from tax assessments, parcel size, environmental status, census, and neighborhood demographics, we associated a sustainability measure with each indicator and introduced it into the dashboard to give a comprehensive sustainability evaluation (Bleicher & Gross, 2010; Stone, 2009).

Of the 721 Passaic County Brownfields identified, 235 are within 500 feet of a river

or navigable waterway and, due to climate change, are subject to repeated flooding (Dickerson, 2013; Leichenko & Solecki, 2013; Zimmerman, 1979)

Passaic County, NJ - Brownfields within 500 ft of rivers and streams

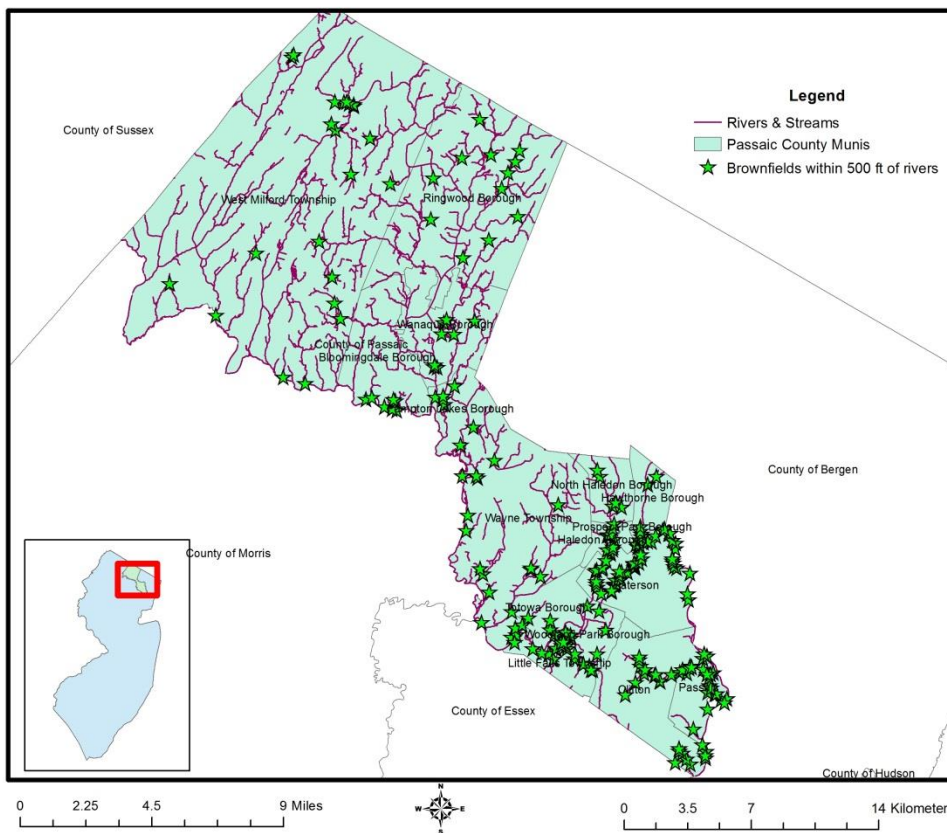


Figure 3.3: Passaic County Brownfields (235 sites) within 500 ft. of a river or navigable waterway

To identify and prioritize the Brownfield sites in Passaic County that are greater than 500 feet from a river, and meet the LEED-ND Smart Location & Linkage criteria, we applied Criterion Planners (2011) seven parcel-level steps, within the dashboard, to identify LEED-ND eligible locations (Figure 3.4).

Passaic County, NJ - Brownfields more than 1500 ft from river or stream

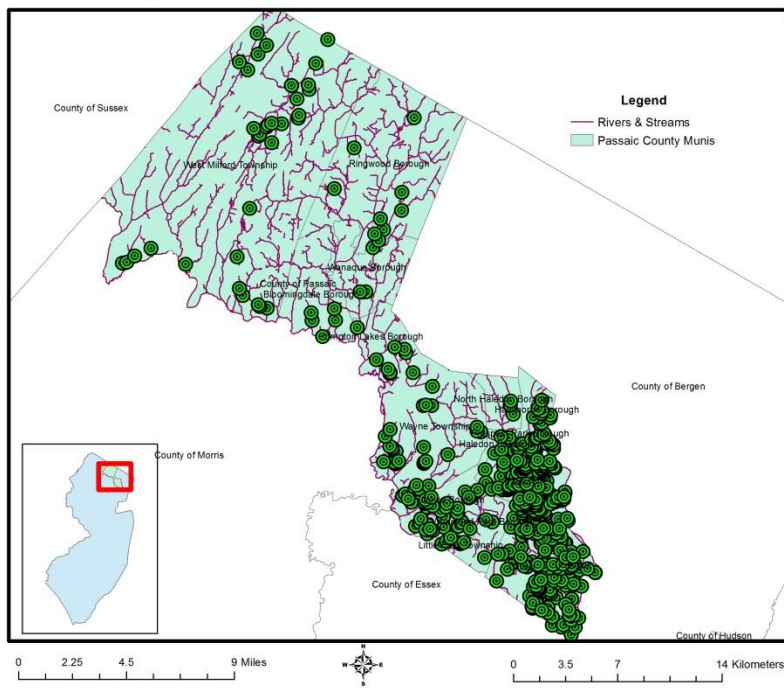


Figure 3.4: Passaic County Brownfields (486 sites) greater than 1500 ft. from a river or navigable waterway

Figure 3.5 presents a map of the Passaic County showing the results of the Sustainability Assessment of the Brownfield Redevelopment Sites, by municipality, as visualized by the dashboard. The 61 candidate sites shown were selected subject to the following conditions: The map displays the Priority Brownfield sites that are Pending Assessment by NJDEP and are greater than 500 feet from a river or waterway. The Pending Assessment status illustrates several major aspects of sustainable Brownfield revitalization decision making.

Passaic County, NJ - Brownfields more than 1500 ft from river (Pending Phase I Assessment)

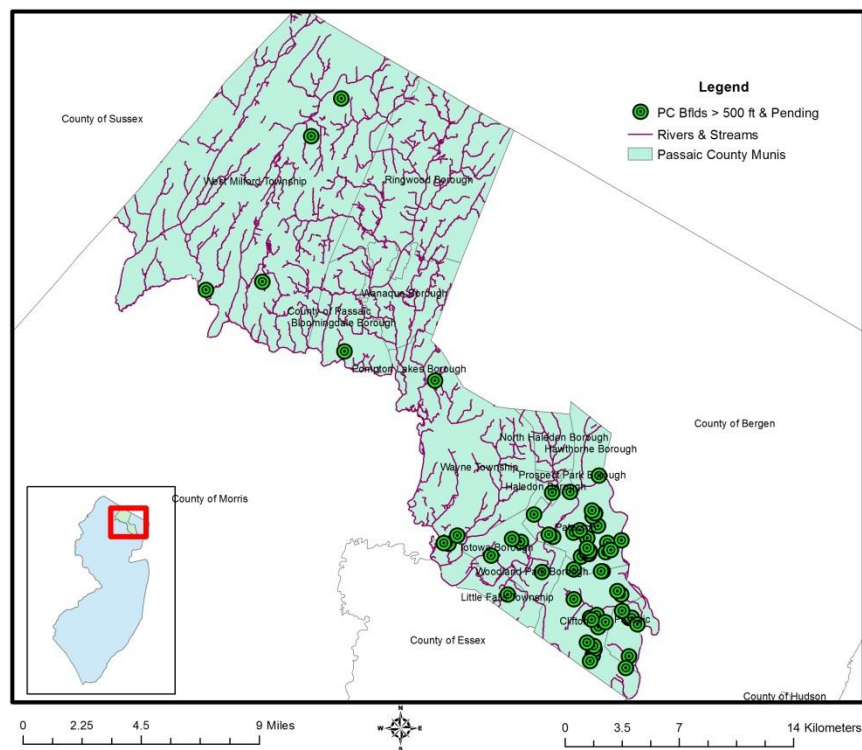


Figure 3.5 Passaic County highest priority sites more than 1500 feet from a river Pending Assessment

3.3 Discussion

Integration of the Executive Dashboards, with the data management and visualization capabilities of GIS, revealed an effective tool in which stakeholders can gather and consolidate environmental, social, and economic data from LEED-ND. The findings confirm that Third Party assessments, when integrated with dashboards, enable stakeholders to identify Brownfields with the highest potential for redevelopment.

The basic premise of the Brownfield site prioritization process is that each property has characteristics that are either suitable or not suitable for the redevelopment

activities that are being planned for the site. Site suitability is determined through a systematic examination of the different aspect of the site. Inputs into the dashboard model include a variety of environmental, social, and economic factors, which could inform each stakeholder's decisions (Morio, Schädler, & Finkel, 2013). We conducted a Multi Criteria Evaluation (MCE) in ArcGIS 10.1 to produce a "Site Suitability/Priority Analysis." The results are displayed on GIS maps that highlight suitable or unsuitable sites, to ensure properties are cleaned to a standard of their highest and best use (Berardi, 2013; Berke & Conroy, 2000; Farr, 2007)

The dashboards enable public and private stakeholders to prioritize *Brownfield redevelopment* in Passaic County, New Jersey *within* the context of third party rating systems. The goal was to identify the highest priority sites for long-term and short-term redevelopment in a subset of properties in each of the county's sixteen municipalities. The study introduced these assessments into an interactive decision support tool to gather and consolidate environmental, social, and economic data. The assessment was also intended to present a tool for Passaic County's decision-makers to redevelop Brownfield properties and to register with Sustainable Jersey with the least investment but most output.

3.4 Conclusions

On a national level, according to the USEPA (2013), Brownfield redevelopment creates many benefits for local communities. The agency asserts that Brownfields revitalization leveraged \$17.79 per each dollar that EPA expends and leveraged 85,883

jobs nationwide. Redevelopment can increase residential property values 2 to 3 percent when nearby Brownfields are addressed, and promotes area-wide planning. In New Jersey, the Brownfields redevelopment program has had some successes (Michael Greenberg, Lowrie, Solitare, & Duncan, 2000; D. Lange & McNeil, 2004a), and some blatant misses (Barnett, 2006; Masilamani, 2010). Our study indicates that Passaic County has over 712 Brownfields, and, of that number, 235 are within 500 feet of a river or navigable waterway and, due to Climate Change, are potentially subject to repeated flooding. This has indicated a need for methods to inform the Brownfields decision support system that enables the prioritization of Brownfield redevelopment to achieve sustainable neighborhood revitalization.

This study was designed to inform Brownfields decision support efforts in Passaic County. The study includes such principals as sustainability, renewable energy, and smart growth, and adds to the lessons learned from the experience of Brownfield redevelopment. The prioritization of Brownfields redevelopment projects using a multi-criteria decision model is informed by third party rating systems, stakeholder input, and spatial data analysis. The findings presented suggest that on a local level, our Sustainable Brownfields Decision Support Dashboard shows that LEED for neighborhood Development and Sustainable Jersey are rating systems capable of evaluating multiple components of a sustainable community.

This is important because, unlike other LEED programs, LEED-ND does not rate individual buildings. It takes a rather holistic approach by addressing the entire

community. Smart Location and Linkages encourages the community to address transportation and preserve sensitive lands and discourages sprawl. Neighborhood Pattern and Design encourages communities that are healthy, diverse, and walkable. Green Infrastructure and Buildings bring into play the remediation of Brownfields and prioritizes infill site redevelopment.

With numerous redevelopment projects and limited funds, these third party rating systems will play an important role in sustainable redevelopment. Third party rating systems provide a monitoring and recordkeeping system that ensures properties are cleaned to a standard allowing for their highest and best use. Dashboards provide decision support by providing tools that enable stakeholders to analyze and visualize key performance indicators. Coupled with GIS, these tools provide interactive spatial models that correlate environmental, social, and economic data and make it easier for users to peruse data and identify trends and, ultimately make informed decisions.

Our study confirms that in the case of Passaic County, New Jersey, Brownfield redevelopment in higher socioeconomic areas realize a greater potential value than properties in neighborhoods of lower value or those on the fringe (Brasington & Hite, 2005). However, such studies have often involved goals that are in direct conflict with sustainable development, since the latter encompasses a much wider social responsibility than pure economic performance. This study focuses on employing the third party rating systems, using them to prioritize various projects, and comparing the outcomes from these rating systems to determine which projects have the higher potential for

redevelopment. The Dashboard applies a multi-criteria genetic algorithm framework for Brownfield reuse optimization, which improves redevelopment options based on stakeholder preferences. This allows the user to make tradeoffs among eligible options.

The study demonstrates that dashboards are effective tools that can be used to prioritize Brownfield redevelopment. We found that effective Brownfields redevelopment must consider the entire neighborhood and policy makers must consider the results of multiple scenarios in developing remediation strategies. This web-based dashboard will act as a decisional support system, which can be used for Brownfield Redevelopment planning by decision makers at local and regional levels alike.

3.5 References

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Chapter 4

Decision-Support Models and Tools for More Sustainable Societies: Prioritizing Sustainable Development Projects for Public Complexes

Abstract

The prioritization of urban redevelopment to achieve sustainable neighborhood revitalization has received considerable attention. The context for this study is research supporting the development of an environmental management decision-support tool for prioritizing sustainable development projects for large public complexes, especially for those sites built on historic landfills and Brownfields. These sites include publicly owned properties such as colleges, universities, prisons, military bases, and hospital centers, which have expansive footprints, where, “storm water runoff occurs, or snowmelt flows over hard surfaces such as roads, driveways, and parking lots, instead of soaking into the ground” (Rutgers, 2014). According to the fifth and final volume of the United Nations Intergovernmental Panel on Climate Change (IPCC), these sites not only have an impact on water quality, they also have a direct effect on air quality and climate change. With numerous redevelopment projects and limited funds, we anticipate that spatial decision-support systems (SDSS) can play an important role in prioritizing sustainable development of these large complexes. The current study utilizes a business intelligence executive-dashboard as an interactive tool to gather and consolidate data and to present an evaluative means for decision-makers. In this study, satellite images and GIS datasets

are integrated into an SDSS to inform redevelopment initiatives at the public complex and landscape scale. During the investigative phase of our study area of Montclair State University, located in Northern New Jersey, it was discovered that the university was built on an abandoned quarry, which was subsequently turned into a sanitary landfill. The SDSS tool was used to identify, delineate, and remediate several areas of interest at the site. Then a Return on Investment (ROI) analysis of a solar installation project was introduced as an example of how a GIS/Remote Sensing based SDSS tool could improve the decision support process when informed by third party rating systems, stakeholder input, and spatial data analysis. We found the tool allows identification of the highest priority initiatives for both long-term and short-term redevelopment. These types of analysis are important elements of a tool-kit for implementing assessment for more sustainable societies.

4. Introduction

The fifth and final volume of the United Nations Intergovernmental Panel on Climate Change (IPCC) reports that greenhouse-gas emissions from residential and commercial buildings are affecting climate change (IPCC, 2014). According to the report, "...global emissions of greenhouse gases have risen to unprecedented levels despite a growing number of policies to reduce climate change. Emissions grew more quickly between 2000 and 2010 than in each of the three previous decades" (IPCC, 2014). The report also indicates energy use and subsequent greenhouse-gas emissions from the built environment are growing and, without coordinated action, will continue to grow.

However, the IPCC (2104) report, suggests the technology needed to reduce energy use and reduce emissions currently exists and cautions that, if solutions to energy use and emissions are not acted upon now, it will be harder to find affordable methods to avoid severe long-term climate extremes. According to Chris Pyke (2014), one of the authors of the report, "...buildings, in the broadest sense, must be part of a coordinated, economy-wide effort to address greenhouse-gas emissions. Buildings offer some of the most cost-effective mitigation opportunities and absent action in the building sector create long-term challenges."

The context for this study is research supporting the development of an environmental management decision-support tool for prioritizing sustainable development projects for large public complexes, especially college campus sites built on

historic landfills and Brownfields. Brownfields are real property whose expansion, redevelopment, or reuse may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant (USEPA, 2013b).

Brownfields differ from Superfund sites in the degree of contamination. Superfund sites pose a real threat to human health and/or the environment. Brownfields are not enough of a serious health or environmental threat to warrant cleanup, under the Federal Superfund program. Instead, they represent a local economic or social threat, since they prevent development and, therefore, stifle local economies. (USEPA, 2003)

These publicly owned Brownfields include properties such as colleges, universities, prisons, military bases, and hospital centers, which have expansive footprints, where “storm water runoff occurs, or snowmelt flows over hard surfaces such as roads, driveways, and parking lots, instead of soaking into the ground” (Henthorn, 2013; NJDEP, 2014; Rutgers, 2014). As noted by Bilodeau, Podger, and Abd-El-Aziz (2014), colleges, universities and other institutions of higher education have a unique opportunity, and a responsibility to “... provide a leadership role to develop and mobilize knowledge to meet societal needs... and, in fulfilling this mission, universities can also serve as agents of sustainable development on campus and in communities they serve.”

The prioritization of redevelopment of large public complexes has received considerable attention (Kunc, Martinat, Tonev, & Frantal, 2014; Kurtović, Siljković, & Pavlović, 2014). However, there is limited literature available regarding the integration of spatial analysis, urban redevelopment, sustainability, and third party rating systems utilizing a Business Intelligence Dashboard. With numerous development projects and

limited funds, we anticipate that third party rating systems can play an important role in prioritizing sustainable campus development.

Third party rating systems provide a monitoring and recordkeeping system that ensures properties are developed to a standard of their highest and best use. Dashboards provide decision support by providing tools that enable stakeholders to analyze and visualize key performance indicators. Coupled with GIS, these tools provide interactive spatial models that correlate environmental, social, and economic data and make it easier for users to peruse data, identify trends, and make informed decisions.

4.1 Materials and Methods

4.1.1 Study Area: Montclair State University

In 2002, New Jersey Governor James E. McGreevey signed into law Executive Order #24 (USGBC, 2011), requiring that all new schools incorporate Leadership in Energy and Environmental Design (LEED) guidelines, which requires the New Jersey Economic Schools Construction Corporation to use LEED standards, but not requiring certification of new projects built under its \$12 billion public school construction program. In 2008, Governor Corzine signed Senate Bill 843 into law, requiring all new state-owned buildings of 15,000 square feet or greater to earn LEED Silver certification or an equivalent certification, as determined by state authorities.

This paper focuses on how the LEED process is utilized in a spatial decision support system (SDSS) dashboard at Montclair State University (MSU). The SDSS allows tracking of sustainability projects from design through construction to final

certification of occupancy (CO). It is used to review options and strategies to determine the feasibility of implementing LEED standards. It allows decision-makers to evaluate lessons learned and other potentially valuable tactics being developed for green building initiatives. The current study looked at the economic impact of LEED to help stakeholders ascertain what added costs were incurred to comply with the LEED standards. Cost estimates are input into the dashboard, which provide a comparison of the potential increase in up-front costs when designing a sustainable building.

In the case of University Hall, and other green building initiatives on MSU's campus, management of the construction projects with the LEED process can improve existing environmental management problems and minimize environmental impacts. If the strategy highlighted in this study is implemented in other public complex construction projects, the social, political, economic, and educational value of the campus as a living laboratory could be enhanced.

When Montclair State University, New Jersey's second largest university opened in 1908 as the New Jersey State Normal (i.e. Teacher's) School at Montclair, there were one hundred and eighty seven (187) students on the twenty-five (25) acre campus. Over the past one hundred years, the school has grown to encompass 246 acres, and is spread over three towns in Northern New Jersey, (Montclair, Clifton, and Little Falls), and two counties (Essex and Passaic). The campus has over 20,000 undergraduate and graduate students (95% are New Jersey natives), and is the size of a small city.

As a clear indication of its commitment to sustainability in education and

environmental issues, in 2008 Montclair State University became the first educational institution in the nation to sign a Memorandum of Understanding (MOU) with the Environmental Protection Agency (EPA) committing to utilize the latest green technologies and practices (USEPA, 2008). By signing the MOU, the University agreed to the management and operational principles that will ensure that it will meet high environmental standards and reduce its carbon footprint. The University pledged that green activities and sustainability would be integrated into all facility operations. In addition, the University agreed that all new buildings constructed on campus would incorporate green building technology and materials.

The University has been working on initiatives to reduce its carbon footprint in keeping with the 2007 American College and University Presidents' Climate Commitment (ACUPCC) agreement. The commitment requires that each signatory institution engage in activities through research, educational programs, and reduction of greenhouse gas emissions to reduce its negative environmental impact on the planet. One of its main objectives is that colleges supply a progress update regarding their activities. The dashboard is able to fulfill that objective.

On October 24, 2012, in keeping with the United Nations Decade of Education for Sustainable Development, Montclair State University celebrated the 10th Annual Campus Sustainability Day by confirming its commitment to being a "Green Campus", and by establishing a United States Green Building Council (USGBC) Center for Green Schools Student Chapter (MSU Green Team) (MSU, 2014). In August 2013, a new

cogeneration plant designed to supply electricity, hot water, and centralized cooling was put into operation on the main campus. This venture was made possible through a public-private partnership between the University and UMM Energy Partners, LLC. This plant replaces an older, less efficient and less effective cogeneration plant, which did not supply centralized cooling to the campus buildings. The new plant, which uses natural gas for electric energy production, continuously produces 5.7 megawatts of power. The excess electric energy from the cogeneration plant is sold to PSE&G New Jersey, under contractual terms of agreement. The construction of the plant indicates MSU's commitment to achieving carbon neutrality and reducing its environmental impact.

4.1.2 Dashboards for decision support for public complexes.

The recent IPCC (2014) report suggests that the technology that is needed to reduce energy use and reduce emissions currently exists and cautions that, if solutions to energy use and emissions are not acted upon now, it will be harder to find affordable methods to avoid severe long-term climate extremes. The Spatial Decision Support System leverages Geographic Information System (GIS) and Remote-Sensing methodology to enhance the technology needed to support sustainable development decision-making for Public Complexes.

The dashboard is based on third party rating systems, which, for Montclair State University included the United States Green Building Council's LEED for New Construction, LEED for Schools, LEED for Existing Buildings Operations and Maintenance, and LEED for Neighborhood Redevelopment (Altomonte & Schiavon,

2013; Hersh, 2005; USGBC, 2014).

The purpose of the dashboard is to identify those projects that met the prerequisite LEED points and are, therefore, eligible for development under the LEED standards for green infrastructure, urban design, operations and maintenance, and green construction. The items operationalized within the Dashboard include, “an exterior building and site-maintenance program, metering water and energy use, selection criteria for environmentally preferred products and practices for cleaning and alterations, sustainable purchasing policies, policies for waste stream management, and monitoring for ongoing indoor environmental quality” (USGBC, 2009).

4.1.3 Data collection and analysis

To determine which area of the site were previously disturbed, which meets the LEED site selection prerequisite, we used Remote Sensing (RS) image analysis utilizing New Jersey's 2012 - 2013 High Resolution Orthophotography (Banzhaf & Netzband, 2004; Talen et al., 2013). The features necessary to calculate measurements and map design elements were imported into the GIS, and were subsequently evaluated to determine the potential use of these procedures for selected LEED points. To complete the analysis, a supervised classification of aerial photographs was performed and a subset of the Landsat scene was classified to divided data spaces into discrete regions.

In the case of making a campus land-cover map, these regions corresponded to land cover types. The classification was done using the Maximum-Likelihood algorithm, which required training the computer to recognize the patterns of Brownfields in the area of interest (AOI). This required a supply of signatures composed of training data. The

parametric signatures contained the pixel values from the bands of a Remotely Sensed image. Statistics were extracted and used to define decision boundaries. The RS data set was then divided into those discrete regions. The computer was programmed to identify pixels with similar characteristics such as roof, streets, parking lots, ball fields, and undisturbed areas of the campus.

During the construction of the first LEED Certified building, the university requested a feasibility study early in the design phase to determine the benefits and the cost of the proposed design strategies. Based on the study, it was determined that many of the LEED points that were sought incurred no additional cost; those points that did incur added costs contained beneficial attributes to offset the first cost investment. The project was designed to include the strategies sought and the bids for the project came in on budget, consistent with cost estimates. Although some particular systems and materials may have a premium cost, integrating those solutions into the overall design led to a project cost that met the expectations of the University and the project budget. Through a thoughtful integrated design process, University Hall at 275,000 square feet could be listed (at its completion in 2006) as one of the largest high-performance buildings in the State of New Jersey Higher Education System. Table 4.1 is a list of some of the LEED strategies used for the University Hall/New Academic Building:

Table 4.1 LEED Points received for University Hall

LEED Points	Point received/Points Available
Sustainable Sites	5/14
Water Efficiency	4/5
Energy Atmosphere	4/17
Materials & Resources	6/13
Indoor Environmental Quality	8/15
Innovation & Design	1/5

Through a near real-time LEED tracking report, the project team was able to document all relevant construction phase activities to ensure that the intended design strategies were implemented in the field. The University estimated 28 LEED points at the design phase. The minimum number of points required for a LEED-Certified building is between 26 and 32 points.

4.1.4 Cost-Benefit Analysis of PV Solar Installation

The dashboard includes results from a capstone project (Secilmis, Singh, Patel, Gayle, & Wu, 2011) (Appendix A). The goal was to conduct a cost/benefit analysis of installing solar panels (PV) at the university, to determine if this reduces the campus' overall energy cost. "In higher education and particularly public institutions, saving energy and developing clean energy sources yields two powerful benefits. It reduces the emission of eco-contaminants to the environment, and it saves money" (Secilmis et al., 2011).

PV site-selection feasibility analysis using geographic information system (GIS) and remote sensing (RS) are new mapping and spatial analysis technologies. Remote sensing and GIS were used to analyze aerial photos, building footprints, parking lot areas, open space, etc. to determine the most feasible locations for solar farm, rooftop solar panels, and parking lot canopy panels. GIS and Remote Sensing were also used as a tool

for a preliminary feasibility study to evaluate the technical constraints, economic opportunities, and challenges at the sites. Some of the constraints include limiting PV installation to MSU owned real estate parcels and including only MSU owned buildings in the analysis. The energy generated by the PV has to be consumed at the building site or the most nearby MSU building. Obstruction by trees, roof gables, chimneys, buildings, and other surrounding features will limit PV capacity.

4.2 Results and discussions

The development of the Dashboard began with input of 1930 and 1954 Sanborn maps and aerial photographs. GIS was used to join this data with publicly available information from the University, US Census data (2000 and 2010), Land Use/Zoning data, and property tax records from the New Jersey Tax Record Database. During the investigative phase of the study, it was discovered that the university was built on an abandoned quarry (Houdaille Quarry), which was subsequently turned into a sanitary landfill. These documents were digitized and overlaid with current AutoCAD layers to create Figure 4.1.

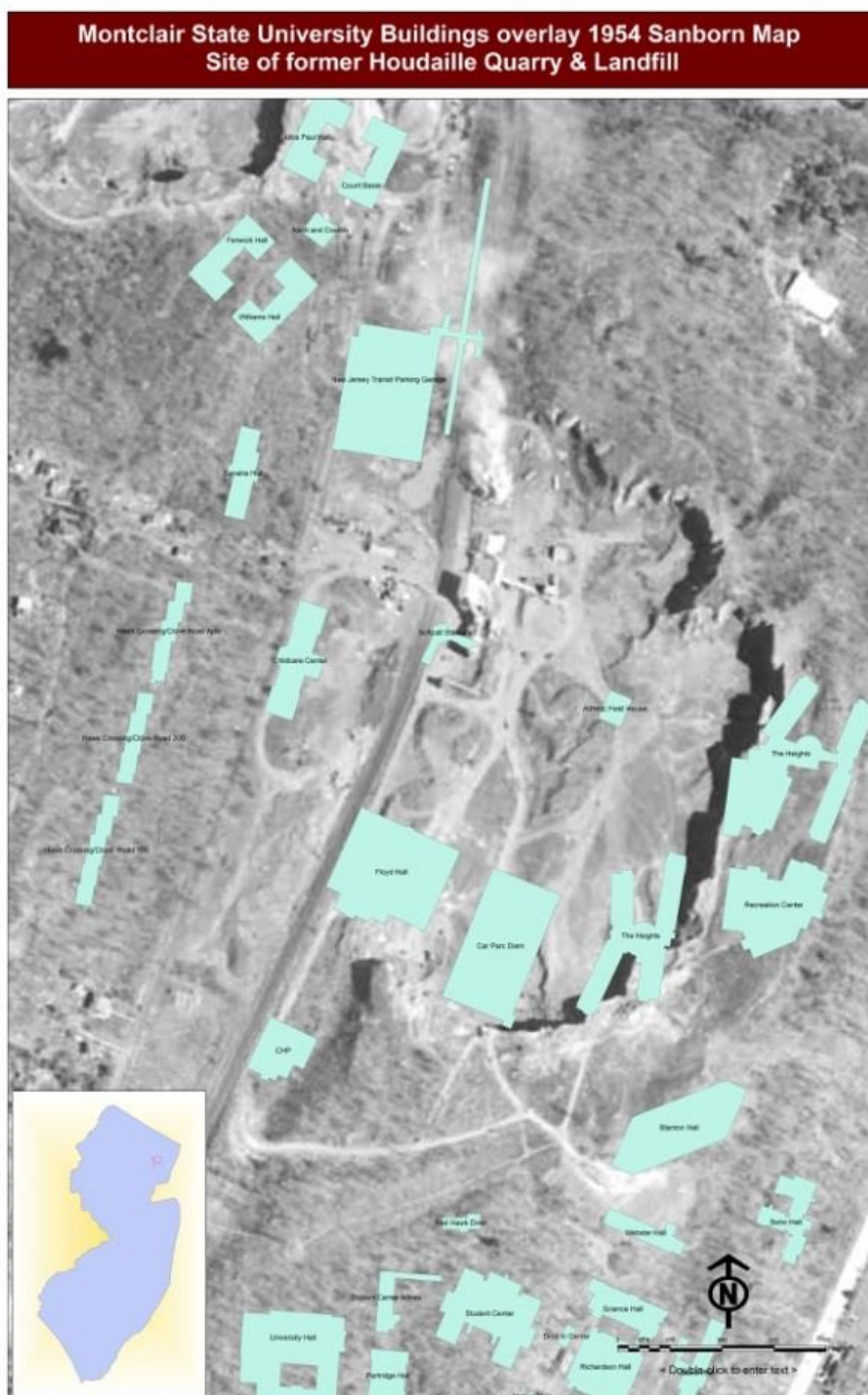


Figure 4.1 Former Houdaille Quarry & Landfill with overlay of MSU buildings



Figure 4.2 Map of potential solar panel locations based on site suitability analysis

4.3 Conclusions

According to the United State Green Building council, (USGBC, 2014) "...a Green Campus is a higher-education community that is improving energy efficiency, conserving resources, and enhancing environmental quality by educating for sustainability and creating healthy living and learning environments." Therefore, the goal is to improve the development of the Spatial Decision Support System (SDSS) dashboard for sustainable development towards the expansion of a Green Campus at Montclair State University.

Today, colleges and universities can be regarded as small cities, especially in regards to their size, population, and the complexities of activities that occur within, and in proximity to, their property boundaries (Alshuwaikhat & Abubakar, 2008). At Montclair State University, these operations and activities can be as diverse as safety oversight during the construction of research laboratories and health centers, conference centers, lodging, art studios, and museums. The campus contains cafeterias, student housing, power plants, and sports facilities. Campus transportation activities include bus and vehicle fleet operation and maintenance. The SDSS dashboard will be a valuable tool to monitor recycling, wastewater treatment, construction, demolition, grounds maintenance activities, as well as the management of hazardous materials, ozone-depleting substances, asbestos, and hazardous wastes.

The dashboard is able to identify those projects that met the prerequisite LEED points and are, therefore, eligible for development under the LEED standards for green infrastructure, urban design, operations and maintenance, and green construction. Several

items are operationalized in the Dashboard, which include “an exterior building and site-maintenance program, metering water and energy use, selection criteria for environmentally preferred products and practices for cleaning and alterations, sustainable purchasing policies, policies for waste stream management, and monitoring for ongoing indoor environmental quality” (USGBC, 2009). The dashboard can be used to “inform green infrastructure use of vegetation, soils, and natural processes to manage storm water and create healthier urban environments” (Alshuwaikhat & Abubakar, 2008).

4.4 References

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CHAPTER 5

5. Conclusion

The worldwide population is expected to increase from 7 billion today to 9.3 billion in 2050 and 10.1 billion in 2100 (Lee, 2011). Nowhere is this population growth more evident than in the major cities of the world, where this rapid increase, coupled with an aging infrastructure and the abandoning of urban manufacturing sites, has created a need for urban redevelopment (IPCC, 2012, 2013). As the population continues to increase, researchers are investigating new techniques that promote economic growth and sustainable development, while minimizing the environmental, social, and economic impacts of urban sprawl (Hak, Kovanda, & Weinzettel, 2011).

The concept of sustainable development, introduced in 1987, at the World Commission on Environment and Development, is the path of progress, which meets the needs and aspirations of the present generation, without compromising the ability of future generations to meet their own needs (Brundtland, 1987). However, twenty-seven years later, the evidence of generations of non-sustainable development is still around us, with an estimated five hundred thousand Brownfields and five million acres of abandoned industrial land throughout the United States (USEPA, 2013).

Brownfields represent economic and social threats, since they affect property values, prevent community development, and, therefore, stifle local economies. While the population growth phenomenon is global, sustainable development issues and resolutions are regional and local. The challenge of a population increase for local and regional

decision-makers is deciding how to prioritize urban redevelopment projects, to achieve holistic and sustainable development at the neighborhood scale (Bleicher & Gross, 2010; Hawkins & Wang, 2012).

Recent studies show that a particularly powerful online toolset, such as this study's Executive Dashboard, can gather information on complex business and economic issues and consolidate valuable information to assemble, integrate, and disseminate data, thus facilitating decision-making (Hu, Almansoori, Kannan, Azarm, & Wang, 2012; Indelicato, 2012). Several dashboards have been developed to show progress towards urban and regional sustainability goals. At the municipal level, dashboards have been developed for the cities of Padua (Italy) and Atlanta, Georgia (USA) (Edwards & Thomas, 2005; Scipioni, Mazzi, Mason, & Manzardo, 2009). At the regional level, the Hartford–Springfield Economic Partnership, a consortium of central Connecticut and western Massachusetts stakeholders, developed a dashboard that tracks indicators in several areas of environmental, economic, and social sustainability. The dashboard for the Hartford–Springfield development was established to provide information to the community, and the indicators developed for the project are important for guiding the plan's policies and implementation. According to the dashboard developers (HSEP, 2012), "...if the performance measures show progress towards a goal, then planners can assume the strategy is working."

Although it seems that dashboards are an effective decision support tool for business intelligence (BI) and most recently for regional and municipal administration,

similar ideas are ideally suited for conveying information to community development leaders at the neighborhood level. There is, however, limited literature available regarding the integration of spatial analysis, and third party rating systems, utilizing a business intelligence dashboard, to prioritize neighborhood redevelopment projects. This research tackles this task via the development of a dashboard for Leadership in Energy and Environmental Design for Neighborhood Development (LEED-ND) purposes. In particular, we developed our Dashboard based on ESRI's Executive Dashboard.

ESRI's Executive Dashboard was developed in November 2012, as a business management tool to be used by local government leaders who need to make decisions with geographic information analysis capability. The dashboard allows stakeholders to identify trends, raise questions, and devise new environmental management and business continuity strategies based on not just socioeconomic and environmental data, but the geographic whereabouts of those data, which provides an immediate location-orientation for decision-makers to answer not only the question of what needs to be done, but where to start first (ESRI, 2012).

The recent study suggests that a prescriptive approach to urban development, the third party rating system, coupled with a dashboard, as a data visualization tool to display the status of redevelopment, can provide feasible and intuitive integration of data in which to prioritize neighborhood redevelopment. The study presents a new framework and key sustainability indicators, based on existing third party rating systems, and introduces these assessments into a Spatial Decision Support System, utilizing a

dashboard as an interactive tool to gather and consolidate data and to present an evaluative means for decision-makers. The aim of the research is to advance knowledge for new concepts for sustainable urban redevelopment projects using decision frameworks for selection among alternative Brownfield redevelopment projects. The tool allows identification of the highest priority sites for long-term and short-term redevelopment of distressed properties.

The first goal of the study was the development of a framework for a spatial decision support system for sustainable development, allowing key decision makers (e.g. federal, state, and local government agencies, and local community development leaders) to improve the allocation of scarce resources. The modeling tool used in the study is similar to ones adapted to model urban residential development (Balmori & Benoit, 2007). Performance indicators were extracted from the data collected during the research and displayed on an online dashboard. The dashboard was designed as an interactive tool, to gather and consolidate information on environmental, social, economic, and political data, in simple graphical formats such as charts, graphs, and maps, and provide stakeholders with a means to visualize and prioritize Brownfields redevelopment, from initial assessment and identification, to its beneficial reuse. The result of this endeavor provides an analysis of what different strategies mean for a community's ability to prioritize the Brownfield redevelopment that occurs in their area, and how third party rating systems aid in such an undertaking. This model can be scaled up, or down, to enable decision-makers to make informed assessments at the national, regional, or local level.

The second goal was to characterize and analyze the relationship between environmental variables and the appearance of Brownfield sites. The hypothesis is that accurate identification and documentation of Brownfields affect the success of redevelopment projects. The study's Brownfield redevelopment prioritization method builds upon an application developed by Criterion Planners, consisting of seven parcel-level steps identifying and prioritizing LEED-ND eligible locations (Planners, 2011, 2012; Talen et al., 2013). We confirmed through windshield surveys that LEED-ND's environmental and/or socioeconomic variables are often linked with the appearance, and therefore, the value of properties.

The third goal was to develop an environmental management decision-support tool for prioritizing sustainable development projects for public complexes, especially for those built on historic landfills, which are also considered Brownfields. The study suggests the dashboard is a valuable tool for prioritizing development of large publicly owned campuses such as colleges, universities, prisons, and hospital centers with expansive campus footprints, "where storm water runoff occurs when it rains, or snowmelt flows over hard surfaces such as roads, driveways, and parking lots, instead of soaking into the ground" (Rutgers, 2014). Campus sustainability is an important element of a tool-kit for implementing assessment for more sustainable societies (Bilodeau, Podger, & Abd-El-Aziz, 2014; Peterson, 2013). The dashboard included real-time and near real-time sensors, meters, and monitors, which enabled decision-makers to measure Leadership in Energy and Environmental Design (LEED) energy use and Indoor Air Quality indicators.

5.1 Environmental Management Implications

One aim of this research was to investigate the effects of Environmental Management Legislation, in particular, Brownfields, Smart Growth, and Anti-Sprawl Legislation on urban redevelopment, as applied within Northern New Jersey. The study suggests the dashboard can be further developed, beyond local sustainable urban redevelopment analysis, to enable decision-makers to identify populations most vulnerable to environmental health and safety hazards. At a national level, according to the United States Environmental Protection Agency (USEPA) (2013), Brownfield redevelopment creates many benefits for local communities. The agency asserts that Brownfield revitalization leveraged \$17.79 per each dollar that EPA expends and leveraged 85,883 jobs nationwide. Successful redevelopment projects can increase residential property values 2 to 3 percent, when nearby Brownfields are addressed, and can promote area-wide planning (USEPA, 2013).

5.2 Limitation of the study

During the redevelopment process, a vast amount of data often inundates decision makers. However, it is often found that the data needed to evaluate emergencies are not readily accessible (Rall & Haase, 2011; Solitare & Lowrie, 2012) or in a format that allowed for the simple adaptation of existing metrics and management frameworks to produce an adequate set of decision-making tools (Edwards & Thomas, 2005; Mississauga, 2009). The quantity and quality of the data received are usually in a format that makes it difficult for decision-makers to process the data into information and make it available in a visual and actionable way. The GIS based Executive Dashboard acts as

an integrating framework to bring these data and technologies together.

The data used in the study are freely available, and since the data is in the public domain, requirements for a research materials agreement or review by the Institutional Review Board (IRB) are waived. The datasets include the New Jersey Department of Environmental Protection's Known Contaminated Site list, the Department of Community Affairs, "Site Mart" database, and the Passaic County Brownfield inventory. Several GIS layers were created or used to compute the variables of interest for the study. Property value layers were derived from the 2010 New Jersey Property Tax System (MOD-IV) database. A Socio-economic Index and a population density layer were derived from United States Census (2010 Block Group level) data. Unemployment rate data was acquired from ESRI, and an Environmental Index was developed, based on past use of the sites.

The study used Remote Sensing (RS) image analysis utilizing New Jersey's 2012 - 2013 High Resolution Orthophotography (Banzhaf & Netzband, 2004; Talen et al., 2013). The features necessary to calculate measurements and map design elements were imported into the GIS, and then evaluated for the potential use of these procedures for selection of Brownfield properties. Our study classifies features and constructs a model in an attempt to analyze economic activity since properties may run the extreme from complete abandonment to multi-year environmental remediation. The data collection portion of the study involved recording data with GPS equipment (during onsite and windshield surveys) and comparing those data with information provided by the commercial remote-sensing applications, to analyze location errors and site desirability.

Each site was evaluated and prioritized as to its importance for economic redevelopment and viability for receiving further assessment. The study showed positive results of identification, assessment, and documentation of Brownfields in Passaic Counties. While the local government decision-makers have the greatest need for such information, other parties responsible for Brownfield inventory, site assessment, and documentation may benefit from a similar approach.

Results from Geographic Information Systems and Remote Sensing analysis are sensitive to the Modifiable Areal Unit Problem (MAUP) and to the choice of the delineation of the study areas (Dark & Bram, 2007; Koohsari, Badland, & Giles-Corti, 2013). “MAUP occurs during the spatial analysis of aggregated data in which the results differ when the same analysis is applied to the same data, but different aggregation schemes are used. An analysis using data aggregated by county will differ from analysis using data aggregated by census tract” (ESRI, 2013). To avoid errors that may arise from MAUP, the current study measured sustainable development projects at the building, parcel (landscape), and block level, then aggregated demographic data from the United State Census (2000 and 2010) to the Block group level (Nielsen & Hennerdal, 2014; Pearce, Schindler, Jaeger, & Caruso, 2013).

5.3 Future research

According to the United State Green Building council, (USGBC, 2014), “...a Green Campus is a higher-education community that is improving energy efficiency, conserving resources, and enhancing environmental quality by educating for

sustainability and creating healthy living and learning environments.” It is, therefore, my goal to work with MSU faculty, staff, students, and the community to improve the Spatial Decision Support System (SDSS) dashboard for sustainability and sustainable development initiatives towards the development of a Green Campus at Montclair State University.

Today, colleges and universities can be regarded as small cities, especially in regards to their size, population, and the complexities of activities that occur within, and in proximity to, their property boundaries (Alshuwaikhat & Abubakar, 2008). At Montclair State University (MSU), these operations and activities can be as diverse as safety oversight during the construction of research laboratories and health centers, conference centers and lodging, art studios and museums. The campus contains cafeterias, student housing, power plants, and sports facilities. Campus transportation activities include bus and vehicle fleet operation and maintenance. The SDSS dashboard will be a valuable tool to monitor recycling, wastewater treatment, construction and demolition, grounds maintenance activities, as well as the management of hazardous materials, ozone-depleting substances, asbestos, and hazardous, solid, infectious, and radiological waste. The dashboard can be used to inform green infrastructure use of vegetation, soils, and natural processes to manage storm water and create healthier urban environments on MSU’s campus. My goal is further development of the SDSS to, “increase accessibility to LEED for university facilities and campus development, to support student leadership and advocacy efforts, and to promote sustainability in the (MSU) curriculum (Center, 2013).

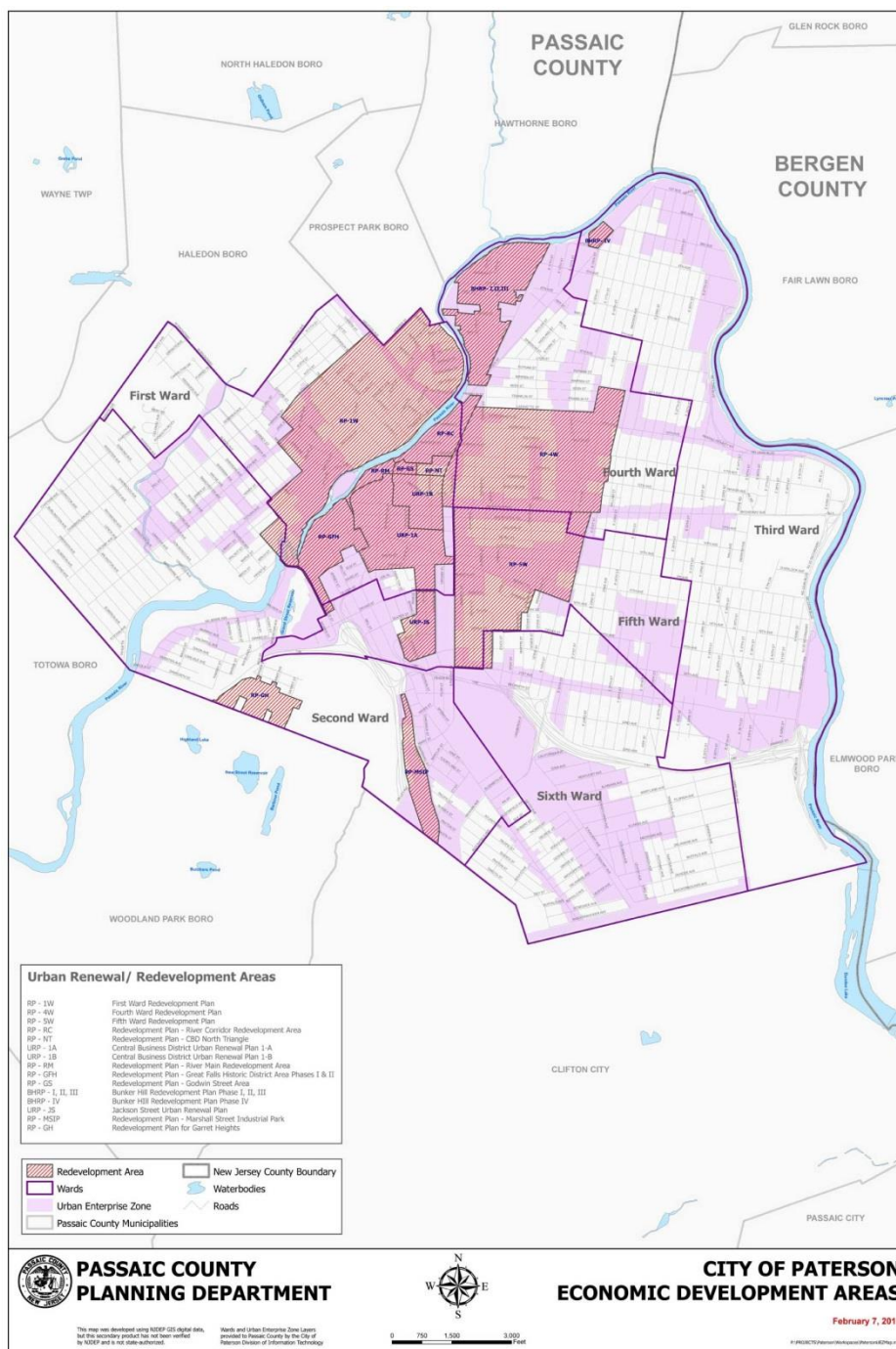
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APPENDIX A

City of Paterson, NJ Economic Development Areas

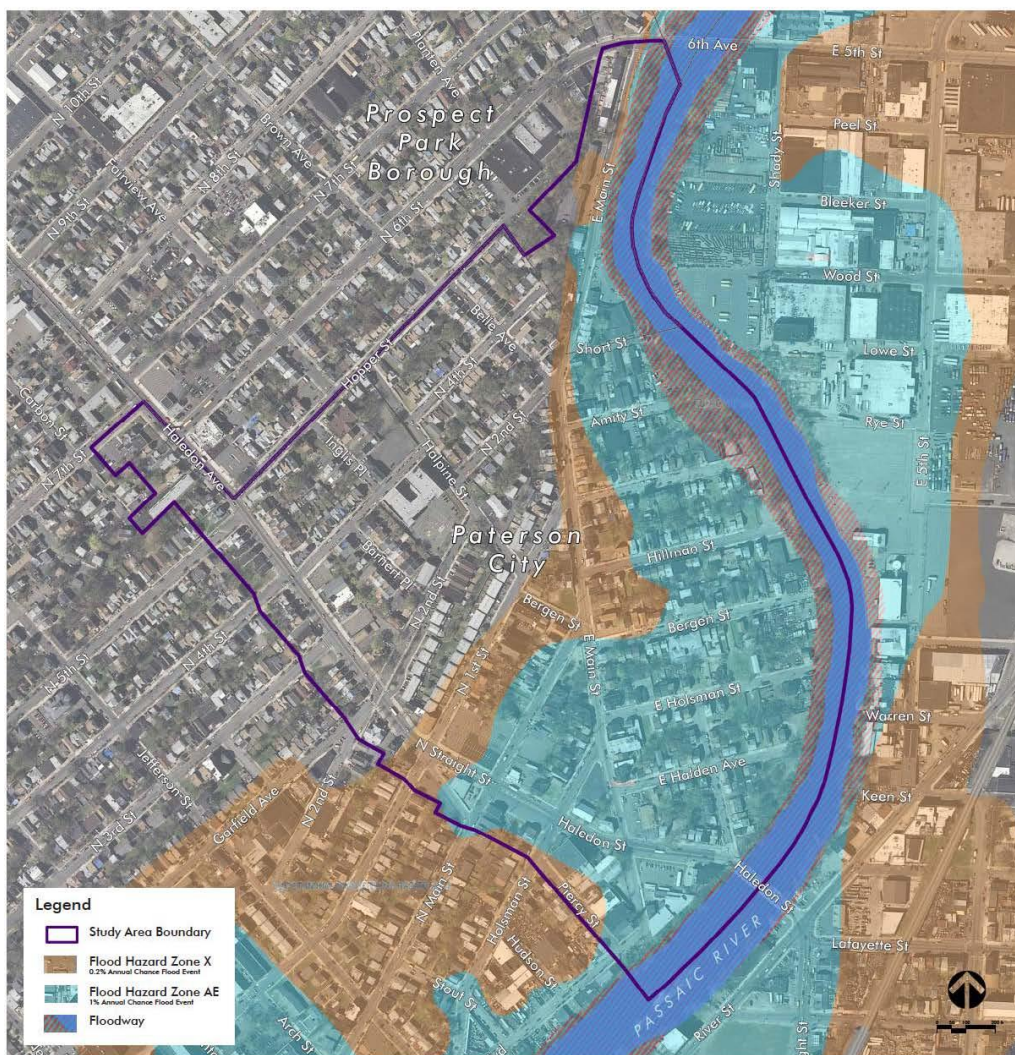


Paterson Northside Community Action Plan - Together North Jersey Study Area



PATERSON NORTHSIDE COMMUNITY ACTION PLAN - Paterson City, Passaic County


STUDY AREA



APPENDIX B

Montclair State University, University Hall, LEED Certification Project

PROJECT PROFILE



**MONTCLAIR STATE UNIVERSITY
UNIVERSITY HALL
MONTCLAIR, NEW JERSEY**

22% less energy use

48% less water use

50% of construction waste diverted from the landfill



LEED® Facts
Montclair State University
University Hall
Montclair, New Jersey

LEED for New Construction 2.1
 Certification awarded September 2008

Certified	28*
Sustainable Sites	5/14
Water Efficiency	4/5
Energy & Atmosphere	4/17
Materials & Resources	6/13
Indoor Environmental Quality	0/15
Innovation & Design	1/5

*Out of a possible 69 points

PROJECT PROFILE

MONTCLAIR STATE UNIVERSITY - UNIVERSITY HALL - MONTCLAIR, NEW JERSEY

From Gray to GREEN

Montclair State University Turns Parking Lot into Campus Icon

PROJECT SUMMARY

In 2002, Montclair State University, New Jersey's second largest and fastest growing university, identified the need for a new flagship, mixed-use facility to rejuvenate and enhance its expanding campus, both academically and physically. The University's goal was to accommodate the massive building program in an architectural style reminiscent of its historic campus buildings, on the 5-acre site of a treeless 400+ car parking lot, at the outer edge of the academic campus core.

UNIVERSITY HALL FACILITIES

Designed in the university's distinctive Spanish Mission style architecture, University Hall is the largest and most sophisticated building in Montclair State University's history, and has become the campus icon for learning and teaching excellence in the 21st century.

The south wing of University Hall provides a state-of-the-art new home for the university's nationally recognized College of Education and Human Services, including the ADP Center for Teacher Preparation and Learning Technologies, the Center for Pedagogy, the Literacy Enrichment Center, the Institute for the Advancement of Philosophy for Children, and offices and conference rooms for the more than 150 faculty and staff in the College of Education and Human Services.

Two floors of the north wing of the building are dedicated to the university's information technology services and house a large Information Commons and Technology Solutions Center for students, faculty and staff.

Located on the seventh and top floor of University Hall is the region's newest and most sophisticated conference center and banquet facility, complete with meeting, conference and event space for groups of up to 500 people.

PROJECT CHALLENGES/ACHIEVEMENTS

- The contextual design of the university's largest building in its distinctive Spanish Mission style, while maintaining a sense of the building's size and scalability in relation to the rest of the campus;
- An extremely brief and firm timetable of three years from start of design to end of construction - and a fixed budget of little more than \$54 million;
- A complex list of specific programming criteria that included 52 classrooms, administrative offices for two large academic departments, open lecture areas on the bottom floors and a spacious conference center at the uppermost level;
- A building site that had once been a rock quarry, making soil conditions problematic. Much of the underlying soil had to be removed and replaced with soil that could withstand the structure's weight;
- More than 1000 cu yds of rock removed from the site was crushed and reused on site.
- An institutional intention to incorporate sustainability in design and materials.

LEED STRATEGIES & RESULTS

- Storm-water management, featuring filter units that remove dissolved phosphorus
- Water-efficient plumbing fixtures and waterless urinals
- Construction waste management
- Energy performance exceeding ASHRAE requirements by 22%
- Recycled content in steel, concrete, aluminum, gypsum board, suspended ceilings, carpet
- Certified wood for doors, trim, and blocking
- Low-Emitting materials such as paints, sealants, carpets, and composite wood products
- Native and adaptive plants eliminate irrigation requirements and reduce maintenance considerations
- Third Party Commissioning and Peer Review of MEP Design
- On Site Storage and Collection of Recyclables
- Greenguard Furniture specified throughout the Facility

© 2008 Chapter. Printed on 100% post consumer recycled, process chlorine-free paper with non-toxic soy inks. Eted molore magna feugait enim et, sent ilis alit illud et.

"University Hall is an exemplary example of environmental stewardship and our model for future buildings, in terms of accommodating the University's teaching and research program needs in an environmentally friendly manner."

University Provost Richard Lynde, as he executed the Memorandum of Understanding between the federal EPA and Montclair State University



Owner/Developer: Montclair State University
 Architect: The S/L/A/M Collaborative
 Landscape Architect: The S/L/A/M Collaborative
 LEED Consultant (design): The S/L/A/M Collaborative
 LEED Consultant (contract administration):
 Chrissner Group
 GC: Terminal Construction
 Commissioning Agent: Domotech
 Owners Representative: Walter Kanzler, Director of Design
 Montclair State University

Engineers:
 Structural: The S/L/A/M Collaborative
 Civil: Yu & Associates Inc.
 Mechanical: R. G. Vanderweil Engineers, Inc.
 Electrical: R. G. Vanderweil Engineers, Inc.
 Geotechnical: Melick-Lully & Associates P.C.

Project size: 272,000 square feet
 Construction cost: \$54 million, or \$200 per square foot
 Date of completion: 2005
 Number of floors: Seven

Photograph Courtesy of: The S/L/A/M Collaborative

ABOUT USGBC NJ

The mission of the NJ Chapter is to be New Jersey's foremost coalition in the public and private sectors promoting the planning, design, construction, and operation/maintenance of buildings that are environmentally responsible, cost effective, productive, and healthy places to live, learn, and work.



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APPENDIX C

ROI - Solar Potential Calculations for select MSU building roofs Source (Secilmis et al., 2011)

Site ID	Name	Roof Area (SF)	60% of Roof Area (SF)	Price = 8*Area* \$4.25	Energy=Area*8 (Watts)
R1	Sprague Library	47,376	28,426	966,473	227,405
R2	Blanton Hall	43,477	26,086	886,939	208,692
R3	Panzer Gym	39,775	23,865	811,411	190,920
R4	Student Center	38,753	23,252	790,565	186,015
R5	Dickson Hall	30,780	18,468	627,912	147,744
R6	Life Hall	30,373	18,224	619,602	145,789
R7	Richardson Hall	25,935	15,561	529,077	124,489
R8	Freeman Hall	25,835	15,501	527,040	124,009
R9	Calcia Hall	20,466	12,279	417,499	98,235
R10	Memorial Auditorium	17,045	10,227	347,720	81,816
R11	Bohn Hall	16,187	9,712	330,209	77,696
R12	Stone Hall	16,143	9,686	329,309	77,485
R13	Science Hall	16,013	9,608	326,665	76,862
R14	Mallory Hall	12,455	7,473	254,087	59,785
R15	Partridge Hall	12,248	7,349	249,861	58,791
R16	Mallory Hall	11,365	6,819	231,841	54,551
R17	Finley Hall Annex	10,312	6,187	210,358	49,496
R18	Webster Hall	9,825	5,895	200,439	47,162
R19	Student Center Annex	8,594	5,156	175,310	41,249
R20	Speech Building	8,400	5,040	171,358	40,319
R21	Athletic Field House	4,732	2,839	96,524	22,711
R22	University Police	4,525	2,715	92,311	21,720
		Total	309,655	9,192,511	2,162,944

Financial Analysis

Solar Energy Funding Alternative 1: Capital Investment

Cost of the project= \$24,551,007

Total electricity that will be generated from solar = 4,833,744 watts X 5 hours (per day)
X 365 days = 8,821,583 kWh per year.

Existing electricity use at MSU = 15,885,983 kWh so 55.5% will be from solar.

Existing electricity rate that MSU pays = 14 cents

Value of the electricity generated from solar = \$1,235,022

Maintenance fee = 2 cents per watt per year = \$96,675

Annual Net Cash Flow = \$1,235,022- \$96,675 = \$1,138,347

1. Payback Period

This means the time in which the initial investment made for the project is returned. It is easier to understand and hence one of the important measures for the managers to estimate the time the project will return the investment.

$$x = \frac{\text{Cost of the project}}{\text{Annual Net Cash Flow}}$$

$$X = \$24,551,007 / \$1,138,347$$

$$X = 21.6 \text{ years}$$

Our project payback period in 21.6 years it means that after 21.6 years from the project start date the initial investment will be received. As a not-for-profit entity, MSU cannot take advantage of a 30% federal tax incentive and favorable depreciation treatment. This is a big factor for private investment.

2. ROI

Return on Investment: This is a percentage expression to show how much we could gain on investment annually.

$$\text{Return on Investment} = \frac{\text{Annual Net Cash Flow}}{\text{Cost of Project}}$$

$$\mathbf{ROI} = \$1,138,347 / \$24,551,007 = 4.6\%$$

Break Even Point in time= 21.6 Years

X stands for Year. Y stands for Dollar.

