AN ABSTRACT OF THE DISSERTATION OF

Evan Erasmo Gutierrez for the degree of Doctor of Philosophy in Environmental Sciences presented on December 8, 2015.

Title: Collaborative Neighborhood-Scale Sustainability Assessment and Planning using the Spatial Optimization for Urban Resource Conservation and Engagement (SOURCE) Tool: Applying the Analytic Hierarchy Process for Spatial Decision Support

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A fundamental problem that emerges during the planning of a city or neighborhood is how to prioritize sustainable development criteria and where to focus efforts. Solving this problem is a complex task requiring an integrated approach, which considers environmental, economic, and social criteria, as well as stakeholder preferences. Given the complexity of the problem and its spatial dimensions, it may be examined by combining Analytic Hierarchy Process (AHP) methods in a Geographical Information System (GIS) environment. These approaches, which are based on the collective definition and weighting of multiple criteria and indicators of neighborhood sustainability, create a spatial decision support system (SDSS) to inform land use planning. The Spatial Optimization for Urban Resource Conservation and Engagement (SOURCE) DSS was created to identify priority development areas for the South of Market EcoDistrict, an urban renewal area in Portland, Oregon. Environmental,

economic, and social criteria and indicators were selected and evaluated through content analysis of comprehensive plans, official reports, and stakeholder-derived data. The priorities of top-down and bottom-up stakeholders were organized into a hierarchical decision structure to facilitate a series of pairwise comparisons.

This AHP-based methodology resulted in a systematic weighting of sustainable development indicators that were spatially optimized for shared public and private values. The preferences of these stakeholders were spatially modeled to identify the location of poor performing blocks in the neighborhood that have a shared interest among stakeholder groups. The final result was an SDSS that identified the most suitable sites for neighborhood-scale sustainable development projects based on a need for mitigation and shared public and private values. The ability to adapt current sustainability development indicators to the neighborhood scale was also evaluated. Combining AHP with GIS proved to be a useful method in participatory sustainability planning when alternative projects need to be identified and prioritized to guide the development of a neighborhood.

Collaborative Neighborhood-Scale Sustainability Assessment and Planning using the Spatial Optimization for Urban Resource Conservation and Engagement (SOURCE) Tool: Applying the Analytic Hierarchy Process for Spatial Decision Support

by
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APPROVED:

Major Professor representing Environmental Sciences

Director of the Environmental Sciences Graduate Program

Dean of the Graduate School

I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

Evan Erasmo Gutierrez, Author

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DEDICATION

I dedicate this work to all those who have sacrificed themselves for others; particularly, my grandparents Erasmo Gutiérrez-Colin and Laura Gutiérrez-García and my mother Patti Sander. Their love, determination, and kindness continues to inspire and uplift me. Also, to the McNair Scholars program for their encouragement and support.

Chapter 1 Introduction

The term sustainable development has become nearly ubiquitous with regards to urban planning and mitigating climate change, however it often lacks tangible conceptualization and means of operationalization, particularly at the neighborhood scale. Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their needs (Brundtland et al., 1987). The concept of sustainable development is flexible and extremely interdisciplinary; spanning several sectors from building, transportation, technology, education, food, health, and energy to name a few. However, it has also been criticized for its lack of clarity (Adams, 2006; Krause & Sharma, 2012). Typically, cities address sustainable development by adopting comprehensive plans of goals and policies as well as sustainable development projects to direct future growth. The broad concept of sustainable development projects can take many forms; a resource efficient building, green infrastructure, local goods production and sales, gathering spaces, community organizations and partnerships, as well as educational opportunities. In general, the term applies to any planned course of action to achieve environmental, economic, and social objectives (Boterro, 2015). As the impacts of global climate change have increased, cities desperately scramble to reduce their consumption of natural resources and mitigate negative impacts on ecosystem services while still finding sustainable ways to accommodate growth. With hundreds of potential sustainable development projects to select from (for examples visit http://www.sustainia.me), cities struggle to systematically and equitably select and site development projects that will have the greatest impact on sustainability.

My dissertation research study addresses the central question of how to utilize a multi-criteria spatial decision support system (GIS-MCDA) to select and site sustainable development projects at the neighborhood scale. The context behind this study lies at the intersection between three major bodies of literature including collaborative urban land use planning, neighborhood sustainability assessment and geographic information science. Research in the multi-criteria spatial decision support system context has provided empirical support for the use of GIS-MCDA for group decision making to foster sustainable land use decisions through tools to consider environmental and social outcomes along with economic (Bottero, 2015; Chen & Lin, 2011; Girard, Cerreta, & De Toro, 2012; Lee & Chan, 2008; Lofti, Habibi, & Koohsari, 2009). While much of this research focused on developing this method as a form of spatial decision analysis from an expert perspective, recently the focus has shifted to exploring how collaboration in assessment methods promotes social capital and ultimately the success of a project (Chandio et al., 2013; Gonzalez et al., 2013; Kurka, 2013; Ligmann-Zielinska, Church, & Jankowski, 2008; Poveda & Lipsett, 2013; Miller et al., 1998; Schadler et al., 2013; Strager & Rosenberger, 2006; Uribe et al., 2014). With the advancement of computer-based mapping and decision software, methods like the Analytic Hierarchy Process (AHP) have provided systematic assessment to support collaborative decision making in complex spatial problems involving conflicting viewpoints (Malczewski & Rinner, 2015). Solving these problems is an elaborate task that requires an integrated approach that considers environmental, economic, and social constraints, as well as stakeholder preferences.

Due to the intricate spatial dimensions of sustainability, it may be explored by combining Analytic Hierarchy Process (AHP), an MCDA method, in a Geographical Information System (GIS) environment. These approaches, which are based on the collective definition and weighting of multiple goals and indicators of neighborhood sustainability, create a spatial decision support system (DSS) to inform land use planning. Thus, from a sustainable urban land use planning perspective, utilizing GIS-MCDA can help to distill the decision process and engage the entire spectrum of stakeholders in the land use planning process. Since the research supports the benefits of MCDA for urban land use planning (Chandio et al., 2013; Huang, Keisler, & Linkov, 2011; Malczewski, 2006) and the GIS provides an environment to facilitate spatial analysis of decision makers' preferences (Chakhar & Mousseau, 2007; Jankowski et al., 2008; Malczewski, 1999; Reynolds & Hessburg, 2014; Schädler et al. 2013), one might wonder whether GIS-MCDA for group decision making might also have benefits for sustainable land use planning at the neighborhood scale. The main goal of the present study is to explore that possibility using a case study based in Portland, Oregon.

The South of Market (SoMa) neighborhood was chosen as the location for the study site because of the area's dedication to sustainability with the 2010 adoption of an EcoDistrict development plan along with the timing of Portland's comprehensive plan update. EcoDistricts are neighborhoods committed to advancing sustainability by integrating building and infrastructure projects with community and individual action. The SoMa EcoDistrict was chosen because of its high level of urban development and potential for partnerships. The SoMa neighborhood is an active, highly educated, and well-connected urban community where students, educators, residents, employees, and business owners live, work, learn, and play. The approximately 92-acre study area is located in the south downtown area of Portland's Central Business District bordered by SW Market Street to the north, SW Harbor Way Drive to the east, and I-405 to the south and west (see figure 1.1 for aerial photo). The area offers unparalleled transit access, a

Figure 1.1 Aerial photo of study area (Google Inc., 2015)

public research university, revered greenspaces, and a mix of residential, commercial, and retail uses.

Motivation for the Study

Although my focus on this particular area of research began developing about four years ago, my interest in community-driven sustainable development dates back much further. While working on a public-private partnership sustainable development project, in collaboration with Tribal communities in northern Wisconsin, an architectural non-profit (Design Coalition), and the University of Wisconsin with funding from the US Department of Housing and Urban Development and the McNair Scholarship, I realized what an important role collaborative planning and management had on the success of a sustainability project. With a strong natural sciences background, I understood the technical aspects of sustainability, but this was my first time experiencing the dynamic social context in which it occurred. It became clear to me that such a project does not operate in isolation, rather within a complex, interconnected social-ecological system. Thus, I began to wonder how I, as a resource manager and urban planner, might assess sustainability and design plans that incorporate a broader perspective of sustainability and implement community-relevant, place-based, sustainable solutions. Soon enough, I encountered a contemporary body of empirical literature waiting for me to explore and apply.

My desire to further investigate the field of urban sustainable development drew my attention to the urban planning mecca of Portland, Oregon. It just so happens that my entry into the graduate program coincided with a key turning point in the history of urban planning in Portland. The development of a second comprehensive plan for the city had just begun since the first groundbreaking comprehensive plan in 1980. All of the major city governance agencies, as well as an extraordinary number of stakeholders and experts, were to be involved in the planning of the city for the next 30 years. I knew this would be an exciting time to experience innovative comprehensive planning first hand.

It became immediately clear that the tone of the new comprehensive plan was a collaborative approach to community-driven sustainable development. What was unclear however, was how exactly the city would get there. There was a strong need for decision support tools and assessment frameworks. The EcoDistricts framework, developed by the non-profit Portland Sustainability Institute, immediately drew my attention as a promising approach to sustainable development. I reached out to Dr. Vivek Shandas about one of his collaborative EcoDistrict assessment projects and began working with his team in the Sustaining Urban Places (SUPR) Lab at Portland State University. Together, we reached out to district stakeholders and collaboratively, with an EcoDistrict steering committee and Portland Sustainability Institute, created a development plan for the South of Market EcoDistrict (Portland Sustainability Institute, 2012). As I further explored the field of decision support and sustainability assessment frameworks, I became increasingly interested in the ability of the Analytic Hierarchy

Process, particularly spatial AHP, to optimize or enhance, standardize, and increase equity in the decision making process. Specifically, I was excited by the potential for spatial AHP to serve as a collaborative sustainability assessment and planning tool, which is why I have dedicated my dissertation work to investigating the potential of spatial AHP assessment to optimize the neighborhood sustainable development process.

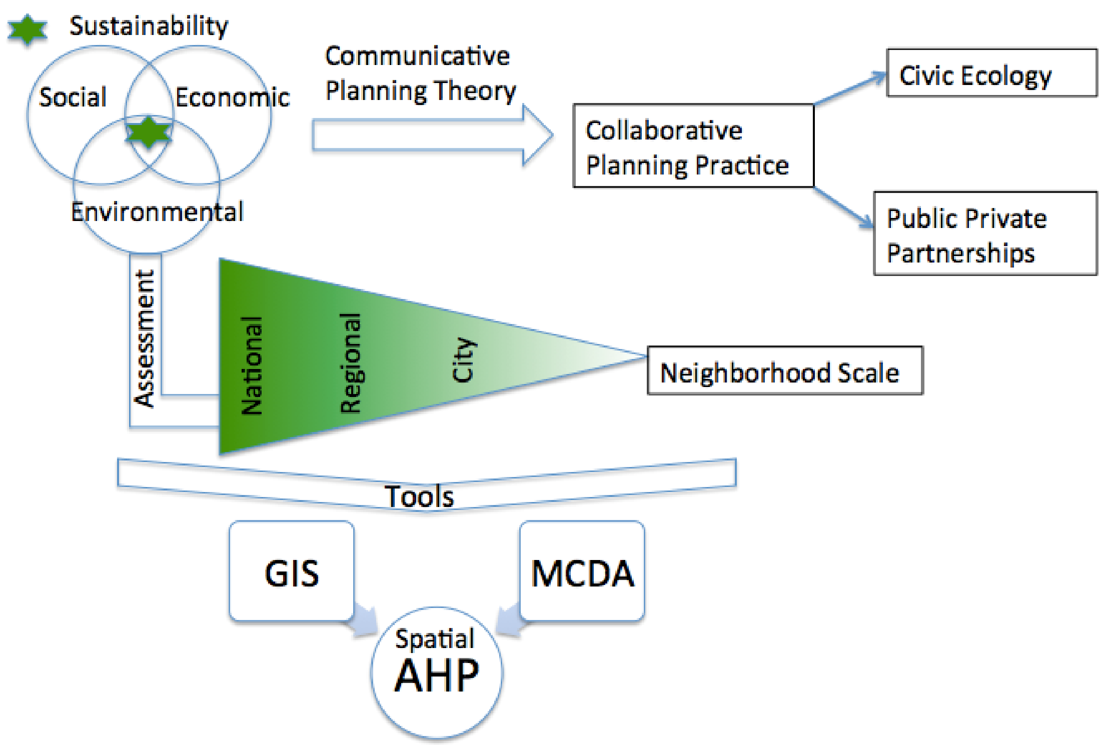
Overview

In chapter 2, I present a review of the relevant literature on collaborative urban planning, neighborhood sustainability assessment and GIS-MCDA. This allows me to position the present study within the larger bodies of research and create a space for my investigation. Chapter 3 includes the detailed methodology of assessment framework, and data collection and analysis procedures. In chapter 4, I present the results of the qualitative, quantitative, and spatial analyses and chapter 5 includes a detailed discussion and interpretation of the results and sustainable development project recommendations. I end with a conclusion chapter where I discuss broader implications and limitations of the study, as well as offer suggestions for future research. The appendices include detailed guidelines for coding and quantifying textual features in the compositions and AHP calculations used, so that other researchers can readily replicate this study.

Chapter 2 Review of Literature

A prerequisite to the investigation into the impact of GIS-MCDA for group decision making on neighborhood-scale sustainability project and site selection is a discussion of three bodies of research literature: communicative planning theory and collaborative practices, sustainability assessment, and the use of GIS to support multiple criteria decision making. The literature review begins by situating the theories of sustainable development within a collaborative planning frame work, focusing on civic ecology, and public-private partnership practices. Then I transition to a discussion of neighborhood sustainability assessments used in collaborative management settings. Narrowing the context to the multi criteria decision analysis (MCDA) methods and spatial analysis, the concepts of spatial decision support systems using AHP are presented and discussed in light of empirical findings. Finally, a descriptive examination of the research literature surrounding GIS-MCDA for group decision making and its uses, benefits, and potential challenges in land use planning situates the present study and makes a case for further investigation into the potential impact of spatial AHP-based DSSs on neighborhood scale sustainability assessment and planning. See figure 2.1 for a concept map of the topics covered in this literature review.

Figure 2.1 Conceptual map of literature review topics



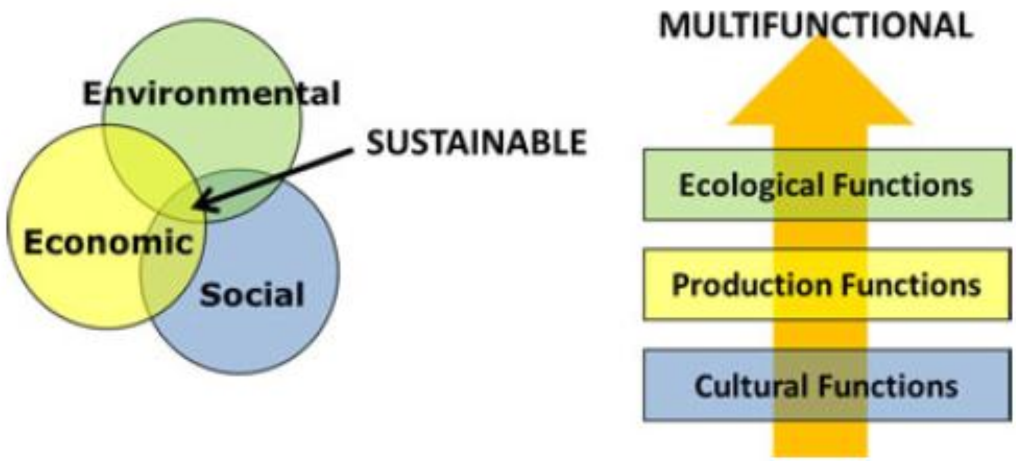
Sustainable Development

Current trends in resource management emphasize the importance of sustainable development. Strongly supported by theoretical underpinnings as well as empirical research, the goal of sustainable development has become increasingly common in a variety of contexts across the globe. Starting with the 1987 World Commission on Environment and Development's (WCED) report entitled "Our Common Future," and reinforced by Agenda 21 developed at the 1992 UN Conference on Environment and Development, sustainable development has become a global initiative (Persson, 2004). Both reports focus on defining the concept of sustainable development and the changes needed to meet that goal. To reiterate, according to Brundtland et.al, (1987), sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

While sustainable development has been defined and interpreted in a variety of ways, there are essentially four noteworthy characteristics of the construct (Grosskurth & Rotmans, 2005). To begin, sustainable development is intergenerational. It requires a period of 25 to 50 or more years. Second, sustainable development is relative to and differentiated by multiple scales and contexts. That is, what's sustainable at a local level is not necessarily sustainable at larger scales, and might not translate to other locations at the same scale. Third, sustainable development is multi-dimensional, involving economic, ecological, and socio-cultural disciplines. Thus, when defining the concept, we must situate it along the intersection of these three spheres.

Lovell and Taylor (2013) re-conceptualized sustainability in terms of landscape multi-functionality to introduce the concept of multi-functional green infrastructure. The authors incorporated the framework of landscape multi-functionality into land management decisions of urban areas to benefit environmental, social and economic systems through the use of multi-functional green infrastructure. The authors contend that the concept of multi-functionality is more tangible than sustainability when applied to the landscape scale (see figure 2.2 for conceptualization image).

Figure 2.2 Conceptual image of sustainability vs multi-functionality (Lovell & Taylor, 2013)



Sustainability is traditionally represented by the intersection of three overlapping circles: economic, environmental, and social. Similar to the concept of sustainability, landscape multi-functionality, which consists of cultural, ecological, and economic functions, can be envisioned as blocks that can be stacked to achieve greater performance. In cities, the multi-functional landscape approach is best applied through green infrastructure. Green infrastructure is a system of planned and managed networks of green spaces to provide synergistic benefits through multi-functionality (landscape Institute, 2009). Multi-functional green infrastructure can occur in open spaces that are planned or un-planned, public or private, and have been shown to increase local social capital, physical activity, visual quality, carbon sequestration, soil infiltration, microclimate control, primary production, and plant biodiversity (Lovell & Taylor, 2013).

Despite the widely accepted and innocuous fundamental characteristics, the term sustainable development has been highly contested and heavily criticized as unclear (Adams, 2006; Krause & Sharma, 2012). The holistic and elastic nature of the concept has contributed to widespread acceptance of the idea, but also to divergent viewpoints about it's definition, policy implications, and methods of implementation. The term sustainable development has been adopted by diverse groups in multiple contexts because it covers a complex range of ideas and meanings. Consequently, the term's meaning changes relative to context and user. Environmentalists, governments, urban planners, and businesses can co-opt the term to justify a management of systems to meet their own ends (Krause & Sharma, 2012). Taken to the extreme, the term is often used to consider financial criteria or environmental criteria, but rarely both or other social outcomes. By itself, the idea of sustainable development has the power to unite a diversity of people, organizations, and governments but lacks a means to help them reach a consensus. There is also a lack of tools and metrics for defining the extent to which sustainability is being achieved (Adams, 2006). To stop sustainable development from becoming a vague cliché that divides groups, it must be used to unite disparate interests in the stewardship of shared goals and values. It is imperative that scholars understand how differing conceptions of sustainability influence debates, priorities, and foster action in cities that are made up of multiple and conflicting viewpoints (Krause & Sharma, 2012).

Collaborative Planning

Calls for sustainable development involve the restructuring of dominant planning theories and practices to include a diversity of stakeholders in the planning and management of urban and natural spaces. Since the initial articulation of sustainable development, there now exists an extensive body of communicative planning theory research (Allmendinger & Tewdwr-Jones, 2002; Bond &Thompson-Fawcett, 2007; Brinkerhoff & Brinkerhoff, 2011; de Liefde, Wong, & Rasmussen, 2012; Forester, 1993; Healey, 1992, Healey 2003). Subsequently, several authors have discussed the communicative turn in planning theory and collaborative models of practice as a response to calls for sustainable development and failures of rational planning models (Biermann et al., 2012; Faehnle, 2014; Fainstein, 2000; Poledica, 2013; Sokol, 2012). The theory of communicative planning and practice of collaborative planning have been well explored and encompass several aspects. Described most aptly by Healey (1992), the collaborative planning model is an extension of communicative planning theory, which includes many principles. Collaborative planning is an inclusionary and interactive methodology for engaging diverse stakeholder communities in respectful discussion, conflict mediation, and policy development. It is also is a practical method to generate new planning discussions and build understanding.

Practical applications of the considerations of communicative planning theory have been explored in the literature on the collaborative planning model (Holvandus, 2014; Svendsen, 2010; Tewdwr-Jones, 2002). Specific practices derived from communicative planning theory are known as collaborative planning. Assessed on the basis of the principles identified above, collaborative planning is primarily concerned with issues of context and structure. The model of collaborative planning seeks to resolve issues and adopt focuses on the development of more democratic planning practices. Despite the ability of collaborative planning to increase democratic participation in the planning process, it has been criticized by researchers for lacking a focus on sustainability and for internal conflicts of private sector participation (Koppenjan & Enserink, 2009).

Civic Ecology

The present study is theoretically based on a combination of collaborative planning and civic ecology practices as a means for supporting the sustainability of a neighborhood. Civic ecology is a type of collaborative planning specifically focused on environmental preservation at the community level. "Civic ecology practices are community-based, environmental stewardship actions taken to enhance green infrastructure, ecosystem services, and human well-being in cities and other human-dominated landscapes" (Krasny, Russ, Tidbull and Elmqvist, 2014, p. 1). Theoretical groundings of civic ecology originate from both social-ecological systems thinking and adaptive co-management (Krasny et al., 2015). Central to both theories is the notion that information related to the outcomes of management actions is used to inform better management of the system. Thus, the use of a collaborative approach, combined with adaptive management for the resilience of the social ecological system is at the heart of civic ecology. Furthermore, by involving diverse stakeholders, the reflection process extends beyond technical aspects of planning to consider social aspects as well**.**

In recent years, the popularity of civic ecology practices for collaboratively managing urban ecosystems has increased (Krasny et al., 2015; Krasny, Russ, Tidball, & Elmqvist, 2014; Shandas & Messer, 2008). Shandas and Messer (2008) explored involving citizens in the planning and management of water resources in neighborhoods of Portland, Oregon in an attempt to develop locally-relevant, community-based programs to manage water resources. A community watershed stewardship program (CWSP) was created by forming strong local partnerships among three main groups: community members, the Bureau of Environmental Services, and Portland State University. Based on a set of four core principles, the CWSP framework is collaborative in nature and provides opportunities for participants to find common ground, become more involved, expand local capacity, increase participation, and restore ecological function (Shandas & Messer, 2008).

This study serves as an example of how citizens can become more involved in the stewardship of their local watershed, how to balance a mix of partnerships (technical expertise vs. community capacity), and how to develop a local governance system that allows community groups to focus their efforts on proposed projects rather than following bureaucratic planning procedures. My study broadens these lessons learned from a neighborhood scale community based partnership management of water resources, to include more diverse aspects of the neighborhood. Moreover, one might wonder whether this model could apply to not only environmental, but all aspects of resource management at the neighborhood level.

Krasny, Russ, Tidball, and Elmqvist (2014) explored how civic ecology practices not only create green infrastructure that produces ecosystem services such as provisioning, regulating, and supporting, but also how these practices themselves can serve as a social-ecological process that directly generates cultural ecosystem services and other associated benefits to human well-being which have been unexplored and under theorized. The authors' presentation of considerations for measuring ecosystem services produced by practitioner-scientist partnerships makes me wonder if the synergistic effects of collaborative ecosystem service management can apply to social and economic aspects of neighborhood scale sustainability assessment, planning, and management. This model is a fine example of what the present study is attempting to achieve. That is, by engaging in collaborative work on neighborhood revitalization projects, policy makers can enhance not only processes and services, but also social benefits like capacity building and sense of place. I plan to translate the success of civic ecology practices that steward the natural environment to other aspects of neighborhood development.

In the research on civic ecology practices, authors have explored the importance of collaboration and partnerships among community, non-profit, and government environmental stewardship initiatives toward understanding urban environmental governance (Fisher, Campbell, & Svendsen, 2012; Krasny et al., 2015; Svendsen and Campbell 2008). More specifically, Krasny et al. (2015) examined the variety of forms civic ecology practices take to understand how humans can positively influence ecosystem services and contribute to community well-being in cities. Rather than traditional ecosystem services valuation, the researchers built on previous work in urban environmental stewardship by applying a practice theory framework that focused on the elements of practice to compare civic ecology practices. By focusing on key practice elements, competencies, meanings, and resources, they suggested a practice theory-informed protocol to civic ecology practices. They recommended giving more consideration to the aspects of social and communication competencies, the way meaningfulness can motivate volunteers and sustain practices, and the nature of the resources being stewarded.

AHP is an ideal means for facilitating this process by clearly visualizing stakeholder's preferences, competencies, and values in order to promote hands on stewardship, development projects, and neighborhood management discussions. The process focuses on a need to articulate a vision, build collaborations, and manage volunteers, rather than just technical competencies. Thus, my research will explore the extent to which the principles of civic ecology practices are applicable to multiple dimensions of neighborhood sustainability. That is, does stewardship work inherently need to be focused on green infrastructure? Furthermore, by acknowledging that these aspects of social and communication competencies, meaningfulness of participation, and the nature of stewarded resources influence the outcome of civic ecology practices, we can design partnerships with these considerations in mind.

Public-Private Partnerships

Public-private partnerships (PPPs) in urban resource management have not only improved habitat function but also social aspects of neighborhoods (Connolly, Svendsen, Fisher, & Campbell, 2013). AHP can be used to select projects with a high propensity for public-private partnerships based on shared values, a need to increase sustainability performance, and development. In general, PPPs are long-term cooperative institutional arrangements between public and private actors. Khanom (2010) explored the different functions of public-private partnerships (PPPs) including as a way of managing and governing organizations, as an institutional arrangement for financial relationship, as a development strategy, and also as a language game. The present research will focus on the potential of PPPs as a governance and development strategy.

For the purposes of this study, Bovaird's (2004) definition of public-private partnerships is a step in the right direction: PPPs are "working arrangements based on a mutual commitment (over and above that implied in any contract) between a public sector organization with any other organization outside the public sector " (p. 200). Thus, partnership implies a cross-sector relationship where the actors involved bring both commitment and competence to the table, thereby creating the classic synergy, or the whole being more than the sum of the parts. PPPs offer the promise of mobilizing resources beyond those available to the public sector alone and bottom-up solutions to complex problems. The present research study will identify PPPs through the implementation of AHP, which align with these definitions.

Numerous researchers have approached sustainable development by creating partnerships that mitigate environmental conditions while facilitating positive social and economic outcomes (Connolly, Svendsen, Fisher, & Campbell, 2013; Fonyo & Boggess, 1989; Koppenjan & Enserink, 2009; Lederer, 2007; Nijkamp, Van Der Burch & Vindigni, 2002). Connolly, Svendsen, Fisher, & Campbell (2013) explored how stewardship groups serve as bridge organizations between public agencies and civic organizations. Conducted within a social-ecological systems framework, the investigation worked across scales and sectors to build the flexible and multi-scaled capacity needed to manage complex urban ecosystems through the integration of civic ecology practices. This illustrates how public-private partnerships can help manage complex urban ecosystems. In light of this, the present study will incorporate AHP to identify those partnerships and suggest sustainable development projects. In a similar yet alternative manner, Lererer (2007) explored a university's role in the collaborative planning process of downtown revitalization of a mid-sized city as well as potential partnerships. Grounded in collaborative planning theory, the researcher examined the role of community-university partnerships in downtown planning issues. Their review showed universities primarily add to downtown revitalization through economic development and human capital investment. Additionally, university service learning projects can play a major role in developing community through engaging and educating stakeholders. The benefits of scale in a mid-size city were also explored in relationship to partnership forming. Portland State University has demonstrated a strong commitment to service learning (the school motto is “let knowledge serve the city”) and there is a great availability of partners in the downtown area who support a collaborative university-community approach to downtown revitalization in the study area. The present research will help to bolster support for the potential of university-community partnerships in downtown revitalization.

Nijkamp, Van Der Burch & Vindigni (2002) compared the success of nine different land use and revitalization projects using public-private partnerships. This study identified the critical drivers of successful PPP projects of urban revitalization, including collaborative planning, clear and transparent mapping, and relevant scale. Koppenjan & Enserink (2009) explored governance practices that help private sector participation in sustainable urban infrastructure development projects. These analyses of PPPs raised important questions with regard to governance and development. The present study hopes to explore these concepts including the application of PPPs at the neighborhood scale specifically focused on sustainable neighborhood development and/or redevelopment and collaborative governance. By combing economic, environmental, and social assessment strategies, AHP will provide a framework around which to build collaborative governance and civic ecology practices.

Neighborhood Sustainability Assessment

Governments, natural resource managers, urban planners, and community groups have been relying on an incomplete set of neighborhood sustainability assessment (NSA) tools that could be improved in a myriad of ways by incorporating the use of GIS-AHP. Employing such a tool could allow for a more relevant scale, inclusive participation of stakeholders, and more accurate focus on all aspects of sustainability at the neighborhood level (Reith & Orova, 2015; Sharifi & Murayama, 2013). Cities around the world have been spatially organized into neighborhoods or districts as the fundamental unit since early civilizations. From the early twentieth century, planners have experimented with designs and programs for improving the quality of life in urban neighborhoods by focusing on neighborhoods as the building blocks of cities (Mumford, 1954; Fainstein, 1987; Patricios, 2002). Despite a long history and intimate connection to everyday life, it was not until the turn of the 21st century that planners and environmentalists began to design neighborhood scale sustainability assessment tools (Berardi, 2013; Luederitz, Lang, & Von Wehrden, 2013; Orova & Reith, 2013; Reith & Orova, 2015; Sharifi & Murayama, 2013).

Neighborhood Sustainability Assessment (NSA) tools are the latest generation of impact assessment tools. Beginning in 1969 with the passage of the National Environmental Policy Act, project scale Environmental Impact Assessment (EIA) tools were the first generation of tools developed to address increasing pressures on the environment. Later, in the 1980's and 1990's respectively, Strategic Environmental

Assessment and Integrated Sustainability Assessment tools were developed for environmental impact assessment of policies, plans, programs, and projects (Therivel, 2012; NEAA, 2006). Despite ample assessment tools focusing on the project, city, and regional level, there is a need for further development of assessment tools on the scale of urban neighborhoods. Given that the neighborhood is the scale at which land development takes place and as a unit, drives the sustainability of the greater city, increased focus on developing assessment frameworks and tools for the urban neighborhood is justified, especially considering sustainability initiatives like Our Common Future and Agenda 21 (Berardi, 2013; Reith & Orova, 2015; Sharifi & Murayama, 2013). Attaining a sustainable city requires that its components foster sustainability, which reinforces a need to examine the neighborhood level (Alberti et al., 2007; Williams, Dair, & Lindsay, 2010; Wu, 2010).

An NSA tool evaluates and rates the performance of a neighborhood against a set of goals and criteria to assess the neighborhood's progress toward sustainability goals. Worldwide, several NSA tools are in use and can be divided into either optional third party "spin-off" or mandatory plan embedded tools (see table 2.1). Sharifi & Murayama (2013) analyzed aspects of development and application of the top seven NSA tools (LEED-ND, EarthCraft Communities, BREEAM Communities, CASBEE-UD, HQE2R, Ecocity, and SCR) for the ability to realize their aim of contributing to sustainable development. To analyze the development and application of both types of NSA tools, the authors developed an assessment framework which included seven elements; sustainability coverage, inclusion of prerequisites, adaptation to locality, scoring and weighting, participation, presentation of results, and applicability.

Table 2.1 Popular neighborhood sustainability assessment tools (Sharifi & Murayama, 2013)

Tool Name	Developer(s)
LEED-ND	USGBC, CNU, and NRDC
ECC	Atlanta Home Builders Association, Atlanta Regional Commission, Urban Land Institute, and Southface
BREEAM Communities	Building Research Establishment
CASBEE-UD	Japan Sustainable Building Consortium and Japan Green Building Council
QSAS Neighborhoods	Gulf Organization for Research Development
Green Star Communities	Green Buildings Council of Australia
Green Mark For Districts	Building and Construction Authority
Green Neighborhood Index	Malaysian Institute of Architects and the Association of Consulting Engineers Malaysia
Neighborhood Sustainability Framework	Beacon Pathway
HQE2R	CSTB
Ecocity	EU research project
SCR	Victorian State Government
EcoDistricts Assessment Toolkit	Portland Sustainability Institute
Sustainable Project Appraisal Routine	ARUP
One Planet Living	BioRegional Development Group and WWF International
Cascadia Scorecard	Sightline Institute

Sharifi & Murayama designed their analysis framework with the intent to address the development and application phases of the NSA process with regard to underlying design, methods to measure sustainability performance, and implementation of action plans. Despite a shared goal of sustainability, there are significant differences and shortcomings in how the top NSA tools pursue sustainability. Many authors (Berardi, 2013; Luederitz, Lang, & Von Wehrden, 2013; Orova & Reith, 2013; Reith & Orova, 2015; Sharifi & Murayama, 2013) have identified a list of positive improvements needed to approach sustainability in all of the reviewed NSA tools. Notable areas of improvement were to expand coverage of less tangible socio-economic issues to standardize the weighting and scoring process given conflicting values, (Berardi, 2013) expand opportunities for stakeholder participation in the development and application phases, (Orova & Reith, 2013) and visualize and report assessment results (Sharifi & Murayama, 2013). Authors have also discussed the benefits of plan embedded NSAs due to their mandatory nature as compared to voluntary “spin-off” NSAs (Reith & Orova, 2015). The present research will fill these gaps by incorporating spatial analytic hierarchy process (GIS-AHP) techniques to standardize the scoring, and weighting of a broad list of sustainability indicators. Also, GIS-AHP is well suited to public participation and is easily integrated into local planning frameworks.

La Rosa, Spyra and Inostroza (2015) explored through literature review the lack of indicators for assessment of cultural ecosystem services (CES) in an urban context. Despite a high density of CES, urban environments seem to play a minor role in current ecosystem service assessments. The current research focuses on developing urban CES indicators at the neighborhood scale through the use of AHP and civic ecology practices. Current neighborhood sustainability assessments struggle to accurately assess the impact of CES. Through the use of structured pairwise comparison and collaborative planning in the AHP, the present study will flush out CES indicators relevant to the urban context. The results of the GIS-AHP analysis will communicate where to focus sustainable development projects to build CES and how to measure their progress in more meaningful ways and at the appropriate spatial scale.

Background on Spatial MCDA (GIS-MCDA)

Decisions in urban land-use planning and environmental management have increasingly been made based on the analysis of quantitative and qualitative spatial indicators in geographic information systems (GIS) (Schädler et al. 2013). Geographic information systems (GIS) are computer-based systems for storing and processing spatial and non-spatial information. In addition, GIS also contains a set of procedures to support complex decision-making (Malczewski 1999). The goal of using GIS to provide support for making decisions is to increase the validity and complexity of the decision-making process through either optimization or simulation modeling. Spatial optimization is a normative strategy that provides a formal framework to determine a course of action that meets a specified goal or objective function. The normative approach to spatial optimization is used to provide a baseline to judge the efficiency of the real world against an optimal scenario to determine the best course of action (Faiz & Krichen, 2012; Tong & Murray, 2012). The sustainable development of urban areas is a perfect context for such complex decision-making. Generally, the expected economic and ecological costs and benefits of various planning options have been examined in great detail whereas further aspects of sustainable development are usually not considered on equal terms (Schädler et al. 2013). This can be attributed to the fact that sustainable development is not readily quantifiable because it is extremely context specific with regard to space, time, scale, and stakeholders. The current research employs GIS as a spatial decision support system to optimize a variety of sustainability indicators to achieve neighborhood sustainability goals within a problem-solving environment to overcome these difficulties.

Spatial decision support systems (SDSS) are interactive computer-based systems designed to support semi-structured spatial decision-making (Malczewski, 1999). Decisions optimizing a single criterion function are referred to as single criterion (objective) models, whereas multi-criteria (multi-objective) models are those involving the simultaneous optimization of more than one criterion function. Thomas & Huggett (1980) described the general procedure of spatial analysis techniques and frameworks from a decision analysis perspective. The researchers contend that the overarching goal of spatial optimization models is to identify the ideal, or optimal solution to spatial decision or management problems. Spatial optimization is characterized by a set of decision variables, or alternatives with a geographic or spatial meaning. Each optimization model contains quantities, referred to as objectives or criterion functions, which are to be either minimized or maximized. Typically, a set of constraints is imposed on the decision variables and defines the set of plausible solutions. Therefore, solving an optimization problem involves determining decision variable values subject to a set of constraints. Thus, an optimization model can be written as follows: "minimize or maximize f(x), subject to: x given X, where f(x) is a criterion (objective) function, x is a set of decision variables, and X is a set of feasible alternatives" (Malczewski & Rinner, 2015, p. 5). Spatial optimization models seek to find the best (optimal) solutions to well-defined spatial decision or management problems (Malczewski & Rinner, 2015).

Multi-criteria decision analysis (MCDA) spatial decision support systems (SDSS) are typically used to inform decision-making, especially in the case where the number of influencing factors or planning options are large (Malczewski, 2006). The primary aim of MCDA SDSS is to improve the effectiveness of complex decision-making by incorporating decision makers' knowledge and experience into computer-based procedures and tools for systematically analyzing and modeling spatial and non-spatial problems (Sugumaran & Degroote, 2010). The ability of GIS to integrate these tools and procedures with decision makers' preferences, judgments, arguments, and opinions has ensured the incorporation of MCDA techniques into the library of GIS procedures (Malczewski & Rinner, 2015). Spatial MCDA (GIS-MCDA) procedures handle disagreements over facts by providing more and better information (the GIS portion), and diminishing disagreements over values among conflicting stakeholder groups through structuring decision alternatives (MCDA portion) (Chakhar & Mousseau, 2007; Jankowski, Zielinska, & Swobodzinski, 2008; Malczewski, 1999; Reynolds & Hessburg, 2014). The results of such procedures are maps that integrate geographic data and the preferences of decision makers. These maps can be used as a tangible discussion point for reviewing decision alternatives and offering an avenue to public participation. Additionally, with the rise in web-based SDSS (Rinner, 2003; Sugumaran & DeGroote, 2011) and related participatory GIS technologies, SDSS has been proven as a tool for public participation in the planning process by further expanding the process to non-experts (Dunn, 2007; Jankowski & Nyerges, 2001; Schlossberg & Shuford, 2005). Thus, GIS-MCDA as a technique for expressing and visualizing these types of problems has been applied to various optimization frameworks, in urban and non-urban situations, in various application domains, in conjunction with other methods, in top-down or integrated bottom-up perspectives, and at the entire spectrum of scales.

The roots of GIS-MCDA methods and models stem from the research traditions of urban planning and landscape architecture as well as operations research and management sciences. Urban planning and landscape architecture apply a systematic process to the planning, designing, and management of natural and built areas. Urban planners frequently rely on overlay techniques in which they design plans by analyzing social, ecological, and geographic data to produce the desired outcome. Operations Research and Management Sciences (ORMS) applies mathematical problem solving methods to decision analysis by applying the fundamental concept of efficiency (known as Pareto Optimality) to urban and regional management problems (Malczewski & Rinner, 2015). Next, I will briefly discuss the origins and development of GIS-MCDA.

The fundamental element of modern MCDA theory is the concept of efficiency, or Pareto optimality: a state of allocation of resources in which it is impossible to make any one individual better off without making at least one individual worse off (Malczewski & Rinner, 2015). This concept is central within the broader field of OR/MS and also developed into other fields such as systems analysis, regional science, urban planning, and geography. Another fundamental element of modern MCDA theory is the overlay technique popularized by spatial planners and landscape architects in the twentieth century (Collins, Steiner, & Rushman, 2001; McHarg, 1969; Steinitz, Parker, & Jordan, 1976). Widely recognized as the single most important precursor to later forms of complex GIS-MCDA, the overlay technique was advanced by McHarg (1969). McHarg proposed a procedure that mapped data on the natural and man-made attributes of the environment within a study area. This information was then presented on individual, transparent maps using light to dark shading to indicate respective suitability and superimposing of the individual transparent maps to construct the overall suitability maps for each land use.

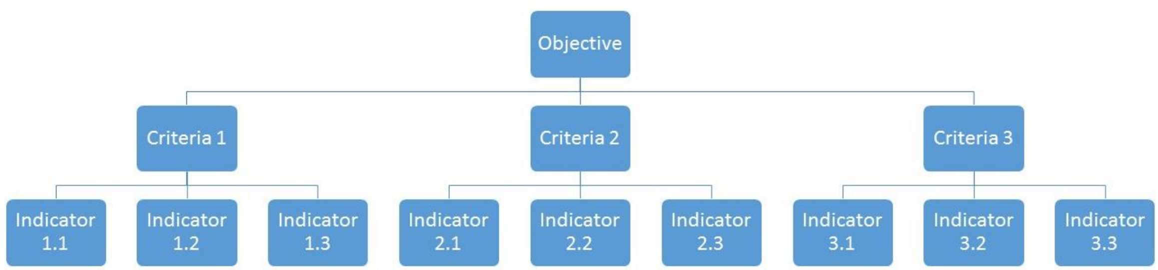
Several key technological aspects resulted from advancements in digital geographic information systems. To begin, tools to support collaboration and group processes have been developed, implemented, evaluated, and refined (Nyerges & Jankowski, 2010; Sugumaran & DeGoote, 2011). As a result, GIS-MCDA has been applied as a collaborative decision support system allowing interest groups to interact with a variety of stakeholders. Further solidifying the place of GIS-MCDA in the GIS literature was a series of National Center for Geographic Information Analysis (NCGIA) Initiatives (NCGIA, 2014) which stimulated the integration of GIS-MCDA tools and Spatial Decision Support Systems (SDSS).

Elements and Basic Concepts of GIS-MCDA and AHP

There are a variety of techniques for defining decision problems within the field of MCDA. Multi-criteria decision problems involve a set of indicators that are evaluated on the basis of conflicting and incommensurate criteria according to the decision maker's preferences. They are based on three elements; decision makers, criteria, and indicators. Coupled with a three-step procedure of value scaling (standardization), criteria weighting, and combination (decision) rule to solve spatial multi-criteria problems (Malczweski, 1999; 2006; Thill, 1999), these elements and basic concepts form the foundation for the AHP and other MCDA methods.

Decisions are evaluated on the basis of a set of criteria, which are comprised of objectives and indicators. Criteria must be comprehensive and measureable. Malczewski (1999) defines an objective as a statement about the desired state of a system under consideration. It is capable of identifying the direction of improvement needed of one or many attributes to maximize an objective function. Thus, to operationalize an objective, one attribute, or criteria measurement, must be assigned that indirectly measures the achievement of the objective in the form of an indicator. The relationship between these objectives, criteria, and indicators can be organized into a hierarchical structure (see fig 2.3) (Saaty, 1980). The top level of the hierarchy is the ultimate goal of the decision at hand, which descends from general to more specific attributes; criteria and indicators, each with an associated performance rating as well as a relative weight. This research accepts Malczewski's (2015) definition of decision alternatives as alternative courses of action among which the decision maker must choose. Taking the definition one step further, geographic decision alternatives consist of what to do (action) and where to do it (location).

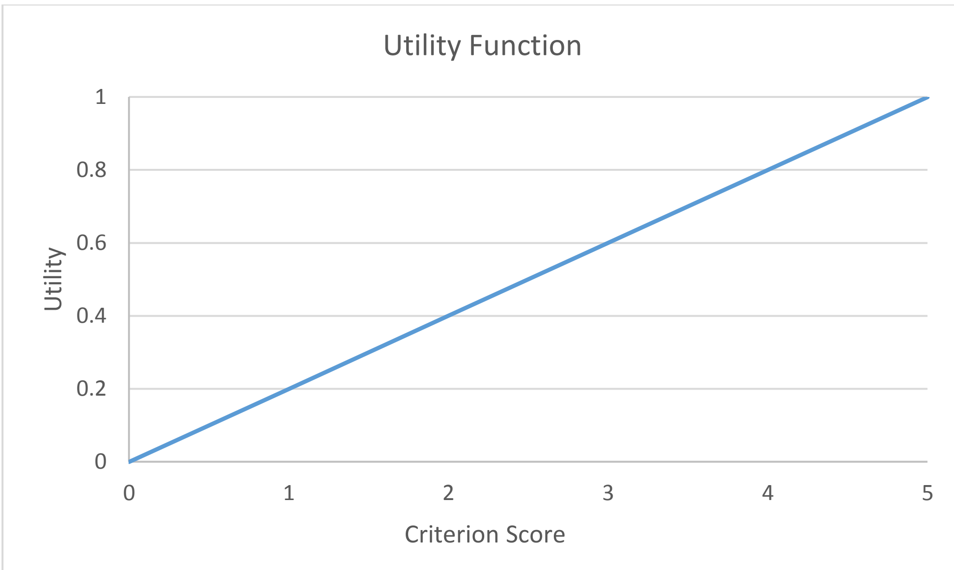
Figure 2.3 Multi-criteria decision making conceptual hierarchy



Value Scaling, Criterion Weighting and Combination Rules

The first step in MCDA methods requires the transformation of the evaluation criteria to comparable units, referred to as value scaling or standardization methods. This research uses the most popular GIS-based method called the score range procedure, for standardizing the performance of evaluation criteria (Malczewski, 2006). This procedure creates a relative performance score based on the highest and lowest performing attribute in the system and normalizes the range from zero to one. This procedure assumes the value function of the criteria score has a linear form, meaning the utility increases proportionally to increases in criteria score (see figure 2.4 for graphical representation).

Figure 2.4 Graph of utility function



The second step in MCDA methods is to assign a weight value to each evaluation criterion that indicates its importance relative to other criteria under consideration. A popular global weighting method is one that assigns a single weight to each criterion. This is the method employed by the majority of studies in the field (Malczweski, 2006). The details of how AHP assigns a global weight value are discussed in the following

Figure 2.5 Conceptual equation for optimization of global weight value combination

$$\text{Max } Ai = \sum_{j=1}^{n} wjxij$$

section (pairwise comparison method). Combination rules define how to integrate the performance data about alternatives with decision makers' preferences into an overall assessment of alternatives. Combination rules can be optimized to show how to minimize or maximize an objective function (Ai) subject to the sum of a set of decision variables (wj), given a set a feasible alternatives (ij) (see figure 2.5 for conceptual equation) (Lofti and Hababi, 2009). Now that the elements of MCDA (decision makers, objectives, criteria, and indicators) and basic concepts (value scaling, criterion weighting, and combination rules) are understood in general, I will apply these to the research using one MCDA method, the Analytic Hierarchy Process (AHP). I will discuss how AHP has been used by other researchers for spatial optimization problems and by reviewing how these authors have applied AHP, I will demonstrate a need for neighborhood scale sustainability assessment SDSS using proven GIS-AHP techniques.

Analytic Hierarchy Process (AHP)

Several authors have discussed theories and analysis procedures for GIS-MCDA. The vast majority of GIS-MCDA studies use one of four conventional MCDA for spatial decision making techniques including weighted linear combination (Carver, 1991; Eastman et al., 1993; Malczewski, 2000), ideal reference point (Malczewski, 1996), outranking methods (Joerin, Theriault, & Musy, 2001), and the most frequently used Analytic Hierarchy Process (Behzadfar & Abdi, 2013; Bottero, 2015; Kara & Kone, 2012; Lee & Chan, 2008; Marinoni, 2004; Satay 1980). This research follows the rich tradition of using AHP as the approach to GIS-MCDA due to its simplistic yet comprehensive nature.

Pioneered by Saaty (1980), the AHP is one of the most influential and comprehensive methods of multi-criteria decision analysis. The method consists of three stages, including decomposition, comparative judgement, and synthesis of priorities. The decomposition stage requires that the decision be broken down into a hierarchy that captures the essential elements of the problem. The comparative judgment stage requires assessment of weights of importance through pairwise comparisons of the elements within a given level of the hierarchy, with respect to their parent node at the next-highest level. The synthesis stage creates an overall priority ranking for each decision alternative. It requires the construction of a composite set of priorities at the lowest level of the hierarchy, derived from the ratio-scale priorities in the various levels of the hierarchy. The details of this process will be presented in the methods chapter. AHP has been integrated with GIS in a variety of decision and management situations such as land use/suitability analysis (Banai, 1993; Chen & Lin, 2011; Tseng et al., 2010), site selection (Jun, 2000; Sumanthi et al., 2008), vulnerability analysis (Gorsevski, Jankowski, & Gessler, 2006), and plan/impact evaluation (Klungboonkrong and Taylor 1998). In addition, the AHP method has also been applied to a broad range of application domains including agriculture and fisheries (Hill et al., 2005; Hood et al. 2006), transportation (Klungboonkrong & Taylor, 1998), waste management (Milutinović, 2014), geomorphology (Gorsevski, Jankowski, & Gessler, 2006), and urban planning (Girard, Cerreta, & De Toro, 2012).

Suitability Analysis

With a history based on the notion of Pareto optimality, the concept of an optimization framework is central to the AHP methodology (Saaty, 1980). Traditionally, optimization frameworks were based on narrowly focused aspects of suitability, although in recent years, more social and environmental concerns have been added, as well as deliberate aims for sustainability. Many authors have chosen to base their optimization frameworks on traditional aspects of suitability (Chandio, Matori, Lawal, & Sabri, 2011; Chandio et al., 2013; Luo et al., 2009; Miller et al., 1998; Strager & Rosenberger, 2006;) while others employ a deliberate sustainability-based optimization framework (Bottero, 2015; Chen & Lin, 2011; Girard, Cerreta, & De Toro, 2012; Gonzalez et al., 2013; Kurka, 2013; Lee & Chan, 2008; Ligmann-Zielinska, Church, & Jankowski, 2008; Lofti, Habibi, & Koohsari, 2009; Poveda & Lipsett, 2013; Schadler et al., 2013; Uribe et al., 2014). I will discuss both groups in the forthcoming sections.

Miller et al. (1998) presented a multi-objective greenway analysis tool based on a GIS suitability analysis approach that integrated economic, environmental, and social data. The researchers assessed the suitability of greenways for Prescott Valley, Arizona based on goals and objectives from the Prescott Valley General plan, published literature, and field inventory, with weights from experts and stakeholders. These goals included providing and expanding recreational services, preserving open spaces and environmental quality, and protecting the sense of place. The researchers normalized the average weighted score of greenway factors, functions, and capability values to create a single integrated score, called the greenway suitability value. The success of this study has made me wonder, with the emphasis Portland is placing on greenway development, could this approach be adapted to other land-use strategies such as sustainability or urban renewal? Also, the success of the greenway suitability analysis at the city scale is evidence that it could be implemented on a neighborhood scale as well.

Strager and Rosenberger (2006) used a GIS-MCDA framework for identifying high priority areas for land conservation by integrating stakeholder preferences with GIS data. The researchers tested for differences in preferences of land prioritization by stakeholder type using a case study in the Cacapon River Watershed in West Virginia. The AHP hierarchy for measuring stakeholders' preferences for land conservation criteria was established through a collaborative process conducted by the Cacapon River Land Trust, experts, and residents of the watershed. Weighting of criteria and indicators occurred through a pairwise comparison survey. This research demonstrates a bottom-up approach to spatial MCDA that empowers local stakeholders. The major consideration of this study is how to incorporate more of the abstract/non-spatial/un-available/un-mappable datasets commonly associated with local stakeholders. This integrated approach also helps to define appropriate future data needs or studies. Since the AHP is an efficient and effective means of measuring people's preferences for land conservation, why not their preferences on neighborhood scale sustainable urban renewal?

Luo et al. (2009) proposed an evaluation method that combined AHP and entropy to assess the land use intensity of districts and counties. The researchers applied their method in the Weiyang district in Xi'an, China, which aimed to develop land use policies according to a land-use intensity framework. This application of AHP also used entropy measurements to normalize indicator weights identified through the AHP. This tool allows policy makers to improve the level of intensive land use by improving the indicator that has the lowest composite score. Given that land use intensity is a tenet of sustainable development, by expanding the definition of optimization to include more than just land use intensity, (i.e. other sustainable development indicators) it could be used as a sustainable development assessment tool.

Chandio et al. (2011) used AHP as a framework for a GIS-MCDA for assessing the suitability of public park proposals. This application of AHP optimized for land availability, accessibility, and socio-economic criteria, and only consulted experts in the relevant decision factors. The result of the process was a composite land suitability score for each alternative. This allowed for quick consideration of the suitability of land for parks in Larkana, Pakistan. This study can inform a framework for the planning process by using GIS with an AHP approach to sustainable development planning through redefinition of the optimization framework to include more social and environmental dimensions.

Chandio et al. (2013) presented a literature review that examined the GIS-based AHP as an MCDA technique in land suitability analysis with a focus on urban planning and development. The general purpose of AHP is to support decision makers in selecting the best alternative given multiple competing priorities. By discussing the success of AHP for various spatial problems including land susceptibility, land use planning, land suitability analysis, and site selection, the authors have observed that AHP has proven to be a robust decision making instrument in finding optimal land for development. Given the success of AHP in land suitability analysis, the method could be further refined using the concept of sustainable development to redefine the most effective solution. With such a tool, decision makers can more easily select and site sustainable development projects given competing priorities and a limited budget. The works of Miller et al. (1998), Strager & Rosenberger (2006), Luo et al. (2009), Chandio et al. (2011), and Chandio et al. (2013) have laid down a solid foundation of optimization based on suitability from which to incorporate more sustainable concepts into the decision-making process.

Sustainability Optimization Frameworks

Recently, numerous authors have begun to explore the incorporation of sustainability into the AHP optimization process (Bottero, 2015; Chen & Lin, 2011; Lee & Chan, 2008; Girard, Cerreta, & De Toro, 2012; Gonzalez et al., 2013; Kurka, 2013; Ligmann-Zielinska, Church, & Jankowski, 2008; Lofti, Habibi, & Koohsari, 2009; Poveda &

Lipsett, 2013; Schadler et al., 2013; Uribe et al., 2014). Lee and Chan (2008) discussed how the lack of thoughtful systematic planning during a period of rapid development in Hong Kong, China (and other cities) has resulted in a non-optimal distribution, underutilization, and inefficient use of scarce resources. They emphasize that urban renewal projects are a typical strategy to combat land constraints and various urban issues, including congestion, lack of amenities, sense of place, and equity and housing. In the past, many urban renewal projects have overlooked environmental and social needs and mainly emphasized economic development (Chan, 2002; Council for Sustainable Development, 2004 as cited in Lee & Chan, 2008; Rapkin 1980; Rothenberg 1969).

Increasingly, the concept of sustainable development has been used to account for economic, environmental, and social objectives when designing urban renewal proposals (Chan & Lee 2006). Using AHP, Lee & Chan (2008) lead an effort to systematically prioritize key principals of sustainable development and associated design considerations for Hong Kong. Using Expert Choice, an AHP software platform, the researchers successfully combined the judgments of 40 experts regarding the relative importance of sustainable urban renewal objectives and design considerations. This resulted in a systematic weighting of objectives and considerations related to sustainable urban renewal in Hong Kong. While Lee & Chan (2008) clearly demonstrated the power of AHP to assess the sustainability level of a potential urban renewal proposal, the methods used were not inherently spatial, only simulated public participation, and were applied on a city scale. My study will build on their urban renewal proposal assessment approach by applying a spatial AHP (GIS-AHP) method to a neighborhood-scale sustainable urban development decision support system using actual stakeholders. The advantage of using a GIS-AHP approach is that it identifies projects and locations based on criteria and indicators without having to first create the proposal to assess. Instead, this process designs urban renewal projects around an optimal spatial arrangement of mutually agreed upon objective, criteria, and indicators.

Ligmann-Zielinska, Church, & Jankowski (2008) demonstrated the applicability of spatial optimization as a modeling technology for generating sustainable land use patterns in suburban and exurban communities. Informed by the schools of sustainable development and new urbanism, the researchers defined "sustainable land use allocation" as a "normative modeling methodology that focuses on evaluating current land use patterns, and introduces changes leading to the increased compatibility of adjacent land uses, infill development, land use compactness, and politically defensible redevelopment" (Ligmann-Zielinska, Church, & Jankowski, 2008, p. 4). Based on the concept of Pareto Optimality, the researchers began their analysis by applying the Sustainable Multi-Objective Land Use Allocation Model (SMOLA) to a hypothetical situation and case study in Chelan, Washington to identify optimal sustainable land use allocations. The researchers optimized for a series of objectives that minimized the development of open spaces, the incompatibilities between land uses of neighboring sites, and the distance between new development and developed sites to maximize the redevelopment of urban areas. The authors furthered this concept by adopting a Modeling to Generate Alternative optimization approach in which high performing alternatives are presented to stakeholders in addition to the Pareto-optimal solution. This approach served as a starting point for discussion of alternative scenarios and necessary trade-offs in a collaborative setting.

Recently, more researchers have attempted to optimize for sustainable land use decision by shifting the paradigm away from solely economic concerns to include environmental and social considerations. Ligmann-Zielinska, Church, & Jankowski (2008) take optimization into a spatial realm by adding considerations of density and contiguity into the process of selecting sustainable land use projects. The framework of optimizing for a series of objectives that minimized the development of open spaces, the redevelopment of urban areas, the incompatibilities between land uses of neighboring sites, and the distance between new development and developed sites could also be adapted to urban neighborhoods. My research can serve as a starting point to first optimize for environmental and socio-economic indicators, which can be further used in spatial optimization, to add considerations like density and contiguity. This will highlight the difference between implicitly spatial and explicitly spatial optimization.

Lofti, Habibi, & Koohsari (2009) presented a GIS-MCDA approach to urban development for the city of Cacolsar, Iran. Using AHP to weight a list of environmental and socio-economic factors, the researchers identified the location most preferable to future urban sustainable development. This same method could be used to redevelop urban areas at the neighborhood scale, as well as be adapted to the collaborative process. Chen & Lin (2011) used AHP in conjunction with the Fuzzy Delphi Method to assess and plan for redeveloping livable urban districts in Taiwan. The model they proposed for assessing and planning livable urban regeneration was based on four constructs including land use sustainability, transit oriented development pattern, district composition, and architectural typology and estate, each with a list of associated indicators. In this study, the researchers relied on the construct of a livable urban district in a similar way that Portland used the concept of a complete neighborhood to assess urban regeneration. The authors surveyed a panel of experts to prioritize a hierarchy of four criteria and 21 indicators based on a literature review of livable cities and urban characteristics. Results showed that the experts' priorities did differ significantly for architectural type and estate by profession and location; meaning that the experts' background knowledge did have an effect on the prioritization of criteria and indicators. Despite diverging points of view among experts, AHP proved to be a robust method for evaluating the performance and "livability" of urban centers. This framework could be expanded to include more stakeholders in the definition and weighing of the problem structure. Also, the model of livable urban cities fits well with the concepts of new urbanism and sustainable development.

According to the Portland Comprehensive Plan Update, many small-scale regeneration plans have not significantly reformed socio-economic factors and the built environment of the SoMa area. Consequently, the present research builds a framework for a block-level performance evaluation system to assess these aspects of neighborhood sustainability. This framework not only consults performance evaluation methods for a sustainable urban neighborhood (Burton, 2002; Hemphill, Mcgreal, & Berry, 2004), but also refers to several Portland local comprehensive plans. This type of smaller-scale spatial decision support system could offer neighborhoods and local governments a comprehensive, collaborative, and technical tool to assess the sustainability of Portland neighborhoods and explore sustainable development project options.

Girard, Cerreta, & De Toro (2012) advanced the debate on urban sustainability assessment and integrated approaches through a case study of Cava de Torreni, Italy City Plan that combined AHP and GIS in a Multi-Criteria Spatial Decision Support System. Stemming from the Strategic Environmental Assessment (SEA) approach, the research applied a more complex evaluation process, Integrated Spatial Assessment (ISA), to produce a series of location susceptibility maps to express the propensity of an area to receive a green function. This demonstrated that combining AHP with GIS-MCDA is a viable method to help identify the interests involved, create broader cohesion regarding environmental protection, stimulate the usability of land while respecting existing resources, and decide land use impacts potentially resulting from plan goals and projects. Relative to the traditional SEA approach, this evaluation guided by an ISA framework was more successful to integrate environmental and socio-economic aspects into the development of plan strategies while both recognizing and balancing the role of stakeholder perceptions and environmental effects with a collaborative decision making process. The present research will apply a similar collaborative process to identify priority sites for sustainable development, but on a neighborhood scale instead of the city scale.

Gonzalez et al. (2013) created a spatial decision support system that integrated an urban metabolism construct within the impact assessment processes given the aim of quantifying the potential performance of proposed planning projects. The researchers compiled urban metabolism environmental indicators and socio-economic indicators at a series of workshops held in five European cities. In each city, a series of workshops was held to collaboratively structure the sustainability assessment using AHP informed by urban metabolism principals. Using this weighted hierarchical structure they assessed the potential sustainability performance of three emission scenarios for each city. This work demonstrated the ability of AHP to inform a SDSS and support the impact assessment process in a collaborative and sustainable manner.

Kurka (2013) evaluated scenario alternatives with regard to their potential to achieve regional sustainable bioenergy generation using AHP. A case study from the cities of Tayside and Fife, Scotland assessed the sustainability of two bio-energy development strategies by a panel of bioenergy experts who participated in an AHP multi-stakeholder forum. The process was able to identify a preferred alternative given the social, environmental, economic, and technical criteria and indicators through the use of a single normalized global priority score. This research demonstrates that with case specific criteria and indicator weighting and performance assessments, AHP can be applied to a wide range of decision-making situations within the sustainable development field.

Poveda and Lipsett (2013) applied the AHP to weight collaboratively agreed upon sustainability indicators of surface mining operations for the Wa-Pa-Su Mine in Alberta, Canada. The results of the weighting process assisted scientists and practitioners by not only identifying those criteria stakeholders considered relevant in the sustainability assessment process, but also by expressing the degree to which the criteria should be addressed in order to accomplish the project's and/or organization's sustainability goals. Similarly, the present research uses the same principals to weight sustainable development indicators for urban re-development using AHP.

Schädler et al. (2013) discussed the issue that contemporary land use planning is based on project-specific evaluation methods from various scientific disciplines and has come to focus more recently on the integration of sustainability issues. The process of using context-specific sets of indicators typically used to evaluate and quantify the sustainability of different planning options relies heavily on expert and stakeholder input and is not easily standardized and assessed. In an effort to raise considerations of sustainability, the paper proposed a method to automate the evaluation of site-specific indicator sets using GIS algorithms. The authors integrated simple landscape metrics with spatial data and stakeholder knowledge on a brownfield near Potsdam, Germany using an indicator set aggregation scheme (similar to AHP) to support a spatially explicit algorithmic evaluation of sustainability indicators to improve the applicability, comprehensiveness and reliability of indicator-based evaluation of sustainability. These methods to evaluate the sustainability of a single project or site could feasibly scale up to a neighborhood, which will be explored in the present research.

Uribe et al. (2014) applied a rank order approach to GIS-MCDA to identify priority areas for Forest Landscape Restoration in the Upper Mixtec region of Oaxaca, Mexico, based on the input of four stakeholder groups. The researchers used the Forest Landscape Restoration framework to guide the collaborative process of restoring the goods, services, and ecological processes of the heavily deforested region. Uribe and colleagues evaluated the opinions of four stakeholders groups (academic, governmental, non-governmental organization, and public), regarding environmental and socioeconomic indicators of local forest restoration. They used a rank order approach to GIS-MCDA to assign relative weights to a list of the ten most mentioned forest restoration criteria to map the most preferred sites for restoration based on the priorities from different stakeholders. The process was successful at producing a map representing the most consensual sites to implement a sustainability restoration plan at the regional sale based on a spectrum of stakeholders. The success of GIS-AHP in forest restoration as demonstrated by this study makes me wonder if it could be translated to urban restoration as well.

Bottero (2015) combined SWOT analysis (strengths, weaknesses, opportunities, threats), MCDA, discounted cash flow analysis, and sensitivity analysis to assess the sustainability of a proposed new boulevard in the master plan of the city of Skopje, Macedonia. Although the process did not involve stakeholders directly, Bottero structured the decision problem by identifying the socio-ecological system and the goals of the boulevard. This research demonstrated the ability of AHP in conjunction with other methods, to support the decision making process in handling heterogeneous information in urban sustainability assessment. The success of the GIS-AHP at the project-scale suggests it could be adapted to a neighborhood-scale approach.

Summary: A Spectrum of Applications, Decision Makers, and Scales

As discussed in the previous sections, current research has applied AHP in urban settings as well as non-urban contexts. Within these contexts, AHP has been applied to a variety of domains including urban renewal (Lee and Chan, 2008; Chen and Lin, 2011), land use allocation (Ligmann-Zielinska, Church, and Jankowski, 2008; Bottero, 2015; Luo et al., 2009), forest landscape restoration (Uribe et al., 2014), greenway suitability (Miller et al., 1998), urban development (Lofti, Habibi, and Koohsari, 2009; Gonzalez et al., 2013), surface mining operations (Poveda and Lipsett, 2013), bioenergy generation (Kurka, 2013), land conservation (Strager and Rosenberger, 2006), land suitability analysis (Chandio et al., 2013), urban environmental assessment (Girard, Cerreta, and De Toro, 2012), public park suitability (Chandio et al., 2011), **and** brownfield remediation (Schadler et al., 2013). This wide variety of contexts to which AHP has been applied (see table 2.2) suggests it is possible to combine these into an integrated and comprehensive suitability assessment of sustainability. By adjusting the optimization framework from these proven examples, I will assess the sustainability of urban neighborhoods using a participatory GIS-AHP approach.

Table 2.2 Urban and non-urban application of GIS-AHP

Non-urban	**Urban**
Uribe et al., 2014	Chen & Lin, 2011
Poveda and Lipsett, 2013	Lee & Chan, 2008
Kurka, 2013	Ligmann-Zielinska, Church, and Jankowski, 2008
Strager and Rosenberger, 2006	Bottero, 2015
Chandio et al., 2013	Luo et al., 2009
	Miller et al., 1998
	Lofti, Habibi, and Koohsari, 2009
	Gonzalez et al., 2013
	Chandio et al., 2013
	Girard, Cerreta, and De Toro, 2012
	Chandio et al., 2011
	Schadler et al., 2013

The implementation of AHP has been expressed in different manners by different studies including using AHP by itself or in conjunction with other methods, studies that consult experts and those that include stakeholders, and the scale of the study. Traditionally, a top-down approach, which only consults experts, has been the focus of several authors (Bottero, 2015; Chandio et al., 2011; Chen and Lin, 2011; Lee & Chan, 2008; Lofti, Habibi, & Koohsari, 2009; Luo et al., 2009). However, growing popularity of participatory planning has lead more authors to include stakeholders in their analyses (Chandio et al., 2013; Church, & Jankowski, 2008; Gonzalez et al., 2013;

Kurka, 2013; Ligmann-Zielinska, Poveda & Lipsett, 2013; Miller et al., 1998; Schadler et al., 2013; Strager & Rosenberger, 2006; Uribe et al., 2014).

AHP has proven effective at a variety of scales (site, district, city, and region), but still needs more testing at the neighborhood scale. Most commonly, AHP has been applied at the site scale (Poveda & Lipsett, 2013; Schadler et al., 2013), city scale (Bottero, 2015; Chandio et al., 2011; Girard, Cerreta, & De Toro, 2012; Lee and Chan, 2008; Ligmann-Zielinska, Church, and Jankowski, 2008; Lofti, Habibi, & Koohsari, 2009; Miller et al., 1998), or regional scale (Gonzalez et al., 2013; Kurka, 2013; Strager & Rosenberger, 2006; Uribe et al., 2014). Two authors have begun to explore the application of AHP at the neighborhood or district scale (Chen and Lin, 2011; Luo et al., 2009). Both studies measure indicators to create a composite suitability score based on land use intensity and livability of urban centers, respectively. Just as these authors explored district regeneration, these frameworks can be expanded beyond land use sustainability, transit oriented development patterns, district composition and architectural typology and estate, based on district context to assess neighborhood sustainability in a similar manner. This approach could be an interesting way to explore the relationship between urban renewal and sustainable development. Thus, it appears there is a need for a spatial decision support system that integrates multiple data types and sources, mitigates internal conflicts in operationalizing urban sustainability, and that can meet neighborhood sustainable development goals.

Despite the evidence that sustainability optimization frameworks for GIS-AHP based assessment and planning have shown to support development and facilitate stakeholder interaction in the planning process, there is mixed support for GIS-AHP's ability to promote public-private sustainability partnerships at the neighborhood scale. Moreover, it remains untold whether or not stakeholders' joint efforts and pooling of resources during AHP-based collaborative planning tasks can positively impact their development options. With the intention of exploring this specific niche, the current study set out to extend the body of empirical research on GIS-AHP based neighborhood scale sustainability assessment. In summary, the empirical research studies to date on the use of AHP in both urban planning and Geographic Information Science indicate that the tool has been increasingly implemented in a variety of resource management and planning contexts for multiple purposes.

Informed by collaborative planning theory and civic ecology practices, the existing research offers important methodological implications for future neighborhood sustainability assessment applications. Although the current body of research literature illustrates AHP's affordances in terms of its universal applicability, systematic assessment, and the fostering of stakeholder interaction and negotiation, further investigation is imperative to explore the benefits of GIS-AHP for neighborhood scale sustainability assessment. Studies on participatory planning with AHP seemed to take a normative approach to planning, using measures to evaluate the performance of indicators selected. Thus, what remains scant is empirical research exploring if and how collaborative GIS-AHP might contribute to the sustainable development planning of a neighborhood. Considering AHP's advantages and the positive influence collaborative planning has been shown to have on sustainability, the question remains: What benefits do GIS-AHP tools offer planners? Although studies have examined distinctions between individual and collaborative AHP, few to my knowledge have looked specifically at the impact of sustainability-based optimization frameworks for neighborhood scale sustainability assessment and planning. The present study will therefore investigate whether or not the suggested benefits of collaborative GIS-AHP can contribute to the identification of sustainable development projects within a neighborhood-scale urban renewal framework.

The present study is guided by the following two research questions:

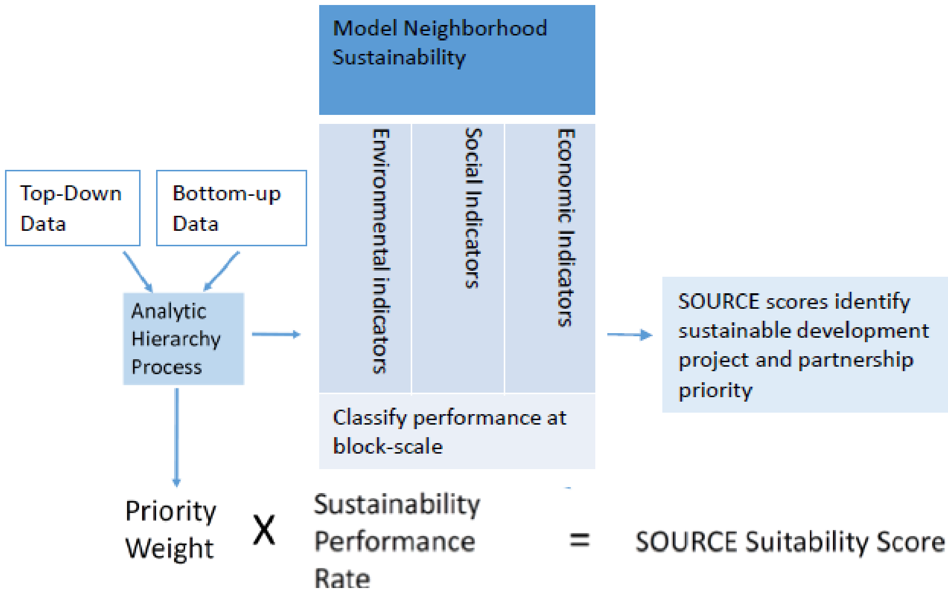
1. To what extent can a spatial AHP method optimize the location of sustainable development projects at the neighborhood scale?
2. Which urban sustainability indicators are capable of describing performance at the neighborhood scale?

Chapter 3 Methodology

In this chapter I introduce the overall design of the methodology and characterize the study area. I also introduce the datasets I gathered and the steps taken to analyze the respective quantitative, qualitative, and spatial data.

The Spatial Optimization for Urban Resource Conservation and Engagement (SOURCE) decision support system (DSS) is based on a combination of collaborative neighborhood sustainability assessment principles and MCDA GIS techniques. This multiple criteria evaluation methodology is informed by both expert knowledge (top-down) and local knowledge (bottom-up) to create a GIS-based DSS that systematically integrates multiple data types (top-down and bottom-up) in a neighborhood sustainability assessment process. Conceptually, SOURCE uses GIS-AHP to assess neighborhood sustainability performance against collectively defined and weighted goals and indicators to identify high and low performing areas and model stakeholder preferences through a single suitability score (see fig 3.1). Areas with the highest SOURCE suitability scores represent the highest priority for potential sustainable development projects based on a need to maximize sustainability performance and mutual values. The SOURCE DSS relies on identifying shared development goals among stakeholders as a basis for sustainability planning. Essentially, SOURCE identifies sustainability projects through this collaborative process that optimizes opportunities and partnerships to affect environmental, economic, and social performance within a neighborhood.

Figure 3.1 SOURCE suitability score conceptual model



The SOURCE DSS has been designed to enable the integration of spatial and non-spatial, and both qualitative and quantitative datasets associated with natural, social, and economic resources into a neighborhood sustainability assessment and optimization framework. Several key aspects have been incorporated into the SOURCE DSS methodology in order to link the methodology with multiple existing pragmatic frameworks. This work draws primarily from collaborative planning, civic ecology, neighborhood sustainability assessment, and spatial Analytic Hierarchy Process (GIS-AHP) techniques. Four critical aspects to the SOURCE DSS tool include:

1. Private stakeholder involvement and interaction with the public sector.
2. Systematic assessment of development project recommendations and indicators.
3. Mitigation of negative impacts on natural resources

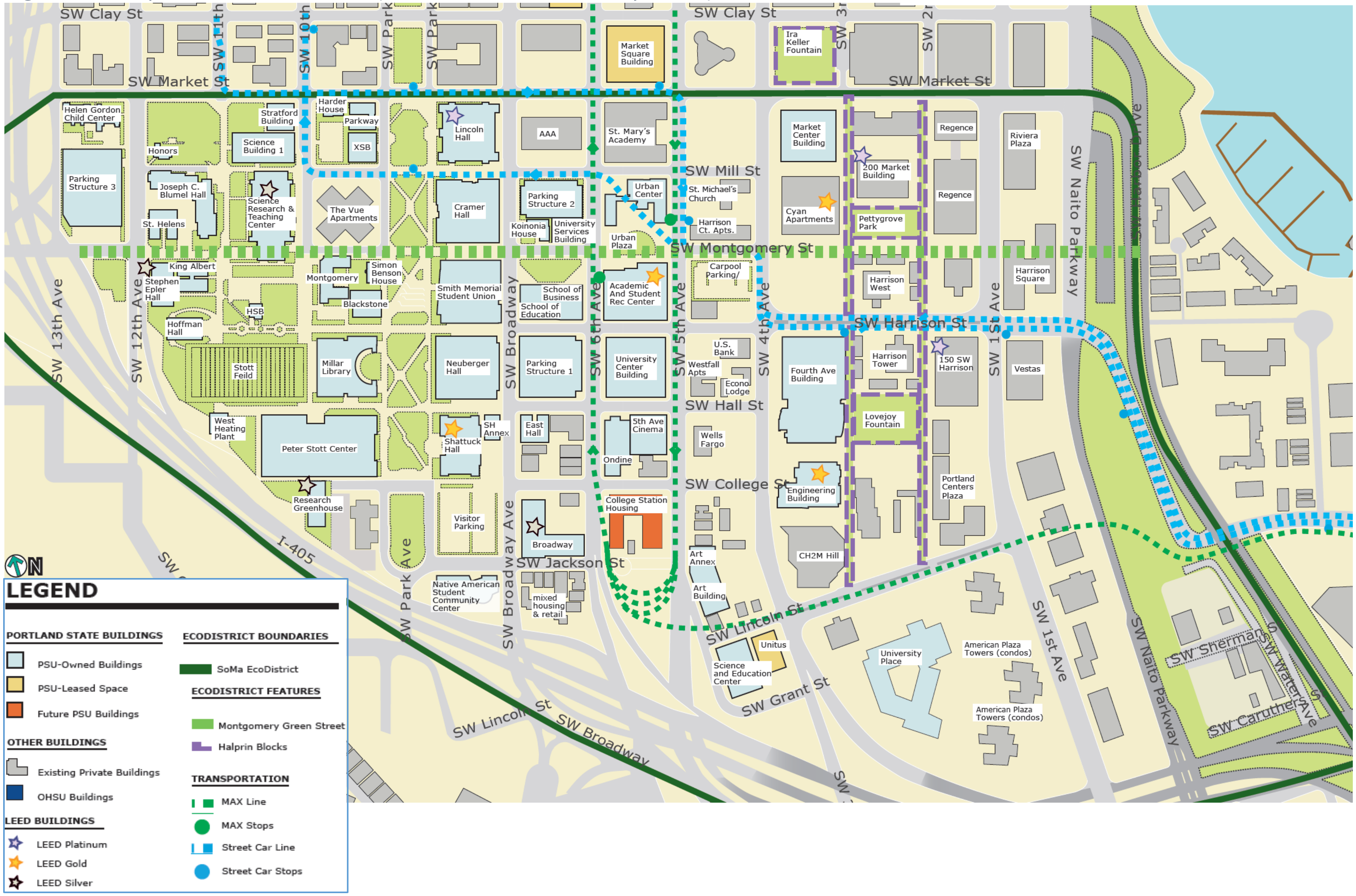
4. Definition of environmental and socio-economic objectives and indicators to assess projects.

Next, I will introduce the study area, followed by a description of the data used and the steps taken to analyze the data.

Study Area

The South of Market (SoMa) EcoDistrict, situated on the southern end of Portland's central city core, is the primary study area (Figure 3.2). The Portland Sustainability Institute succinctly characterizes the SoMa EcoDistrict as "one of the region's most vibrant urban neighborhoods, with unparalleled transit access, a dynamic urban research university, esteemed green spaces, and a diverse mix of business, retail, and residential uses. A well-connected, highly educated urban community, it is a place where students, educators, residents, workers, and business owners choose to live, work, and play" (Portland Sustainability Institute, 2012, p. 4). This description speaks to the unique aspects of SoMa that set it apart from the rest of downtown and the greater Portland area, including diversity, accessibility, education, and green space. Recently, the SoMa Research Group lead an effort to enumerate exactly how SoMa diverges from the rest of Downtown and Portland through in-depth descriptions of the area's socio-demographic, land use, and land cover patterns compared to the other areas of downtown and Portland as a whole (See Appendix A for SoMa Research Group's in-depth study area characterization).

Figure 3.2 Map of SoMa EcoDistrict (Portland State University, 2010)



Conventionally, planning primarily relies on city-scale data, but the data collected by the SoMa Research Group demonstrate that SoMa is distinct from the rest of Portland and Downtown. What works for the rest of Portland may not apply in SoMa and vice versa. Inherently, by tailoring planning to smaller units, projects become more directly applicable to their target audience. When structured within the framework of a network of plans (city, state, or national), small area plans can recognize the individuality of each small area and its value as part of the overall urban mosaic, and describe how small areas relate to each other and to the networks in which they are nested. Small area planning is “both a way to implement communitywide plans by translating their policies into specific physical designs and action, and at the same time a way to address issues, perhaps wider in scope, especially critical, or unique to the small area and its local stakeholders” (Berke & Kaiser, 2006). Also, cities like Nashville, Tennessee; Davis, California; and Portland, Oregon, use completed small area plans to constantly refine citywide plans in an iterative feedback loop (Berke & Kaiser, 2006). SoMa’s distinct characteristics justify the use of a neighborhood-scale approach to sustainability assessment and planning in this study because a neighborhood scale-approach has:

1. The ability to interpret and apply city-scale plans, while revealing and exploring unique issues, opportunities, and priorities not evident in the city-scale plan
2. The potential to broaden the range of issues addressed through citizen participation

3. The opportunity to enhance place making aspects of livability
4. The increased local knowledge base and connection to place of stakeholders
5. Potential for stronger commitment of local government to implement proposals based on more solid citizen support and fact base.
6. The ability to provide more specific project recommendations and designs

This investigation aims to address a crucial need for neighborhood-scale sustainability assessment techniques capable of addressing the dynamic nature of urban areas.

Data Collection

In this section I explain how I accessed the various data sources, beginning with the expert-driven top-down data and followed by the stakeholder-driven bottom-up data. Within each category, I discuss the quantitative, qualitative, or spatial data types associated with each data source.

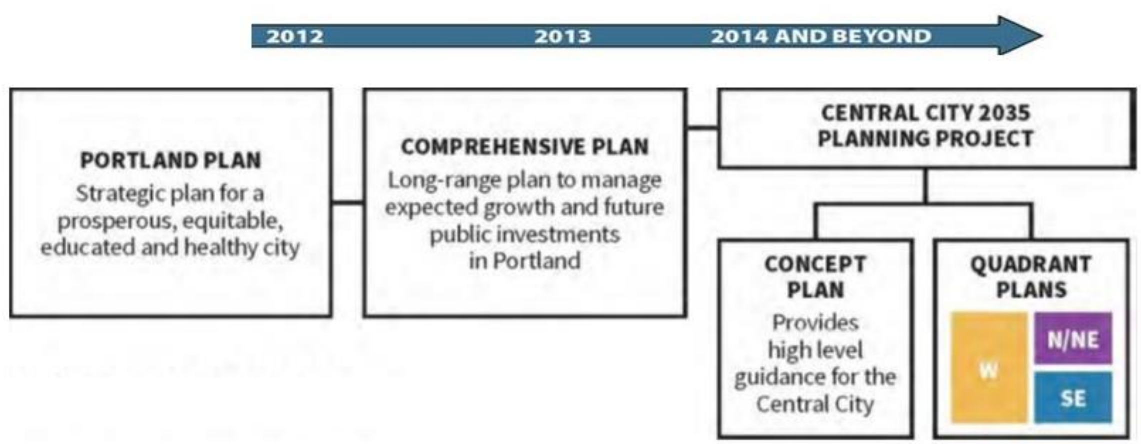
Top-down Data Sources

The top-down data sources that concern this investigation are a series of nested comprehensive plans, official reports, socio-demographic data, and physical data. The comprehensive plans were used in the qualitative assessment to establish a set of weighted district sustainability indicators. The rest of the top-down data sources were used to construct the spatial database and establish a performance rating for each indicator. The different types of top down-data compiled and analyzed are described below.

Comprehensive Plans

The series of comprehensive plans consulted for the present study were the Portland Plan (City of Portland, 2012), The City of Portland's 2035 Comprehensive Plan Proposed Draft (Bureau of Planning and Sustainability, 2014a), and the Central City 2035 West Quadrant Plan proposed draft (Bureau of Planning and Sustainability, 2014b) (see figure 3.3 for flowchart.

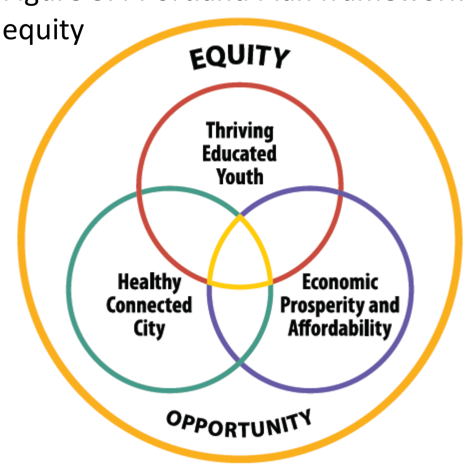
Figure 3.3 Timeline of comprehensive planning process (Bureau of Planning and Sustainability, 2014b)



These three plans are nested both temporally and spatially. The Portland Plan, adopted by the city council in April 2012, presents a framework for equity, three strategies, and 12 metrics to guide land use and investment decisions at the city scale. The overall goal of the Portland Plan is to create prosperous, educated, healthy, and equitable communities. To reach that goal, a strong definition and framework for equity was introduced. The Portland Plan defines equity as a condition, "when everyone has access to the opportunities necessary to satisfy their essential needs, advance their well-being, and achieve their full potential" (City of Portland, 2012, p. 18). Immediately, the plan committed to a series of measurements to indicate realization of equity, including when "all Portlanders have access to a high quality education, living wage jobs, safe neighborhoods, basic public services, a healthy natural environment, efficient public transit, parks and greenspaces, decent housing, and healthy food" (City of Portland, 2012, p. 18). Committing to "all Portlanders" is striving for 100% coverage of those metrics, which shows a strong commitment to equity.

To reach such an ambitious goal, seven steps were detailed in the framework for equity. These steps included closing gaps in disparity of basic public service delivery, engaging the community, building partnerships, launching an ethnic justice initiative, increasing focus on disability equity, and increasing internal accountability. Using that lens of equity to view land use decisions, the Portland Plan presented three integrated strategies to reach a prosperous, educated, healthy, equitable Portland. The strategies included thriving educated youth, economic prosperity and affordability, and healthy connected city (see fig 3.4 source City of Portland, 2012, p. 30). Each strategy is comprised of several elements including an

Figure 3.4 Portland Plan framework for equity

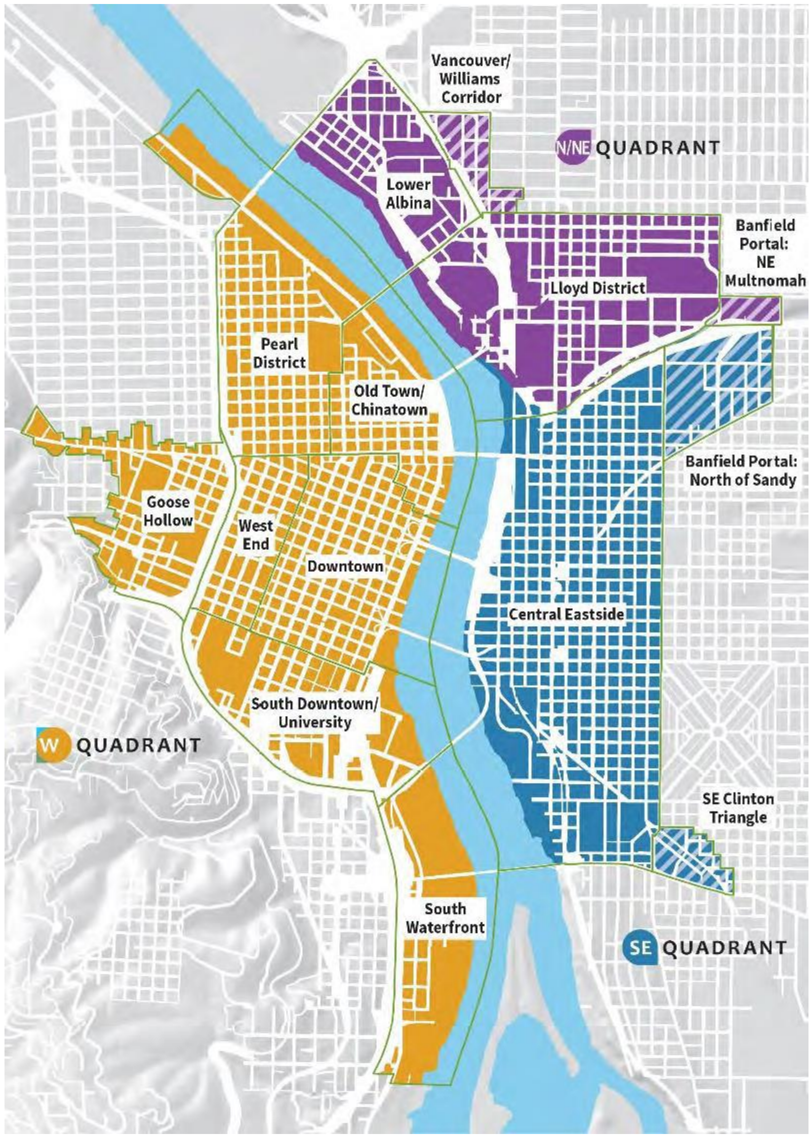


overall goal and corresponding objectives, strategy elements used to group guiding policies, a five year action plan categorized by action areas, and a list of partners. Following the integrated strategies, 13 measures of success, or indicators, were outlined and targets were discussed. These indicators included income distribution, diversity index, resident satisfaction, high school graduation rate, household self-sufficiency, export production rank, total jobs, transportation mode split, carbon emissions, complete neighborhood index, percent at a healthy weight, perceived safety levels, and a water quality index. The Portland Plan was a key visioning document for the comprehensive planning sequence, with concrete and inclusive action items and metrics.

The 2035 Comprehensive Plan (proposed draft August 2014) served to implement the goals and strategies of the Portland Plan. To build on the goals laid out in the Portland Plan, the Comprehensive Plan is guided by a set of five principles, to be considered in every land use decision. They include economic prosperity, human health, environmental health, equity, and resilience. By applying these principles to every facet of the land use planning process, the Comprehensive Plan details hundreds of policies and goals within nine categories that govern all land use and capital improvement projects. These categories include community involvement, urban form, design and development, housing, economic development, environment and watershed health, public facilities and services, transportation, administration and implementation. Each section details what it is about, why it is important, and a list of goals and policies. Overall, the goals and policies of the Comprehensive Plan are designed to follow and advance the guiding principles of prosperity, education, health, and equity of Portland as a whole.

The Central City 2035 plan updated the goals and policies specific to the central neighborhoods in Portland. This plan is comprised of three sections covering each neighborhood of the four downtown quadrants including north and northeast, southeast and west. Each section proposes a unique set of goals, policies, and implementation actions to address the issues relevant to each neighborhood in that quadrant. For the purposes of this study, I focused on the subsection of the West Quadrant Plan that dealt with the South Downtown neighborhood, which overlaps with the study area (see figure 3.5). Topics addressed in the plan included land use, urban design, transportation, public infrastructure, and development entitlements. The Central City 2035 West Quadrant Plan seeks to foster a vision of a downtown area that is a center for innovation and exchange, and to uphold the health and vitality of Portland, the metropolitan region, and at larger scales. The Central City 2035 Plan merges the Portland Plan and the comprehensive plan update by integrating the equity framework and strategies proposed in the Portland Plan with the goals and policies of the Comprehensive Plan, given the unique context of downtown neighborhoods.

Figure 3.5 Map of Central City 2035 planning quadrants (Bureau of Planning and Sustainability, 2014b, p. 1)



Spatial data

Several sources were consulted to construct the spatial database from the indicators identified in the series of previously mentioned comprehensive plans. These include socio-demographic data (US Census and American Community Survey (ACS)), two City of Portland reports (Portland Development Commission's Buildable Land Inventory and Complete Neighborhood Inventory), and physical data, including Regional Land Information System (NAICS codes, greenspace, multimodal access, public-safety), PSU (university growth, green infrastructure, campus utilities), public utilities (PGE and NW natural) and an ad hoc dataset compiled from existing public-private partnerships in the area.

The U.S. Census (2000 and 2010) and the American Community Survey (2000-2013 5-year estimate) provided the socio-demographic data used in this study, including income distribution, transportation mode split (a measure of distribution of travel types) and housing cost burden. A combination of data for the years 2010 and 2000 were collected at the block level (the smallest aggregation unit) to calculate population size, race, and age composition. The 2000 census was used for more specific age categories, gender, income distribution, household status, and education level statistics, which have been eliminated from the most recent census (United States Census Bureau American FactFinder, 2000, 2010). A comparative analysis was run using block group data from both years, which justified using 2000 block-level income data. The American Community Survey 2013 5-year estimate was used to calculate mode split and housing cost burden estimates. Mode split was calculated using a survey of means of transportation to work (United States Census Bureau / American FactFinder (2013a). Housing cost burden estimates were calculated by the ratio of housing costs and fees to household income (United States Census Bureau American FactFinder, 2013b). One consideration of using ACS data is the high uncertainty level at such high resolutions. It is the industry standard to still use ACS cost burden data despite the high uncertainty level, as long as the uncertainty level is published (Coalition for a Livable Future, 2013; Kirwan Institute, 2015). Another tactic of using ACS data is to use census tract-level data, which is more reliable than block level data for the ACS, but less applicable to the neighborhood scale.

Two key City of Portland unpublished datasets (the Buildable Land Inventory and the Complete Neighborhood Index) from a pair of reports-the Growth Scenarios Report (Bureau of Planning and Sustainability, 2015) and the 20-Minute Neighborhood Report (Bureau of Planning and Sustainability, 2012)-provided spatial data on jobs per household and complete neighborhoods. The 2013 Growth Scenarios Report served as a background report for the comprehensive plan update. The purpose of the report was to describe Portland's expected growth over the next 25 years and to measure the performance of different alternate growth patterns to meet Portland's goals and objectives. To achieve this purpose, the report relied on a critical spatial dataset called the Buildable Land Inventory (Bureau of Planning and Sustainability, 2014). This inventory compares the spatial distribution of existing housing and employment indicators against four development scenarios; business as usual, centers-focused, corridors-focused, and central city-focused. For the purposes of this investigation, the existing baseline measurements for number of jobs and households were used to calculate a jobs/household measurement. Another comprehensive plan background report, the 20-Minute Neighborhood Report, provided the essential index of complete neighborhoods in Portland. The report describes the 20-minute Neighborhood Analysis methodology used to create the complete neighborhood index (Bureau of Planning and Sustainability, 2012). Areas are assigned a score according to the distance from each of the following various everyday needs; bicycle, pedestrian and public-transit infrastructure, commercial services, healthy food, parks, and schools. For the purposes of this research, the combined score from each of these categories was used to calculate a complete neighborhood score.

As previously mentioned, physical data were collected from multiple sources including the Regional Land Information System (RLIS), Portland State University campus geodatabase, public utility records and a dataset I compiled from existing public-private partnerships. Portland is fortunate to have three spatial data repositories that I relied on for this study, including CivicApps.org, METRO's Regional Land Information System, and PSU's campus geodatabase. CivicApps.org is a non-profit that partners with public agencies and a broad spectrum of community members to make data more available to every citizen. I consulted the business license layer (City of Portland, 2014a) to calculate the diversity and density of businesses in the study area based on North American Industry Classification System (NAICS) code. To calculate public safety, I consulted the crime incident layers for 2012 (City of Portland, 2013) and 2013 (City of Portland, 2014b). In addition, I also consulted the vegetation layer to calculate the distance from greenspace (City of Portland, 2010). Oregon METRO compiles more than 100 spatial data sets in the Regional Land Information System (RLIS), most of which are available for free online at http://rlisdiscovery.oregonmetro.gov/. To calculate a score for multimodal access, I consulted the bike route (Metro, 2014) and trails (Metro, 2010) layers as well as the frequent transit access layer from the Complete Neighborhood Index (Bureau of Planning and Sustainability, 2012). Portland State University also maintains an extensive spatial database of the campus and surrounding area. The campus geodatabase available on the PSU idrive (Portland State University, 2015) provided spatial data used to measure university growth, green infrastructure, and campus utility usage.

In addition to the established spatial data repositories and reports mentioned above, I also collected public utility data and examples of public-private partnerships in the study area. Public utility data was gathered from Portland General Electric and Northwest Natural. From Portland General Electric, data was aggregated to the feeder-level, usually two to four blocks, to protect customer anonymity. I received annual average and high and low energy usage for 2010-2014 for most feeder zones in the study area (D. Rayborn, personal communication, February 12, 2015). From Northwest Natural, I received an annual average, and high and low gas usage for 2014 for most addresses in the study area (some buildings do not use gas) (Customer accounts, personal communication, February 2, 2015). In addition to utility usage, I also compiled an ad-hoc list of public-private partnerships for sustainability in the study area by word of mouth, Internet search, and email list serves. The sources I ultimately consulted were Portland State University's department of planning and sustainability office of strategic partnerships (Portland State University, 2015b), the West Quadrant Plan stakeholder advisory committee (City of Portland, 2015), and the Kilowatt Crackdown (Kilowatt Crackdown, 2013).

Bottom-up Data Sources

The SOURCE DSS relies on bottom-up data sources, or data derived from a broad spectrum of stakeholders, in addition to top-down data from agencies and experts to systematically weight collaboratively agreed upon indicators. Three bottom-up data collection efforts were adapted for the purposes of this research:

1. Two summaries of workshops, surveys, and community meetings held by the Bureau of Planning and Sustainability during the comprehensive plan update process
2. An extensive survey, charrette mapping exercises, and a summary of 17 community meetings held by the West Quadrant Planning committee
3. Survey results from the SoMa Research Group about stakeholder perceptions of the SoMa EcoDistrict

Regarding the comprehensive plan update, two Bureau of Planning and Sustainability (BPS) reports, *What we Heard from the Public Report* (BPS CIC, 2013), and *What We Heard from the Public, CPU Part II* (BPS CIC, 2014) were obtained from BPS's Community Involvement Committee. The Community Involvement Committee for the Comprehensive Plan Update serves Portland's numerous and diverse communities, ensuring that the perspectives of all Portlanders are reflected in the Comprehensive Plan Update. The first *What we Heard* report summarized public comments from eight different workshops with over 350 people in attendance to discuss issues on business and the environment in six different districts. It also summarized the findings of an online and paper survey containing 427 submissions. Public comments from 175 community presentations between January 2012 and May 2013 with approximately 3,500 people in attendance were also summarized. Finally, nearly 300 public comments collected online, at workshops, and other community meetings were summarized in this report. The report begins by introducing demographic data of workshop participants. It goes on to summarize public comments according to chapters of the comprehensive plan update. The report concludes with a summary of the responses to a policy survey.

The Bureau of Planning and Sustainability continued the public outreach and comment process throughout the Comprehensive Plan Update process and released a second summary report of public comments entitled *What we Heard From the Public, CPU II* (BPS CIC, 2014). The second report summarized stakeholder data from workshops, public meetings, online feedback, the comprehensive plan map application, and emails and letters submitted by the public. In total, nearly 1,100 comments were summarized from 51 community meetings, 33 Map App training events, three BPS information sessions, three district mapping conversations, and three community events. The report summarized the comments by topic, district, and mapping conversation, as well as reported demographic data. The data from both these summaries were used to guide revisions to the comprehensive plan working draft.

Bottom-up data pertaining to the study area were also collected during the West Quadrant Planning process by the Bureau of Planning and Sustainability West Quadrant Plan project team. The efforts included 17 BPS-lead events, an Internet survey, and a series of charrette mapping exercises created by the Stakeholder Advisory Committee. From December 2012 through May 2014 the west quadrant plan team collected stakeholder data from a series of 17 events ranging from planning workshops, land use association and committee meetings, and stakeholder advisory committee meetings. The West Quadrant Stakeholder Advisory Committee works with the project team to review materials and make recommendations for the proposed draft of the West Quadrant Plan. The Issues Summary Report (BPS WQPPT, 2013a) begins by describing the 17 events from which it draws, and then summarizes west quadrant-wide concerns. Additionally, a summary of comments on each district is included, organized by development topic. As an appendix, the project team also included the responses from an online survey (BPS WQPPT, 2013b) to inform the Stakeholder Advisory Committee during the West Quadrant Plan charrette. The 23-question online survey resulted in 101 responses collected between March and May 2013. Nineteen of the questions were multiple-choice. Topics span the range of development and land use issues including housing, transportation, economic/commercial opportunities, and development barriers and priorities. These responses, while not specifically summarized in the Issues Summary Report, were included to inform the Stakeholder Advisor Committee during their West Quadrant Plan charrette. The charrette consisted of 35 maps and drawings created by the Stakeholder Advisor Committee concerning each topic in the West Quadrant Plan, neighborhoods in the west quadrant, and various development strategies (BPS WQPPT, 2013c).

Finally, raw survey results collected by the SoMa Research Group in 2012 were also examined to gather additional stakeholder perceptions of the study area (SoMa Research Group, 2012). From November 2011 through October 2012, I worked with the

SoMa Research Group to design, implement, and analyze a survey of SoMa stakeholders' use and perceptions of the SoMa EcoDistrict called the Neighborhood Life Survey. The SoMa research group's intent was to engage the SoMa community through measuring neighborhood sustainability. The Neighborhood Life Survey contained spatially explicit, quantitative and qualitative data gathered from SoMa stakeholders about their use of the area, socio-demographic data and their perceptions of place. As a combination online and intercept survey, a total of 361 responses were collected. The survey was designed in two sections, first a mapping exercise which asked respondents to place a point with a short description in response to eight questions, followed by a traditional multiple choice portion. The results of the survey were presented to the SoMa EcoDistrict Steering Committee. Also, the data was used to inform the SoMa EcoDistrict Roadmap, a collaborative effort between the Portland Sustainability Institute, the SoMa Steering Committee, and the SoMa Research Group (Portland Sustainability Institute, 2012). For this investigation, two responses from a selection of the mapping exercise were used as an opportunity sample because of their direct relevance, comprehensive nature and robust dataset. These included two response groups: identify locations of assets and identify where change is needed.

Analysis Procedure

This section outlines the way in which I analyzed the various data types. I first outline the textual coding techniques that were employed for the content analysis of comprehensive plans, reports, workshops summaries, charrettes and surveys. These were used to establish neighborhood goals, indicators, and priorities to weight relative performance within the SOURCE DSS and tested via intercoder reliability. Then I outline the Analytic Hierarchy Process used to systematically assign relative weights to the goals and indicators identified in the content analysis. Next, I discuss the steps necessary to convert any data into the spatial database. Then I detail the optimization process by defining the SOURCE analysis rules and composite suitability scoring. I conclude the section by outlining how indicator quality was assessed.

Content Analysis of Top-Down and Bottom-Up Data

Qualitative coding was performed for all of the previously mentioned comprehensive plans, reports, and survey responses using a collaborative social research approach which conforms to the standards of Berg, 2007 (Qualitative research methods for the social sciences). Content was analyzed systematically and objectively through the use of text coding to identify special characteristics and themes of responses. A combination of manifest (what is actually present) and latent (deeper themes) content analysis was applied to the data. This allowed for quantitative analysis (i.e. counts) as well as qualitative analysis of the deeper structural meanings (themes) within the data. The content analysis took a deductive approach in which categorical themes suggested by a theory were used to test a hypothesis (as opposed to an inductive approach where themes emerge from the data). In this investigation, the categorical themes arose from principle theories of sustainability (environmental, social, and economic) to identify which criteria, indicators, and development priorities (weights) were embodied in the various data sources. By categorizing development goals and indicators based on the three principles of sustainability-environmental, social, and economic- data were grounded in the themes that were most meaningful to the goals, priorities, and indicators of urban neighborhood sustainability (Berg, 2007). For a full qualitative coding framework see table 3.1. This coding framework allowed for a synthesis of the intentions for development from a top-down and bottom-up perspective. Specifically, development goals were explicitly defined and lists of indicators of each goal were identified. This prepared the indicators to be weighted during the AHP with respect to each other and the top-down and bottom-up perspective. This construction of development goals and indicator weightings allows for site-specific relevance that reflects the characteristics and promotes the sustainability of the region (Sharifi & Murayama, 2011).

Table 3.1 Qualitative coding framework

1. Development Goal Codes	Subcodes	Definition/Description	Example
A Environmental Goals	**A1** Land Use	**A1** Human use of land including modification and management of built lands	**A1** Prioritize compact development, preserve local identity
	A2 Greenspace/ natural resource/ecosystem service	**A2** Benefits people obtain from ecosystems (supporting, provisioning, regulation and cultural)	**A2** Preserve and enhance habitat, natural resources, and ecosystem services; use green infrastructure to integrate nature
	A3 Air/water	**A3** Subset of A2, specific to air and water goals including CO2 emissions, wastewater, and stormwater	**A3** Improve wastewater and stormwater quality, efficiency and equity, improve air quality
B Social Goals	**B1** Transportation	**B1** Public rights of way, public transportation, active transportation, and trails	**B1** Prioritize pedestrian transportation infrastructure, safe, convenient affordable multi-modal
	B2 Well-being	**B2** Basic material for a good life, freedom and choice, health, social relations, and safety	**B2** Maintain affordable housing supply; Support human health and public safety
	B3 Complete Neighborhood	**B3** Access to goods and services needed in daily life	**B3** Enhance public gathering spaces; Increase access to commercial services
C Economic Goals	**C1** Private Sector	**C1** Individuals and for-profit companies	**C1** Encourage local goods production; Develop neighborhood business district
	C2 Public Sector	**C2** Government-run organizations	**C2** Provide equitable, reliable, and efficient public service delivery
2. Proposed Indicator Codes	Subcodes	Definition/Description	Example
D Environmental Indicators	**D1** Land Use	**D1** Indicators of human use of land including modification and management of built lands	**D1** Land supply (Buildable Land Inventory); Land need
	D2 Greenspace/ natural resource/ecosystem service	**D2** Indicators of benefits people obtain from ecosystems (supporting, provisioning, regulation and cultural)	**D2** Access to greenspace and infrastructure; CO2 emissions; Tree canopy; Habitat connectivity

Continued on next page

	D3 Air/water	**D3** Indicators of air and water goals including CO2 emissions, wastewater, and stormwater	**D3** Sewage overflow event frequency; Water quality; Air quality; CO2 emissions; Green infrastructure
E Social Indicators	**E1** Transportation	**E1** Indicators of public rights of way, public transportation, active transportation, and trails	**E1** % within ¼ mile of public transit; Mode split; Vehicle miles travelled; Bicycle and pedestrian infrastructure
	E2 Well-being	**E2** Indicators of well-being including housing, social capital, education, health, satisfaction, and safety	**E2** % of overweight adults/children; Crime rate; Displacement rate; % cost burdened homes, public involvement
	E3 Complete Neighborhood	**E3** Indicators of goods and services needed in daily life	**E3** Access to commercial services, k-12 schools, and healthy food
F Economic Indicators	**F1** Private Sector	**F1** Indicators of individuals and for-profit companies	**F1** Local good production; Number of local businesses; Jobs/household; Income distribution
	F2 Public Sector	**F2** Indicators of government-run organizations	**F2** Distribution of public services; Regulatory costs; Inter-agency partnerships
3. Thematic Codes	Subcodes	Definition/Description	Example
G Equity	**G** Equity	**G** Goals and Indicators related to the distribution of goods, services, opportunities, and burdens	**G** Increase environmental equity; Distribution of public service delivery
H Partnerships	**H** Partnership	**H** Goals and Indicators related to public involvement in the planning process, public-private partnerships, and interagency agreements	**H** Increase stakeholder participation in the planning process; Number of partnerships to maintain greenspaces/stormwater gardens

Next, I will discuss the units of coding, the qualitative coding process, and the intercoder reliability testing process. Bruce and Berg (2001) identify seven major elements in written messages that can be counted in content analysis: words, themes, characters, paragraphs, items, concepts and semantics. For the purposes of this analysis, themes were the most basic counting unit. Themes are the subject of the piece of writing and are usually a sentence with a paragraph. Both primary and secondary themes can be counted, especially for larger units such a paragraphs. Strict definitions of the content to be analyzed were specified due to the wide variety of content (see table 3.2).

Table 3.2 Qualitative Data Sources and Units Coded

Data Source	**Sections Coded:** Coding Unit
The Portland Plan	**Introduction**: each section as a unit, headings denote new units **Framework for equity:** each section, "we will…" statements, and action items **Integrated strategies:** goals and objectives, strategy elements, guiding policies, and action plan as units **Measures of Success:** each of the 12 measures as a unit
Comprehensive Plan Update Proposed Draft	**Chapters 1-9:** individual goals and policies as units
West Quadrant Plan	**Chapter 5 subsection South Downtown/University pp. 131-142:** district goals, key elements, policies, and implementation actions as coding units
What we Heard from the Public I&II	**Summary of public comments and district by topic**: individual topic summaries and central city district summary topics as coding units
West Quadrant Plan Issues Summary Report, Survey results, and SAC Charrettes	**Issues summary**: west quadrant-wide summary of issues by topic (each point as unit) and south downtown issues summary by topic (each point as unit) **WQP Issues Survey Results**: individual responses to each question as coding unit **SAC Charrettes**: each map element as coding unit
Neighborhood Life Survey results	**Rational for placing point on survey**: each written response justifying the placement of a point in response to two questions (identify assets and desired changes) was used as unit of analysis

I performed the content analysis on all of the documents in the order listed above. Using Adobe Reader, I highlighted primary and secondary themes present in each of the previously listed sections and coding units. Using the comment function, I assigned at least one code, sometime multiple, from the coding frame (table 3.1) for the entire document. After all of the codes were assigned to the coding units, I used the comment search function to identify collocations within the coding units assigned a given code. From that list of, for example "a1" *land use goals*, I summarized the sentiments of the coding unit's theme in an inductive manner consistent with the techniques of Bruce and Berg (2001). This approach often blends manifest and latent content analysis methods by counting both what is directly present in the text as well as deeper themes. An example of this might be an indicator that measures the percentage of people taking alternative forms of transportation. A manifest interpretation would be to count *alternative forms of transportation* as the theme of this indicator, whereas a latent interpretation would be to count this thematically as a *mode split*.

Whenever possible, the latent interpretation of the data was used, as this provided greater continuity within and between documents, which greatly helps when assigning relative weights during the AHP. By having more repetition of themes around a general topic, rather than many individual, specific themes, I was able to more readily identify patterns to establish weights in the AHP pairwise comparison process. One drawback of relying on a latent approach is that it requires an advanced knowledge of urban planning concepts. This issue came to light during the intercoder reliability testing phase, which will be discussed later in the paper.

In addition to recording the code and theme, I also noted which other code(s) occurred in the same coding unit. For example, Comprehensive Plan policy 6.60 "District function: Enhance the function of neighborhood business districts as a foundation of neighborhood livability," (p. 99) was coded as B3 complete neighborhood goal as well as C1 private economic goal. By recording associated codes, I was also able to analyze patterns, or groupings of codes that commonly corresponded. These groupings will be further discussed in the results and discussion section. To count the number of themes and associated codes, I entered the data into an online lexical frequency analysis tool, The Complete Word Lister, from Lextutor.ca. The tool matches text with identical characters and organizes them by frequency. Since this tool is usually used for analysis of words instead of phrases, one processing step was taken. All spaces were deleted from themes that were phrases instead of a single word. For example, the theme *preserve affordable housing* was transformed to *preserveaffordablehousing*. Corresponding codes were also entered into the frequency counter. No additional processing steps were taken to enter the associated code into the frequency counter. The counter returns the list of themes and associated codes in order of most to least frequent, with associated counts. After the frequency analysis, I gathered quotations from the documents that supported the mostly commonly occurring codes and associations. Additionally, quotes were selected that embody deeper sentiments and patterns than could be captured by the most frequently occurring themes and codes. A summary of between and within group comparisons of the top-down and bottom-up documents will be presented in the results section.

Intercoder Reliability Testing

Intercoder reliability is the degree to which different coders evaluate the characteristic of a message and reach the same conclusion (Freelon, 2010). Intercoder reliability testing was performed by two additional trained qualitative researchers to verify the reproducibility of the content analysis. Each researcher was given background on the study, received the coding framework (table 3.1), and was trained on how to apply the framework to coding units. The research assistants were given a selection of the material to code using the same process I outlined earlier. The sections from each document that were re-coded included “Measures of Success” section of the Portland Plan (pp. 106-145), “Environment and Watershed Health” goals and policies section of the Comprehensive Plan update (pp. 109-113), and the “South Downtown/University District” section of the West Quadrant Plan (pp. 133-142).

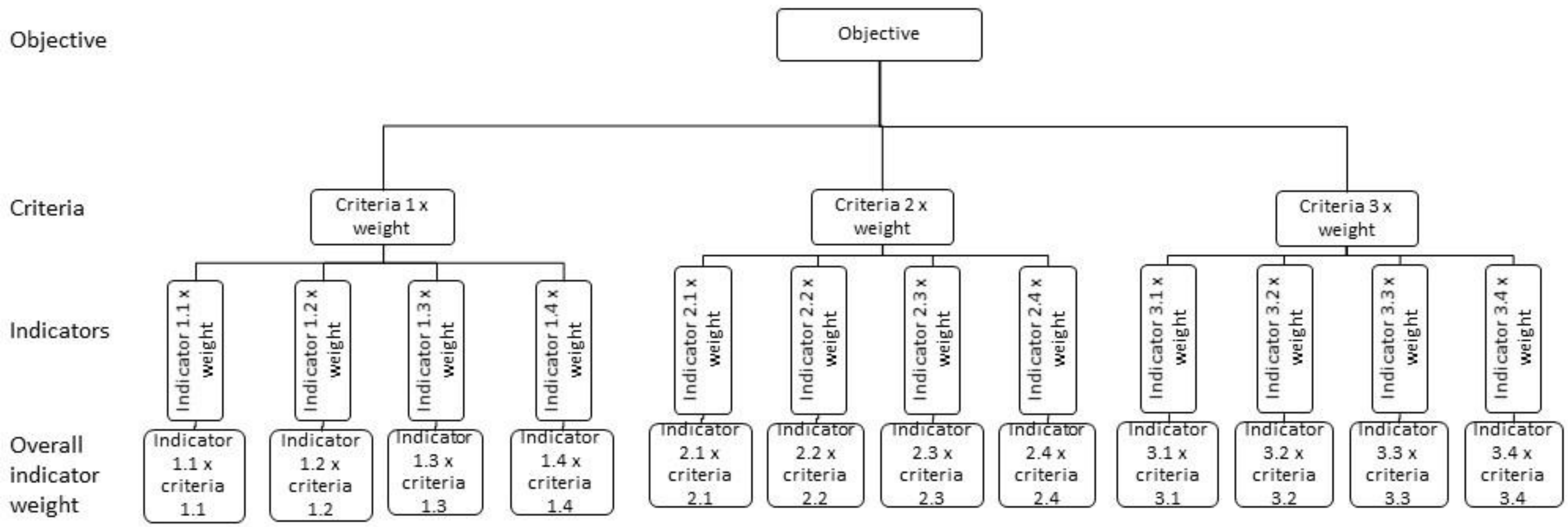
An online tool, Reliability Calculator for 2 coders (ReCal2), was used to compute intercoder reliability coefficients for the data coded by two coders. ReCal2 reports a number of distinct coefficients that summarize the level of reliability attained by independent coders for a given variable including percent agreement, Scott’s π, Cohen’s κ, and Krippendorff’s α. Percent agreement is the simplest of the coefficients, derived by dividing the number of instances of agreement between the two coders by the total number of analysis units; but has been criticized for being overly liberal. To correct for chance agreement between coders, Scott’s π, Cohen’s κ, and Krippendorff’s α coefficients were also calculated. To prepare the intercoder reliability data for the online utility, I transformed the alphanumeric codes to strictly number codes for each instance. For example, code "A1" land use criteria was transformed to "11", and code "E2" well-being indicator was transformed to "42". Using Microsoft Excel, I created a two-column spreadsheet containing each decision of both coders on a given selection (see appendix B). The spreadsheets containing the judgments of both coders for each document were uploaded to the ReCal2 utility (http://dfreelon.org/utils/recalfront/recal2/) which reported percent agreement, Scott's π, Cohen's κ, and Krippendorff's α. An agreement rate of 80% was set as the minimum criteria for accepting the intercoder reliability results.

Analytic Hierarchy Process Methods

The Analytic Hierarchy Process (AHP) is one of the most comprehensive approaches to defining decision problems discussed in field of MCDA (Chandio et al., 2013; Sipahi & Timor, 2010). Multicriteria decision problems involve a set of alternatives that are evaluated on the basis of conflicting and incommensurate criteria and indicators according to decision makers' preferences. MCDA is based on three elements: decision makers, criteria, and alternatives. Coupled with a three-step procedure of value scaling (standardization), criteria weighting, and combination (decision) rule to solve spatial multicriteria problems, these elements and basic concepts form the foundation for the AHP and other MCDA methods (Eastman et al., 1993, Thill, 1999; Malczweski, 1999; 2006).

Traditionally, AHP begins by convening a diverse group of stakeholders to collectively model a problem hierarchically and set criteria and indicators through a variety of participatory processes (charrettes, planning workshops, community meetings, etc.). Then, either collectively in groups or individually, stakeholders relatively rank alternative criteria and indicators in a pairwise manner to derive normalized relative weights of each criteria and indicator respective to an overall objective. In the current study's application of the AHP, these steps have been modified. I chose to perform a content analysis of several data sources due to resource limitations and the abundance of stakeholder and expert-derived secondary data that were directly related to the study area and topic. A combination of top-down and bottom-up documents, planning charrettes, workshop summaries, and surveys were analyzed to construct a hierarchy modeled after decision structure, with an objective at the pinnacle, and criteria and indicators beneath. The Analytic Hierarchy Process (AHP) is based on the concepts of decomposition, comparative judgment, and synthesis of priorities. In the decomposition step, the decision problem is decomposed into a hierarchy that captures the key elements of a problem, including objective, criteria, and indicators (see figure 3.6)

Figure 3.6 Conceptual Hierarchy of objectives, criteria, indicators and overall indicator weight



The present study divided the decision makers into two groups, top-down and bottom-up. Top-down decision makers are official organizations (BPS, PDC, EcoDistricts, planning consultants) that are typically thought of as those responsible for making decisions, whereas bottom-up decision makers are comprised of a variety of stakeholders and interest groups (neighborhood associations, employees, residents, business owners, and property owners). Elements of the decision problem were evaluated on the basis of a set of indicators, which comprise comprehensive and measurable criteria and objectives.

Comparative judgment requires assessment of pairwise comparison of the elements within a given level of the hierarchical structure, with respect to the next highest level. After the problem was defined and the indicators were selected through the content analysis process described above, I organized the objective, criteria, and indicators in a hierarchical structure to facilitate a series of pairwise comparisons to establish priorities. Overall priority at each level was calculated by adding the weighted value of the level below. The process of assigning weights to the criteria and indicators followed a three-step process. First, I constructed an $n \times n$ pairwise comparison matrix based on the number of alternatives (criteria or indicators) at a given level of the hierarchy. Then I compared the relative importance of alternatives (criteria or indicators) in a series or pairwise comparisons based on the sentiments reflected in the variety of stakeholder-derived data. The core of the typical problem to be solved using the AHP methodology to weight the alternatives (criteria) can be represented by the following pairwise comparison matrix (table 3.3):

Table 3.3 Pairwise comparison matrix conceptual image

Criteria X	Indicator X.1	Indicator X.2	Indicator X.3	Indicator X.4	Relative Weight
Indicator X.1	X.1/X.1	X.1/X.2	X.1/X.3	X.1/X.4	Weight X.1
Indicator X.2	X.2/X.1	X.2/X.2	X.2/X.3	X.2/X.4	Weight X.2
Indicator X.3	X.3/X.1	X.3/X.2	X.3/X.3	X.3/X.4	Weight X.3
Indicator X.4	X.4/X.1	X.4/X.2	X.4/X.3	X.4/X.4	Weight X.4

To fill in ratios within each matrix, I used the measurement scale of Saaty (Table 3.4) to assign a relative weight (1-9) to each decision element based on the results of the content analysis. The scale ranges from 1 (equal importance) to 9 (absolute importance of one element over another) (table 3.8). When an element was compared with itself, I assigned a value of 1.

Table 3.4 Fundamental Scale (Saaty, 1980)

Intensity of Importance	**Definition**	**Explanation**
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or Slight	
3	Moderate importance of one over another	Experience and judgment slightly favor one activity over another
4	Moderate plus	
5	Essential or strong importance	Experience and judgment strong favor one activity over another
6	Strong Plus	
7	Very Strong or demonstrated importance	An activity is favored very strongly over another; its dominance is demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
Where: 2, 4, 6, 8	Intermediate values between two judgments	When compromise is needed
1.1-1.9	If the activities are very close	May be difficult to assign the best value but when compared with other contrasting activities the size of the small numbers would not be too noticeable, yet they can still indicate relative importance

The normalized relative weight, or priority vector for each element, can be found by calculating the total of each matrix row and then normalizing to one. The normalized relative weight represents the corresponding value of importance given to each element in the hierarchy. The computation of the weights involves two equations (figure 3.7). First, the pairwise comparison matrix is normalized by equation one and then the weights are computed by equation two.

Figure 3.7 Equations to normalize and calculate relative weights (Lofti and Habibi, 2009)

(1) $$a_{ij}^{*} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \quad \text{for all } j = 1, 2, \ldots, n$$

(2) $$w_i = \frac{\sum_{j=1}^{n} a_{ij}^{*}}{n} \quad \text{for all } i = 1, 2, \ldots, n$$

A Consistency Ratio was calculated to validate the derived priority weights based on the ratio of the Consistency Index to the Random Consistency Index (Malczewski & Rinner, 2015). If the Consistency Ratio was less than .1 then the comparisons were acceptable. For the present study, the priority weights and Consistency Ratios equations were calculated using online AHP calculation software by CGI (CGI, 2013).

The third step of the AHP is the synthesis of priorities, which requires the transformation of the evaluation criteria to comparable units, referred to as value scaling or standardization methods. To create an overall suitability score, this synthesis brings together the results of decomposition and comparative judgment by combining weights for each decision alternative with normalized performance values. These performance values were normalized using the most popular GIS-based method called the score range procedure (Malczewski, 2006). This procedure creates a relative performance score based on the highest and lowest performing attributes in the system and normalizes the range to 1. The synthesis of priority weights and normalized performance scores was then carried out using the weighted linear combination method (figure 3.8).

Figure 3.8 Weighted linear combination equation

$$Ai = \sum_{j=1}^{n} wjxij$$

Where "*Ai* is the value of suitability for i^{th} each alternative (minimum spatial unit), *xij* is the score of i^{th} alternative with respect to the j^{th} standardized criterion value, and *wj* is a normalized weight, so that the sum of *wj=1.* The most preferred was that with the maximum value of *Ai*"(Uribe et al, 2014). To put in the context of neighborhood scale sustainability spatial optimization, locations with the worst sustainability performance score given a high preference weight are the optimal locations to focus neighborhood scale sustainable development efforts. The SOURCE suitability score seeks to maximize block level sustainability performance given relative preference weight of each indicator.

This research, along with the majority of studies (Malczewski & Rinner, 2015), assumes the value function of the criteria score has a linear form, meaning the utility decreases proportionally to increases in criteria score. An overall indicator weight is then assigned to each indicator denoting its importance relative to other criteria under consideration. The present study employs a compensatory, multi-attribute model to spatial decision making. This allows for poor scores in one category to offset a good score in another.

Data Conversions and Relative Performance Rating

In order to import all of the data sources into the spatial database, a series of steps were taken to clip data sets to the boundaries of the study area and assign relative performance ratings to each block in the study area, which is outlined below. First, I describe the clipping of the socio-demographic and physical data. Then I describe the process of assigning relative performance ratings and cumulative suitability scores to blocks.

Socio-demographic and physical data were clipped to the study area following the same procedures as the SoMa Research Group's previous effort to characterize the area. Socio-demographic data were collected from the U.S. Census (2000 and 2010) and American Community Survey (2000 and 2013 5 year estimates) at the block level. Neighborhood boundaries do not align precisely with census blocks (the smallest aggregation unit), and as a result, blocks were selected for analysis if they were 90% contained by the study area boundary. 2010 U.S. Census data was used to calculate population size, race, and age composition. Many questions were dropped from the

Census between 2000 and 2010, including: more specific age categories, gender, income, household status and education level; statistics for the aforementioned categories come from 2000 Census data (Shandas et al 2012). Physical data were clipped, following the same procedure, from the following data sources: the Portland Development Commission's Buildable Land Inventory and Complete Neighborhood Inventory, RLIS data base layers (NAICS codes, greenspace, multimodal access, public safety), PSU (university growth, green infrastructure, campus utilities) public utilities (pge and nw natural), and a dataset I compiled from existing public-private partnerships.

A series of steps was taken to transform the spatial data represented by the various indicators into relative performance ratings for each block in the study area. Once the data for each layer were clipped to the study area, relative performance ratings were assigned to each block based on the average performance of that indicator over the area of a given block using the Zonal Statistics as Table tool in ArcMap. Each indicator layer contained a data table with a variety of information about a layer. To simplify the analysis, only essential data table column headings were kept for the performance analysis. For a complete list of indicators, columns used, performance scale, and source see table 3.5.

Once the unnecessary column headings were turned off, the Zonal Statistics as Table tool was run on each indicator layer, using the block layer previously clipped to the study area. The Zonal Statistics as Table tool works by summarizing the values of a layer within the zones of another dataset and reports the results to a table. In this analysis, the tool reported the average performance of indicators in a given block and displayed results based on a quintile classification scheme. To assign a relative performance rating for each indicator, a rate of 1-5 was assigned based on a quintile classification of indicator performance. This classification scheme was chosen because it divides the data into equal groups which works well for linear data. However, this classification scheme may not be as accurate for highly skewed data such as public participation. The highest performing block received a relative score of 1 and the lowest performing block received a 5. Performance is related to the value of an indicator directly or inversely. The values of some indicators like housing cost burden are inversely related to performance; that is, high housing cost burden value receives a high score, indicating poor performance. Other indicators, like area of greenspace, are directly related to performance in that high areas of greenspace receive a low score, indicating high performance. Performance is inversely related to the SOURCE cumulative score.

SOURCE cumulative suitability scores were calculated for each block using the In Arc Map, the weighted Sum tool to derive the sum of the product of the normalized performance score and the relative weight for each decision element (figure 3.8). The blocks with the highest SOURCE suitability scores represent the areas of highest priority for sustainable development projects, based on a need to improve sustainability performance and shared public-private interests. After the areas with the highest scores were identified, a suite of project recommendations were tailored to each location's conditions, in an attempt to reach neighborhood sustainability through shared public and private interests and opportunities for public-private partnerships.

Possibilities for public-private interactions that promote diverse aspects of sustainability were optimized where the public and private sector had more goals, indicators, and priorities in common and there was a need to improve performance.

Table 3.5 Summary of spatial data

criteria	Indicator	analysis unit	Category	performance scale (1-5)	source
economic sustainability	income distribution	Income Per Capita	PERCAPINC_1	high values-low values	United States Census Bureau/American Fact Finder, 2000 & 2010
	jobs/ household	# of Jobs/ Household	J_per_h	high values-low values	Bureau of Planning and Sustainability, 2015
	diversity of businesses	# of Naics codes/ block	variety	high values-low values	City of Portland, 2014a
	density of businesses	average density businesses/block	Mean	high values-low values	City of Portland, 2014a
	university growth	Ratio of assignable space to footprint	Net assign : BLDG_SQFT	high values-low values	Portland State University, 2015
environmental sustainability	Distance to greenspace	Distance	mean_dist	low values - high values	City of Portland, 2010
	area of green infrastructure	Area	mean_area	high values- low values	Portland State University, 2015
	mode split	alternative transportation rate	pcnt_alt	high values - low values	United States Census Bureau / American FactFinder, 2013a
	% CO2 emissions	Average block gas use	Multiple	low values - high values	Portland State University, 2015; Customer accounts, February 2, 2015
social sustainability	complete neighborhood index	mean complete neighborhood score/block	mean	high values-low values	Bureau of Planning and Sustainability, 2012
	multimodal access	distance to frequent transit, bike routes, and trails	distance	high values-low values	Metro, 2014; Metro, 2010; Bureau of Planning and Sustainability, 2012
	public safety	density of crime	density	low values - high values	City of Portland, 2013 & 2014b
	public involvement	density of participation	density	high values-low values	Portland State University, 2015b
	housing diversity	housing cost burden	cst_brdn	low values - high values	United States Census Bureau / American FactFinder, 2013b

Assessing the Quality of Development Indicators

Crucial to this investigation was the quality of the indicators used. An indicator is something that describes an issue or condition. Its purpose is to conceptualize performance and is typically used to manage systems. Indicators come in many forms and are as varied as the systems they monitor. However, according to sustainablemeasures.com, effective indicators have four characteristics in common:

- **Accessible**; the information is available or can be gathered easily.
- **Easy to understand**, by stakeholders and experts.
- **Reliable**; information is current and trustworthy.
- **Relevant**; can be used to inform decisions about the system.

With these characteristics in mind, this research employed a seven-point indicator assessment protocol developed by Portland non-profit Coalition for a Livable Future (CLF). In 2013 CLF released the Regional Equity Atlas 2.0, an equity-based spatial decision support system. They also released a data source rating system for the Equity Atlas 2.0, which I employed for the purpose of indicator analysis. This analysis directly speaks to research question 2: To what extent can existing sustainability indicators be optimized at the neighborhood scale? Table 3.6 outlines the CLF's data source rating methodology (Coalition for a Livable Future, 2013). Indicators with the highest scores were considered most favorable.

Table 3.6 Data source quality assessment rubric

Collection	How easy/difficult was it to acquire the data?
3pts High	Data are freely available and are downloadable in Excel or GIS-based format
2pts Med.	Data are accessible but require some effort to acquire (e.g. data must be purchased, data must be formally requested from source, data are not available in an ideal format, etc.).
1pt Low	Data do not exist in the form required and must be acquired via primary research or will be extremely costly to acquire.
Processing	Do the data require any processing in order to be usable in a GIS format? How many steps will it take (or level of technical skill required) to prepare the data for use or to combine data sets to create an indicator?
3pts High	No processing is required. Data are downloadable either in a GIS format (e.g. Shapefile) or spreadsheet (e.g. Excel) with a locator field for easy joining or geocoding (e.g. name, address, census tract ID, etc.).
2pts Med.	Data require some processing – e.g. combining multiple data sets into a parent indicator.
1pt Low	Data must be manually compiled, requiring a high level of technical competence and/or significant amount of time (e.g. transcribing records, converting a PDF into an excel spreadsheet).
Updates	How often are the data updated? Are the data available consistently over time to produce a trend?
3pts High	Data are updated annually in a consistent format. (For some indicators, less frequent updates may be acceptable if the data do not change significantly on an annual basis.)
2pts Med.	Data are updated on a regular basis in a consistent format, but updates occur less than annually.
1pt Low	Data are updated sporadically or on an as needed basis only.
Resolution	What is the spatial resolution of the data?
3pts High	Data are available at a high resolution (e.g. point data, census blocks, block groups, or tracts).
2pts Med.	Data are available at a relatively coarse scale.
1pt Low	Data are available only at the state or county level.
Accuracy	How accurate are the data? (This should take into consideration sampling issues, margins of error, and degrees of confidence.)
3pts High	Point data that reflect an actual location; sample data that have a high degree of confidence.
2pts Med.	Sample data with a medium to low degree of confidence (e.g. some ACS data); points that reflect centroids rather than actual locations.
1pt Low	Unable to determine accuracy.
Extent	What is the spatial extent of data availability?
3pts High	Data are available for the entire area that will be mapped.
2pts Med.	Data are available for most of the area that will be mapped.
1pt Low	Data are available only for a limited area.
Consistency	How consistent are the data from area to area?
3pts High	Data are available using consistent measurements and reporting formats across all the geographic areas that will be mapped.
2pts Med.	Data are available consistently for almost all of the geographic areas that will be mapped.
1pt Low	Data measurements or reporting formats vary across geographic areas with little consistency.

To summarize, the SOURCE methodology utilizes top-down and bottom-up data types to construct a mutually agreed upon hierarchical model of a decision problem. Decision elements are aligned in a matrix to derive overall indicator weights. Those weights are then combined with normalized sustainability performance scores to assign each block a cumulative sustainable development project priority score called the SOURCE suitability score. Areas with the highest SOURCE score maximize neighborhood sustainability potential subject to block-level sustainability performance given shared relative preference weights (see figure 3.9 for mathematical optimization concept and figure 3.10 for spatial optimization concept). Finally, the certainty of the SOURCE sustainability scores is directly influenced by the quality of indicators used.

Figure 3.9 SOURCE optimization concept

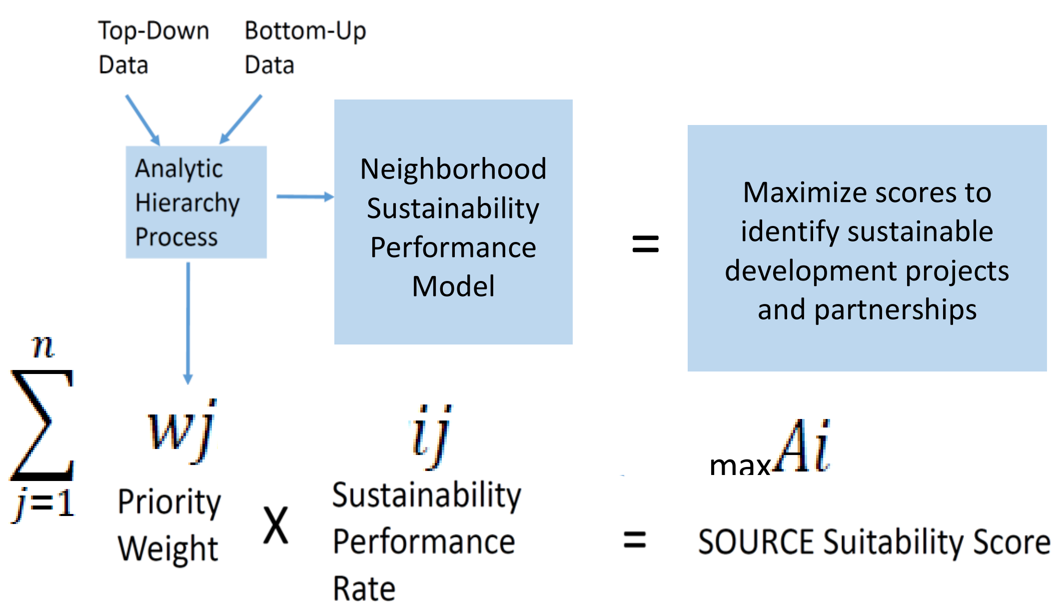


Figure 3.10 Spatial optimization of environmental criteria to create environmental criteria composite score

Chapter 4 Results

The primary aim of the present study was to explore the potential of a GIS-AHP method to optimize the location of sustainable development projects at the neighborhood scale based on shared public and private values and a need to increase sustainability performance. A secondary aim was to determine which urban sustainability metrics are capable of describing performance at the neighborhood scale. This chapter begins by presenting the findings of the content analysis and the results of the Analytic Hierarchy Process based on the data analysis procedures discussed in the previous chapter. First, content analysis findings for each of the three top-down and six bottom-up data sources based on the qualitative coding framework in Chapter 3 are presented and discussed with regard to how they informed the weighting in the corresponding AHP pairwise comparison matrices. This is followed by a presentation of the integrated decision hierarchy, based on among and between group comparisons of top-down and bottom-up sources. The section concludes with a presentation of spatial results generated by the SOURCE DSS and an analysis of the quality of indicators used.

Content Analysis and AHP Results Summary

I will begin by summarizing the qualitative and quantitative findings of the content analysis of three top-down data sources (The Portland Plan, The Comprehensive Plan Update: 2035, and the West Quadrant Plan) followed by the six bottom-up data sources (Comprehensive Plan Feedback and What we Heard Report, West Quadrant

Plan survey, planning charrettes, Issues Summary report, and selected SoMa Research Group Neighborhood Life Survey responses) corresponding to the 28 codes in the coding framework. The results of content analysis for each top-down and bottom-up data source serve as justification for the AHP for each input and are presented concurrently with each document. After an individual review, I will present an integrated decision hierarchy based on among and between group comparisons of top-down and bottom-up matrices. The integrated AHP decision hierarchy serves as the input for the weighting of SOURCE DSS indicators.

Top-down Documents

The Portland Plan neighborhood sustainability criteria

Environmental, economic, and social criteria applied toward the goal of SoMa neighborhood sustainability were identified through content analysis of the Portland Plan using codes “aa”-“c2” of the coding framework. Table 4.1 summarizes the frequency of criteria codes, most frequent criteria themes, and most commonly co-occurring codes. Overall, social criteria codes (“bb” *all social criteria*, “b1” *transportation criteria*, “b2” *well-being criteria*, and “b3” *complete neighborhood criteria*) were identified the most number of times (139), followed by environmental criteria (98) and economic criteria (67). The individual criteria codes that were identified most often were “b2” *well-being criteria* (65), “a2” *greenspace* criteria (38), and “c1” *private sector economic criteria* (35). The most frequently identified theme was *synergy between* *green space, health, and connectivity*, which was represented in multiple categories, but most often “a2”, for example, “an interconnected network of habitat connections, neighborhood greenways and civic corridors will encourage walking and biking and weave nature into neighborhoods and support healthy ecosystems” (City of Portland, 2012, p. 94).

Table 4.1 Portland Plan criteria content analysis results

Code	Code Count	Theme Count	Top 5 Most Frequent Themes	Co-occurrence Count	Top 5 co-occurrence code
aa All environmental criteria	14	5	health	8	b
		3	resilience	5	c
		2	resource resilience		
a1 Land use criteria	27	9	complete neighborhood	10	a2
		4	resilience	5	b1
		3	redevelopment	5	b2
		3	retrofit	5	b3
		3	wellbeing	5	d1
a2 Greenspace and natural area criteria	38	14	synergy between green space health connectivity	8	a3
		6	public green space	8	b1
		2	develop green infrastructure	7	a1
		2	prioritize urban natural resources	6	d2
				4	b3
a3 Air and water criteria	19	5	healthy connected city	9	a2
		3	basic public services	6	b1
		3	watershed health	2	b2
		2	green infrastructure		
		2	making amenities		
bb All social criteria	9	4	synergy between environmental social and economic	8	aa
				7	cc
b1 Transportation criteria	33	8	healthy connected city	11	1a2
		3	active transportation	6	a3

Continued on next page

		3	transportation development supports economic development	4	b3
		2	green infrastructure and active transit	3	a1
		2	multimodal connectivity	3	b2
b2 Well-being criteria	65	5	ada compliance and beyond	10	cc
		4	healthy connected city needs well being	5	aa
		3	basic public services	5	b3
		3	gentrification	5	bb
		3	public engagement throughout the entire policy making process	3	c2
b3 Complete neighborhood criteria	32	4	healthy connected city	7	b2
		4	neighborhood scale	5	a1
		3	Neighborhood centers	4	c1
		2	gentrification	3	b1
		2	transit	3	e3
				2	a2
				2	a3
cc All economic criteria	26	3	equity	11	bb
		2	community goals	10	aa
		2	link infrastructure development with equitable economic development	4	b2
		2	prosperity	3	partnerships
		2	reduce barriers to employment		
c1 Private sector criteria	35	4	support employment districts	4	f1
		3	business development resources	3	a1
		3	target cluster industries	3	b2
		3	Job growth	3	b3
		2	Private urban innovation	3	partnerships
		2	neighborhood businesses		
c2 Public sector criteria	6	2	affordability	3	b2
		2	economic prosperity	2	c1
				2	f2

The focus on greenspace to promote connectivity and improve stormwater, transit, human and environmental health, and resilience is a key strategy presented in the Portland Plan. Social criteria are another main focus. For example, "Prioritize the placement of community services in neighborhood centers — such as health clinics, day care centers, senior centers, libraries and educational facilities" (City of Portland, 2012, pg90). These findings lend themselves to a conservative interpretation of the priorities embodied by the Portland Plan to translate the findings into relative weights for the pairwise comparison stage of the AHP. These findings support an equal importance of environmental and social criteria (40% each), both taking precedence over economic criteria (20%). See table 4.2 for the full Portland Plan criteria matrix.

Table 4.2 Portland Plan criteria matrix
Consistency Ratio 0
Max Eigen value 3

Goal: neighborhood sustainability	Environmental	Economic	Social	Relative weight
Environmental	1	2	1	0.4
Economic	1/2	1	1/2	0.2
Social	1	2	1	0.4

Portland Plan indicators of environmental, economic, and social criteria

Eighteen indicators of economic, environmental, and social criteria applied toward the goal of SoMa neighborhood sustainability were identified by content analysis of the Portland Plan using codes “dd”- “f2” of the coding framework. Table 4.3 summarizes the frequency of indicator codes, most frequent indicator themes, and most commonly co-occurring codes. Overall, social indicator codes (“ee” *all social indicators*, “e1” *transportation indicators*, “e2” *well-being indicators*, and “e3” *complete neighborhood indicators*) were identified the most number of times (159), followed by environmental criteria (106) and economic criteria (85). The individual criteria codes that were identified the most often were “e2” *well-being criteria* (95), “d2” *greenspace* (45), and “f1” *private sector economic indicators* (44). The most frequently identified theme was *active transport* (15), which was represented in multiple categories but most often “e1”, for example, “Active transportation: Portland residents have reduced the number of miles they travel by car to 11 miles per day on average and 70 percent of commuters walk, bike, take transit, carpool or telecommute to work” (City of Portland, 2012, p. 83).

Table 4.3 Portland Plan indicator content analysis results

Code	Code Count	Theme Count	Top 5 Most Frequent Themes	Co-occurrence Count	Top 5 co-occurrence code
dd All environmental indicators	4	*	*	*	*
d1 Land use indicators	31	3	mixed use public infrastructure	6	e1
		3	watershed health	5	d2
		2	accessibility of housing	5	d3
		2	brownfield redevelopment	4	partnerships
		2	gentrification	3	a1
d2 Greenspace and natural area indicators	45	7	greenspace	5	e1
		6	active transportation	4	a2
		5	green infrastructure	4	d3
		5	tree canopy	2	b1
		4	active lifestyle	2	2_e2
d3 air and water indicators	26	6	co2 emission reduction	3	d2

Continued on next page

		6	healthy watersheds		
		4	natural waters quality		
		3	green infrastructure		
ee All social indicators	7	*	*	*	*
e1 Transportation indicators	24	15	active transportation	2	d3
		2	co2 reduction		
e2 Well-being indicators	95	8	educated workforce	2	ff
		8	human health		
		7	household economic security		
		6	educated youth		
		6	safety		
e3 Complete neighborhood indicators	33	4	community infrastructure	3	e2
		4	walkable scale		
		3	complete neighborhood		
		2	equity		
		2	place making		
ff All economic indicators	29	4	cost of living	3	e2
		3	Job growth		
		2	employment equity		
		2	household prosperity and affordability		
f1 private sector economic indicators	44	4	equity and inclusion	*	*
		3	job growth		
		3	neighborhood business vitality		
		2	economic prosperity and affordability		
		2	household economic security		
f2 Public sector economic indicators	12	*	*	*	*
j Equity	22	2	equity of basic services	7	b2
				6	aa
				6	bb
				6	cc
				3	a1

* Theme only recorded once

Considering possible synergistic effects of the ecosystem services value of parks to provide green infrastructure, wildlife habitat, neighborhood character, active transportation pathways, and C02 reduction, it is not surprising that these indicators have the highest relative weights in the matrix of indicators of environmental criteria (see table 4.4 for environmental indicator matrix). Indicators of economic criteria tended to focus on the percentage of cost burdened homes and income distribution (see table 4.5 for economic indicator matrix). Indicators of social criteria focused primarily on the complete neighborhood index followed by well-being indicators such as graduation rate and diversity (see table 4.6 for social indicator matrix). The statement, "Prioritize the placement of community services in neighborhood centers — such as health clinics, day care centers, senior centers, libraries and educational facilities" (City of Portland, 2012, p. 90), is an example of an indicator that makes up the complete neighborhood index and supports its relatively high priority.

Table 4.4 Portland Plan environmental indicator decision matrix
Consistency Ratio .07
Max Eigen value 6.36

Environmental indicators	water quality index	tree canopy area	% within 1/2 mile of parks	carbon emissions (% below 1990 levels)	% use alt. transit	% effective impervious area	Relative weight
water quality index	1	1/4	1/3	1/3	1/2	1	0.07
tree canopy area	4	1	1	1	1/2	2	0.19
% within 1/2 mile of parks	3	1	1	2	3	2	0.28
CO2 % below 1990	3	1	1/2	1	2	2	0.20
% use alt. transit	2	2	1/3	1/2	1	2	0.17
% effective impervious area	1	1/2	1/2	1/2	1/2	1	0.09

Table 4.5 Portland Plan economic indicator decision matrix
Consistency Ratio .02
Max Eigen value 5.08

Economic Indicators	# of jobs	%above self sufficiency	income distribution	export value	neighborhood business leakage	relative weight
# of jobs	1	1/3	1/3	1	2	0.13
%above self sufficiency	3	1	1	3	3	0.33
income distribution	3	1	1	3	3	0.33
export value	1	1/3	1/3	1	2	0.13
business leakage	1/2	1/3	1/3	1/2	1	0.09

Table 4.6 Portland Plan social indicator decision matrix
Consistency Ratio .05
Max Eigen value 7.28

Social Indicators	graduation rate	diversity index	crimes / 1000	20 minute neighborhood	% satisfied living in the city	% within 1/2 mile of healthy food	adults and 8th graders at healthy weight	relative weight
graduation rate	1	3	3	1/3	3	1	1	0.17
diversity index	1/3	1	3	1/3	2	1/3	1/3	0.09
crimes/ 1000	1/3	1/3	1	1/3	1	1/3	1/3	0.06
20 minute neighbor-hood	3	3	3	1	3	1	1	0.24
% satisfied living in the city	1/3	1/2	1	1/3	1	1/3	1/3	0.06
% within 1/2 mile of healthy food	1	3	3	1	3	1	1	.19
adults and 8th graders at healthy weight	1	3	3	1	3	1	1	.19

Comprehensive Plan neighborhood sustainability criteria

Environmental, economic, and social criteria applied toward the goal of SoMa neighborhood sustainability were identified by content analysis of the Comprehensive Plan using codes “aa” - “c2” of the coding framework. Table 4.7 summarizes the frequency of criteria codes, most frequent criteria themes, and most commonly co-occurring codes. Overall, environmental criteria codes ("aa" *all environmental criteria*, "a1" *land use criteria*, "a2" *greenspace criteria*, and "a3" *air and water criteria*) were identified the most number of times (329), followed by social criteria (98) and economic criteria (121). The individual criteria codes that were identified most often were "a1" *land use criteria* (153), "a2" *greenspace* (116), and "b1" *transportation criteria* (103). The most frequently identified theme was *preserve and enhance habitat, natural resources, and ecosystem service*s (20), which was captured by "a2," for example, "Promote equitable, safe, and well-designed physical and visual access to nature while also protecting significant natural resources, fish, and wildlife" (Bureau of Planning and Sustainability, 2014a, p. 114).

Table 4.7 Comprehensive Plan criteria content analysis results

Code	Code Count	Theme Count	Top 5 Most Frequent Themes	Co-occurrence Count	Top 5 co-occurrence code
aa All environmental criteria	15	2	land use development and infrastructure decision lined to prosperity, health, equity, and resilience	6	cc
		2	Land use promotes environmental health	5	bb
		2	land use promotes human health	3	jj
		2	land use should expand equity	2	b2
		2	Land use should promote resilience		
a1 Land use criteria	153	9	prioritize compact development	16	a2
		6	support job growth	11	b1
		5	preserve local identity	11	b3
		4	manage building design to promote public good	9	jj
		4	building efficiency	9	kk

Continued on next page

a2 Greenspace and natural area criteria	116	20	preserve and enhance habitat natural resources and ecosystem services	10	c2
		8	use green infrastructure to integrate nature	8	a1
		6	prioritize habitat and biological communities with investments	8	b1
		5	resilient built and natural environment	7	kk
		3	active transportation green infrastructure and habitat connections	6	b2
a3 Air and water criteria	45	5	waste water and stormwater quality efficiency and equity	5	a2
		3	improve air quality and watershed health	4	b2
		2	integrate green infrastructure	4	jj
		2	drinking water quality efficiency and equity	3	gg
		2	improve connectivity	3	kk
bb All social criteria	6	*	*	5	aa
				4	cc
				2	jj
b1 Transportation criteria	103	7	prioritize pedestrian transportation infrastructure	12.70%	a1
		7	safe convenient affordable multimodal transportation	12.70%	b3
		5	active transportation green infrastructure and habitat connections	12.70%	a2
		4	equitable transportation infrastructure	11.11%	jj
		4	reduce automobile transportation	9.52%	e1
b2 Well-being criteria	68	10	maintain affordable housing supply	15	jj
		7	socially and economically diverse housing options	11	c2
		4	human and environmental health and safety	11	a1
		4	public safety and emergency response	8	a2
		3	mitigate gentrification	6	cc
b3 Complete neighborhood criteria	67	7	protect cultural landscape	12	a1

Continued on next page

		7	enhance public gathering places	6	jj
		4	centers anchor complete neighborhoods	6	b1
		4	promote strong links between building and site design streets and the public realm	5	cc
		3	improve recreation sites	5	kk
cc All economic criteria	38	5	prosperous healthy equitable and resilient	7	jj
		4	Land use policies support growth and vitality of business districts	6	bb
		4	support job growth in employment districts	6	aa
		2	ecosystem service conservation	6	a1
c1 Private sector criteria	23	2	develop business environment	5	b3
		2	encourage local goods production	3	a1
		2	grow the equity and vitality of neighborhood business districts	3	jj
		2	protect success of industrial districts	3	kk
				2	a3
c2 Public sector criteria	60	6	coordinate plans services and investments with other initiatives/agencies	11	a2
		5	public facilities are resilient and reliable	10	kk
		4	high standards for public service delivery	9	a1
		3	maintain/increase supply of affordable housing	7	b2
		3	public services in neighborhood centers	5	b3

* Theme only recorded once

Social criteria are another main focus: "GOAL 3.A: Portland’s built environment is designed to serve the needs and aspirations of all Portlanders, promoting prosperity, health, equity, and resiliency. New development, redevelopment, and public investments reduce disparities, and encourage social interaction to create a healthy connected city" (Bureau of Planning and Sustainability, 2014a, p. 29). These findings lend themselves to a more straightforward classification of relative weights for the AHP and support a prioritization of environmental criteria, followed by social criteria, and finally economic criteria. See table 4.8 for the full Comprehensive Plan criteria matrix.

Table 4.8 Comprehensive Plan criteria decision matrix
Consistency Ratio .07
Max Eigen value 3.14

neighborhood sustainability	environmental	economic	social	relative weight
environmental	1	3	3	0.58
economic	1/3	1	1/3	0.14
social	1/3	3	1	0.28

Comprehensive Plan indicators of environmental, economic, and social criteria

Fifteen indicators of economic, environmental, and social criteria applied toward the goal of SoMa neighborhood sustainability were identified by content analysis of the Comprehensive Plan using codes "dd" – "f2" of the coding framework. Table 4.9 summarizes the frequency of indicator codes, most frequent indicator themes, and most commonly co-occurring codes. Overall, environmental indicator codes ("dd" *all environmental indicators*, "d1" *land use indicators*, "d2" *greenspace indicators*, and "d3" *air and water indicators*) were identified the most number of times (42), followed by social (25) and economic (23) indicators.

Table 4.9 Comprehensive Plan indicator content analysis results

Code	Code Count	Theme Count	Top 5 Most Frequent Themes	Co-occurrence Count	Top 5 co-occurrence code
dd All environmental indicators	1	*	*	*	*
d1 Land use indicators	20	*	*	5	d2
				3	a1
				3	e2
d2 Greenspace and natural area indicators	21	2	connectivity	5	d1
		2	tree canopy area	2	a2
d3 air and water indicators	13	*	*	5	a3
ee All social indicators	1	1	*	*	*
e1 Transportation indicators	14	2	parking supply	6	b1
		2	reduce vehicle miles travelled	2	a1
				2	f2
e2 Well-being indicators	6	*	*	3	d1
e3 Complete neighborhood indicators	5	2	proximity to grocery store	4	b3
ff All economic indicators	7	*	*	*	*
f1 private sector economic indicators	1	*	*	*	*
f2 Public sector economic indicators	15	*	*	5	c2
j Equity	77	7	public services	21	b2
		5	environmental equity	13	ii
		3	consider housing potential of low and moderate income households	11	a1
		3	housing diversity	8	b1
		3	transportation infrastructure	8	b3
k Partnership	74	7	regional governmental agency coordination	9	c2
		7	diversity of participants	6	a1
		5	environmental stewardship	5	a2
		5	intergovernmental coordination	3	a3
		4	accessible participation	3	b1

* Theme only recorded once

Themes of individual criteria codes were extremely diverse, with only five repeated themes out of all 91 possible indicator codes. By grouping themes and correlating them with previously coded criteria, I have identified *amount of greenspace*, *equitable access to public services,* and *% of cost burdened homes as the highest* relatively weighted indicators of environmental, social, and economic criteria, respectively (see tables 4.10 – 4.12 for economic, environmental, and social indicator decision matrices).

Table 4.10 Comprehensive Plan economic indicator decision matrix
Consistency Ratio .18
Max Eigen value 4.55

economic	jobs/ household	income distribution	% cost burdened homes	diversity of business types	relative weight
jobs/ household	1	3	1/2	1	0.24
income distribution	1/3	1	1	1/3	0.15
% cost burdened homes	2	1	1	3	0.37
diversity of business types	1	3	1/3	1	0.23

Table 4.11 Comprehensive Plan environmental indicator decision matrix
Consistency Ratio .22
Max Eigen value 7.10

Environ-mental	CO2 reduction 1990 levels	water quality index	% impervious surface	green space	green infrastructure	mode split/vehicle miles travelled?	relative weight
CO2 reduction 1990 levels	1	3	1	1/3	3	1/3	0.17
water quality index	1/3	1	1	1/3	1/3	1/3	0.07
% impervious surface	1	1	1	1/3	1	2	0.14
greenspace	3	3	3	1	2	1	0.27
green infrastructure	1/3	3	1	1/2	1	3	0.18
mode split	3	3	1/2	1	1/3	1	0.18

Table 4.12 Comprehensive Plan social indicator decision matrix
Consistency Ratio .04
Max Eigen value 5.14

social	access to public services	complete neighborhood index	housing diversity	education/ job training	# of partnerships	relative weight
access to public services	1	1	3	3	3	0.34
complete neighborhood index	1	1	2	3	3	0.30
housing diversity	1/3	1/2	1	3	3	0.19
education/job training	1/3	1/3	1/3	1	1	0.09
# of partnerships	1/3	1/3	1/3	1	1	0.09

West Quadrant Plan neighborhood sustainability criteria

Environmental, economic, and social criteria applied toward the goal of SoMa neighborhood sustainability were identified by content analysis of the West Quadrant Plan using codes “aa” – “c2” of the coding framework. Table 4.13 summarizes the frequency of criteria codes, most frequent criteria themes, and most commonly co-occurring codes. Overall, environmental criteria codes were identified the most number of times (66), followed by social criteria (36) and economic criteria (8). The individual codes that were identified most often were “a1” *land use criteria* (28), “a2” *greenspace* (23), and “b1” *transportation criteria* (23). The two most frequently identified themes *were access to greenspace* and *improve connectivity*. Examples of criteria that embody these often-linked themes are, “4. Green Loop. Implement the Green Loop through the district, connecting the Tilikum Crossing Bridge to the South Park Blocks and locations further north with high quality pedestrian and bicycle accommodations as well as improved opportunities for habitat and wildlife movement. Support connections between the “Green Loop” and existing open spaces, particularly Waterfront Park and the Halprin Open Space Sequence” (Bureau of Planning and Sustainability, 2014b, p. 147). As well as goals like, “4. Urban Riverfront. Encourage the development of a distinctly urban riverfront that balances human activities including river transportation, recreation and development with habitat enhancement” (Bureau of Planning and Sustainability, 2014b, p. 150). Despite appearing fewer times, social criteria are often synergistic with environmental and economic criteria.

Table 4.13 West Quadrant Plan criteria content analysis

Code	Code Count	Theme Count	Top 5 Most Frequent Themes	Co-occurrence count	Top 5 co-occurrence code
aa All environmental criteria	0	n/a	n/a	n/a	n/a
a1 Land use criteria	28	2	zoning flexibility	4	a2
		2	high density	3	d1
		2	land use diversity	2	b1
		2	multimodal accessibility	2	d2
a2 Greenspace and natural area criteria	23	6	access to green space	6	d2
		4	green loop	5	a1
		2	access to river	5	a3
		2	high performance buildings technologies and site design	5	ii
		1	active transit	4	b1
a3 Air and water criteria	15	5	access to river	5	a2
		3	cultural significance of river	5	d3
		3	habitat quality	4	ii
				3	d2
				2	a1
bb All social criteria	0	n/a	n/a	n/a	n/a
b1 Transportation criteria	23	6	improve connectivity	5	a2
		5	green loop	2	a1
		5	multimodal access		
b2 Well-being criteria	6	2	multifamily housing	*	*
		2	Public safety		
b3 Complete neighborhood criteria	8	3	sense of place	*	*
		3	vibrant		
		2	neighborhood services		
cc All economic criteria	0	n/a	n/a	n/a	n/a
c1 Private sector criteria	5	4	retail corridor	*	*
c2 Public sector criteria	3	*	*	*	*

* Theme only recorded once
n/a never observed

These findings lend themselves to a conservative interpretation of the priorities embodied by the West Quadrant Plan to translate the findings into relative weights for the AHP. These findings support an equal importance of environmental and social criteria, but a moderate importance of social over economic criteria, resulting in social criteria as the highest relative weight over all. See table 4.14 for full West Quadrant Plan criteria matrix.

Table 4.14 West Quadrant Plan criteria decision matrix
Consistency Ratio .01
Max Eigen value 3.01

neighborhood sustainability	environmental	economic	social	relative weight
environmental	1	2	1	0.39
economic	1/2	1	1/3	0.17
social	1	3	1	0.44

West Quadrant Plan indicators of environmental, economic, and social criteria

Ten indicators of economic, environmental, and social criteria applied toward the goal of SoMa neighborhood sustainability were identified by content analysis of the West Quadrant Plan using codes dd-f2 of the coding framework. Table 4.15 summarizes the frequency of indicator codes, most frequent indicator themes, and most commonly co-occurring codes. Overall, environmental indicator codes were identified the most number of times (31), followed by social and economic (1). Individual criteria codes that were identified most often were land use (13) and greenspace indicators (10).

Table 4.15 West Quadrant Plan indicator content analysis results

Code	Code Count	Theme Count	Top 5 Most Frequent Themes	Co-occurrence Count	Top 5 Co-occurrence code
dd All environmental indicators	0	n/a	n/a	n/a	n/a
d1 Land use indicators	13	*	*	3	a1
				3	d2
				2	a2
d2 Greenspace indicators	10	*	*	7	a2
				3	a3
				3	d1
				3	d3
				2	a1
d3 air and water indicators	8	2	number of marina users	4	a3
				3	a2
				3	d2
ee All social indicators	0	n/a	n/a	n/a	n/a
e1 Transportation indicators	7	2	street type diversity	3	b1
e2 Well-being indicators	4	*	*	n/a	n/a
e3 Complete neighborhood indicators	4	*	*	n/a	n/a
ff All economic indicators	2	*	*	n/a	n/a
f1 Private sector economic indicators	1	*	*	n/a	n/a
f2 Public sector indicators	0	n/a	n/a	n/a	n/a
j Equity	2	*	*	n/a	n/a
k Partnership	5	*	*	n/a	n/a

* Theme only recorded once
n/a never observed

Themes of individual criteria codes were diverse, with only two repeated themes out of 47 total themes. By grouping themes and correlating them with previously coded criteria, I have identified *complete neighborhood index*, *access to greenspace* and *mode* *split* (tied), and *number of neighborhood based businesses*, as the highest relatively weighted indicators of social, environmental, and economic criteria respectively (see tables 4.16 – 4.18 for economic, environmental, and social indicator WQP matrices).

Table 4.16 West Quadrant Plan economic indicator decision matrix
Consistency Ratio .04
Max Eigen value 3.07

economic	# of neighborhood based businesses	university growth	job growth	relative weight
# of neighborhood based businesses	1	4	3	0.61
university growth	1/4	1	1/3	0.12
job growth	1/3	3	1	0.27

Table 4.17 West Quadrant Plan environmental indicator decision matrix
Consistency Ratio 0
Max Eigen value 4

environmental	land density (FAR)	access to greenspace/ways	access to river	mode split (>80% non single occupancy	relative weight
land density (FAR)	1	1/3	1	1/3	0.13
access to greenspace/ways	3	1	3	1	0.38
access to river	1	1/3	1	1/3	0.13
mode split (>80% non single occupancy	3	1	3	1	0.38

Table 4.18 West Quadrant Plan social indicator decision matrix
Consistency Ratio 0
Max Eigen Value 3.01

social	housing diversity	public safety	complete neighborhood index	relative weight
housing diversity	1	1/2	1/3	0.16
public safety	2	1	1/2	0.30
complete neighborhood index	3	2	1	0.54

Bottom-up Documents

Comprehensive Plan data sources' neighborhood sustainability criteria

Environmental, economic, and social criteria applied toward the goal of SoMa neighborhood sustainability were identified by content analysis of the *Comprehensive Plan Feedback report* and *What we Heard Report* 1 and 2*,* using codes "aa" – "c2" of the coding framework. Table 4.19 summarizes the frequency of criteria codes, most frequent criteria themes, and most commonly co-occurring codes. Overall, environmental criteria codes were identified the most number of times (87), followed by social criteria (59) and economic criteria (33). The individual criteria codes that were identified most often were "a1" *land use* (43), "a2" *greenspace* (33), and "b1" *transportation criteria* (31).

Table 4.19 Comprehensive Plan bottom-up data sources' criteria content analysis results

Code	Code Count	Theme Count	Top 5 Most Frequent Themes	Co-occurrence Count	Top 5 co-occurrence code
aa All environmental criteria	0	n/a	n/a	n/a	n/a
a1 Land use criteria	43	7	increase public involvement in planning process	18	d1
		6	mixed use development	5	b1
		4	increase density	5	kk
		3	protect historic properties	3	c1
		2	intensify commercial areas	3	e1
a2 Greenspace and natural area criteria	33	14	develop green space and green transportation infrastructure	15	d2
		4	increase tree canopy	3	e1
		3	maintain and enhance habitat	2	a3
		2	green infrastructure	2	b1
		2	habitat connectivity	2	d3
a3 Air and water criteria	11	2	air quality	7	d3
		2	green infrastructure	2	a2
				2	b2
				2	d2
				2	e2
bb All social criteria	1	*	*	*	*
b1 Transportation criteria	31	5	parking supply	13	e
		4	develop green space and green transportation infrastructure	4	a1
		4	improve pedestrian access	4	d1
		2	coordinate land use development with public transportation	3	a2
		2	pedestrian safety	2	c2
b2 Well-being criteria	17	3	emergency preparedness	7	e2
		3	public safety	2	a3
		2	affordable housing	2	d3
		2	public health		
b3 complete neighborhood criteria	10	5	access to amenities and services	4	e3
cc All economic criteria	6	2	investments to accommodate job growth	3	ff
c1 Private sector criteria	11	2	intensity commercial areas	3	a1

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		2	locally owned businesses		
c2 Public sector criteria	16	3	equitable access to public services	5	f2
		2	coordinate infrastructure improvements	3	a1
		2	cost of greenways	3	d1
		2	maintain existing public infrastructure	2	b1

* Theme only recorded once
n/a never observed

The most frequently identified criteria themes were *develop greenspace and green transportation infrastructure,* for example, “The role of City Greenways as transportation connections needs to be strengthened, and greenways should be considered as part of a more comprehensive network of bicycle facilities” (Bureau of Planning and Sustainability, Community Involvement Committee, 2014, p. 5). Despite fewer occurrences, social criteria were a main focus: "Allow for more local retail and other services in many centers, such as groceries, pharmacies, health clinics and other services” (Bureau of Planning and Sustainability, Community Involvement Committee, 2014, p. 4). Comments also called for including public parks, play areas, and public art in centers. Also, many environmental criteria were linked to social and economic criteria as well. For example: “An indirect goal of green infrastructure is to support the development of children” (Bureau of Planning and Sustainability, Community Involvement Committee, 2013, p. 13). The relationship between economic health and well-being was also mentioned in connection with environmental health (Bureau of Planning and Sustainability, Community Involvement Committee, 2013, p. 13) as well as in policies like, “align land use and other city actions with poverty reduction and economic self-sufficiency goals” (Bureau of Planning and Sustainability, Community

Involvement Committee, 2013, p. 11). These findings support a slight priority of social criteria over environmental and economic criteria. See table 4.20 for full *Comprehensive Plan Feedback* and *What We Heard Report* criteria matrix.

Table 4.20 Comprehensive Plan data sources criteria decision matrix
Consistency Ratio 0
Max Eigen value 3

neighborhood sustainability	environmental		economic	social	relative weight
environmental	1		1	1/2	0.16
economic	1		1	1/2	0.30
social	2		2	1	0.54

Comprehensive Plan bottom-up data sources' indicators of environmental, social, and economic criteria

Fourteen indicators of economic, environmental, and social criteria for the goal of SoMa neighborhood sustainability were identified by content analysis of *Comprehensive Feedback Report* and *What We Heard Reports* using codes dd-f2 of the coding framework. Table 4.21 summarizes the frequency of indicator codes, most frequent indicator themes, and most commonly co-occurring codes. Overall, environmental indicator codes were identified the most number of times (64), followed by social indicator codes (54) and economic indicator codes (20). Individual indicator codes that were identified most frequently are "d1" *land use indicators* (31), "e1" *transportation indicators*, and "d2" *greenspace indicators* (26). The top two themes were *amount of greenspace and green transportation infrastructure* (8) as well as *public participation in the planning process* (6).

Table 4.21 Comprehensive Plan bottom-up data sources' indicator content analysis results

Code	Code Count	Theme Count	Top 5 Most Frequent Themes	Co-occurrence Count	Top 5 Co-occurrence code
dd All environmental indicators	n/a	n/a	n/a	n/a	n/a
d1 Land use indicators	31	6	public participation	10	a1
		5	mixed use	3	kk
		3	density		
		2	commercial in commercial centers		
d2 Greenspace and natural area indicators	26	8	develop green space and green transportation infrastructure	15	a2
		5	habitat connectivity	4	b1
		3	tree canopy	3	e1
				2	a3
				2	d3
d3 air and water indicators	7	2	air quality	n/a	n/a
		2	greenway access to river		
ee All social indicators	n/a	n/a	n/a	n/a	n/a
e1 Transportation indicators	27	5	parking supply	*	*
		3	greenway		
		3	improved crosswalks		
		2	bike lanes		
		2	side walk connectivity		
e2 Well-being indicators	15	3	affordable housing supply	*	*
		3	public safety		
		2	emergency preparedness		
		2	public health		

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e3 Complete neighborhood indicators	12	3	access to amenities and services	*	*
ff All economic indicators	5	*	*	*	*
f1 private sector economic indicators	8	2	equity of public infrastructure	*	*
f2 Public sector economic indicators		2	reduce infrastructure disparities	*	*
j Equity	7	3	public participation in planning process	*	*

* Theme only recorded once
n/a never observed

Overall, indicators were mentioned less repetitiously than criteria, spreading a wide net. The highest weighted indicator was amount of green space and infrastructure (.46), followed by job diversity (.36), and public involvement (.31) (see tables 4.22 - 4.24 for full economic, environmental, and social indicator decision matrices).

Table 4.22 Comprehensive Plan bottom-up data sources' economic indicator decision matrix
Consistency Ratio .09
Max Eigen value 5.35

economic	infrastructure investment	job diversity	commercial density	cost of public services	business retention rate	relative weight
infrastructure investment	1	1/3	1/3	1	1/3	0.10
job diversity	3	1	3	1	3	0.36
commercial density	3	1/3	1	1	1	0.18
cost of public services	1	1	1	1	1	0.19
business retention rate	3	1/3	1	1	1	0.18

Table 4.23 Comprehensive Plan bottom-up data sources' environmental indicator decision matrix
Consistency Ratio .19
Max Eigen value 4.57

environmental	density	green infrastructure	impervious surface	tree canopy	relative weight
density	1	1/3	2	1/3	0.16
Green infrastructure	3	1	3	3	0.46
impervious surface	1/2	1/3	1	2	0.18
tree canopy	3	1/3	1/2	1	0.20

Table 4.24 Comprehensive Plan bottom-up data sources' social indicator decision matrix
Consistency Ratio .06
Max Eigen value 5.25

social	public involvement	% mixed use	multimodal access	diversity of housing	access to amenities and services	relative weight
public involvement	1	2	3	2	1	0.31
% mixed use	1/2	1	1/3	1/3	1/3	0.08
multimodal access	1/3	3	1	1	1	0.18
diversity of housing	1/2	3	1	1	1/2	0.17
access to amenities and services	1	3	1	2	1	0.25

West Quadrant Plan bottom-up data sources' neighborhood sustainability criteria

Environmental, economic, and social criteria applied toward the goal of SoMa neighborhood sustainability were identified by content analysis of the West Quadrant Plan survey, charrettes, and *Issues Summary Report* using codes "aa" – "c2" of the coding framework. Table 4.25 summarizes the frequency of criteria codes, most frequent criteria themes, and most commonly co-occurring codes. Overall, social criteria codes were identified the most number of times (101), followed by environmental criteria (92) and economic criteria (23). The individual criteria codes that were identified the most often were "b1" *transportation criteria* (53), "a2" *greenspace criteria* (49), and "b3" *complete neighborhood criteria* (32).

Table 4.25 West Quadrant Plan bottom-up data sources' criteria content analysis results

code	code count	theme count	Top 5 most frequent themes	co-occurrence count	Top 5 co-occurrence code
aa All environmental criteria	0	n/a	n/a	n/a	n/a
a1 land use criteria	25	6	develop waterfront	12	d1
		2	concentrate commercial development	3	b1
		2	land use diversity	3	b3
		2	improve east west connectivity	3	e1
a2 Greenspace criteria	48	5	expand river greenway	13	d2
		3	increase access to greenspace	3	d1
		3	Montgomery green street	3	d3
				3	j
a3 Air and water criteria	19	4	connect city with river	5	d3
		2	pedestrian access	5	e3
		2	riparian restoration	2	b1

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		2	water related recreation	2	e1
		2	watershed health		
bb All social criteria	0				
b1 transportation criteria	53	3	improve connectivity to adjacent areas	17	e1
		3	improve multimodal access	4	d1
		3	parking supply	3	a1
		2	bicycle infrastructure on naito	2	e3
		2	expand active transportation infrastructure		
b2 Well-being criteria	16	3	diversity of housing	*	*
		2	affordable housing		
		2	public safety		
b3 Complete neighborhood criteria	32	8	neighborhood services and amenities	*	*
		3	connect city with river		
		2	grocery store		
		2	schools as multipurpose community center		
		2	preserve cultural landscape		
cc All economic criteria	4	2	prioritize economic development	*	*
c1 Private economic criteria	10	2	increase concentration of retail	4	a1
		2	4th Ave retail corridor		
c2 Public economic criteria	9	4	schools as multipurpose community center	2	k

* Theme only recorded once
n/a never observed

The most frequently identified theme was *neighborhood services and amenities*. An example from the *Issues Summary Report* is, “PSU needs more retail and a strong main street” (Bureau of Planning and Sustainability, West Quadrant Plan Project Team, 2013a, p. 15). Survey responses, statements, and charrette maps were identified that addressed both social and environmental criteria, particularly *greenspace* and *connectivity* (for example see Bureau of Planning and Sustainability, West Quadrant Plan Project Team, 2013c, pp. 5, 17, 18, or 22). The focus on greenspace to promote connectivity, improve stormwater, transit, human and environmental health, and resilience is a key strategy presented in these documents, for example: “The Central City needs a pair of native plant-dominated greenway/wildlife corridors connecting river through West Quadrant to other parts of the City” (Bureau of Planning and Sustainability, West Quadrant Plan Project Team, 2013a, p. 4). Social criteria are another main focus: "Need more housing diversity - affordability, housing type, worker and family market-rate housing” (Bureau of Planning and Sustainability, West Quadrant Plan Project Team, 2013a, p. 3). These findings support an equal importance of environmental and social criteria (.4), both with importance over economic criteria (.2). See table 4.26 for full criteria matrix.

Table 4.26 West Quadrant Plan survey, charrettes, and *Issues Summary* criteria decision matrix
Consistency Ratio 0
Max Eigen value 3

neighborhood sustainability	environmental	economic	social	relative weight
environmental	1	2	1	0.4
economic	1/2	1	1/2	0.2
social	1	2	1	0.4

West Quadrant Plan bottom-up data sources' environmental, economic, and social criteria

Fourteen indicators of economic, environmental, and social criteria for the goal of SoMa neighborhood sustainability were identified by content analysis of the West Quadrant Plan survey, charrettes, and *Issues Summary Report* using codes "dd" – "f2" of the coding framework. Table 4.27 summarizes the frequency of indicator codes, most frequent indicator themes, and most commonly co-occurring codes. Overall, social indicator codes we identified most frequently (101), followed by environmental (92) and economic (19) indicators. The indicator codes that were identified the most often were "e1" *transportation indicators*, "d2" *greenspace indicators*, and "d3" *indicators of air and water*.

Table 4.27 West Quadrant Plan bottom-up data sources' content analysis results

Code	Code Count	Theme Count	Top 5 Most Frequent Themes	Co-Occurrence Count	Top 5 Co-occurrence Code
dd All environmental indicators	0	n/a	n/a	n/a	n/a
d1 Land use indicators	27	4	develop waterfront	4	a1
		2	east west connectivity	2	b1
		2	redevelop commercial area	2	cc
d2 Greenspace and natural area indicators	50	6	greenway habitat connectivity	*	*
		3	Montgomery green street		
		2	access to greenspace		
		2	recreational opportunities		
		2	riverfront greenway		
d3 air and water indicators	15	5	access to the river	*	*
		2	connect city with river		
		2	water related recreation		
ee All social indicators	0	n/a	n/a	n/a	n/a
e1 Transportation indicators	52	5	pedestrian access	*	*
		3	parking supply		
		2	pedestrian safety		
		2	bicycle infrastructure on naito		
		2	free ride zone		
e2 Well-being indicators	16	3	affordable housing	*	*
		2	housing type		
		2	public safety		
e3 Complete neighborhood indicators	33	4	grocery store	*	*
		3	connect city with river		
		3	neighborhood services and amenities		
		2	cultural landscape		

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		2	schools as multipurpose community center		
ff All economic indicators	4			*	*
f1 private sector economic indicators	10	2	4th Ave retail corridor	*	*
f2 Public sector economic indicators	8	3	schools as multipurpose community center	*	*
j equity	0	n/a	n/a	n/a	n/a
k partnership	2	2	schools as multipurpose community center	*	*

* Theme only recorded once
n/a never observed

The most frequently identified indicator themes were *greenway habitat connectivity* and *multiple interpretations of accessibility.* Considering a focus on greenspace and complete neighborhood indicators, the findings support *amount of greenspace* (.36), *multi-modal access* (.25), and *retail growth* (.29) as the highest relatively weighted indicators (see tables 4.28-4.30 for economic, environmental, and social indicator matrices).

Table 4.28 West Quadrant Plan bottom-up data sources' economic indicator decision matrix
Consistency Ratio .11
Max Eigen value 4.32

economic	job growth	retail growth	institutional growth	greenspace revenue	relative weight
job growth	1	1/3	1/3	3	0.15
retail growth	3	1	3	4	0.29
institutional growth	3	1/3	1	3	0.47
greenspace revenue	1/3	1/4	1/3	1	0.08

Table 4.29 West Quadrant Plan bottom-up data sources' environmental indicator decision matrix
Consistency Ratio .01
Max Eigen value 4.02

environmental	greenspace	greenways	Green infrastructure	access to river	relative weight
greenspace	1	1	2	3	0.36
greenways	1	1	2	2	0.33
Green infrastructure	1/2	1/2	1	1	0.16
access to river	1/3	1/2	1	1	0.15

Table 4.30 West Quadrant Plan bottom-up data sources' social indicator decision matrix
Consistency Ratio .06
Max Eigen value 6.28

social	diversity of housing	public safety	neighborhood services	neighborhood amenities	multipurpose community uses	multi-modal access	relative weight
diversity of housing	1	4	1	1	3	1/3	0.19
public safety	1/4	1	1/3	1/3	2	1/2	0.08
neighborhood services	1	3	1	1	3	1	0.21
neighborhood amenities	1	3	1	1	3	1	0.21
multipurpose community uses	1/3	1/2	1/3	1/3	1	1/3	0.06
multi-modal access	3	2	2	2	3	1	0.25

Neighborhood Life Survey neighborhood sustainability criteria

Environmental, economic, and social criteria applied toward the goal of SoMa neighborhood sustainability were identified by content analysis of responses to the Neighborhood Life Survey prompts using codes "aa" – "c2" of the coding framework. Table 4.31 summarizes the frequency of criteria codes, most frequent criteria themes, and most commonly co-occurring codes. Overall, social criteria codes were identified the most number of times (218), followed by environmental criteria (197) and economic (58). The individual criteria codes that were identified most often were "a2" *greenspace criteria* (160), "b1" *transportation criteria* (103), and "b3" *complete neighborhood criteria* (85).

Table 4.31 Neighborhood Life Survey criteria content analysis results

Code	Code Count	Theme Count	Top 5 Most Frequent Themes	Co-occurrence Count	Top 5 co-occurrence code
aa All environmental criteria	0	n/a	n/a	n/a	n/a
a1 Land use criteria	34	7	redevelop university place	20	d1
		5	increase mixed use		
		3	protect historical properties		
		2	reduce construction		
a2 Greenspace and natural area criteria	160	67	south park blocks	33	d2
		25	maintain/increase existing greenspace	2	b2
		13	maintain Keller and Lovejoy fountains	2	e2
		5	improve riverfront park		
		5	increase seating areas		
a3 Air and water criteria	3	2	reduce smoking air pollution	*	*
bb All social criteria	0	n/a	n/a	n/a	n/a
b1 Transportation criteria	103	16	public transit	68	e1
		13	pedestrian safety	3	a1
		8	improve on off ramp 405	2	d1

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		8	pedestrian infrastructure		
		6	redevelop parking lots		
b2 Well-being criteria	30	22	public safety	20	e2
		3	homeless services		
b3 Complete neighborhood criteria	85	14	food carts	25	e3
		11	restaurants		
		9	neighborhood businesses		
		9	urban center plaza		
		5	farmers market		
cc All economic criteria	0	n/a	n/a	n/a	n/a
c1 Private sector criteria	10	9	increase local businesses	5	f1
c2 Public sector criteria	48	22	PSU	2	f1
		2	computer lab		
		2	PSU building updates		
		2	retrofit Unitus building		
		2	update Science One		

* Theme only recorded once
n/a never observed

The most frequently identified theme was overwhelmingly focused on the South Park Blocks, but often focused on social aspects, for example: "Wonderful place for people to enjoy the sunshine and hang out and study and assemble etc." (SoMa Research Group, 2012). The focus on greenspace to promote social criteria is a key strategy identified by survey respondents. These findings support a high priority of social criteria over environmental criteria and a moderate priority over economic criteria. See table 4.32 for full SoMa survey criteria matrix.

Table 4.32 Neighborhood Life Survey criteria decision matrix
Consistency Ratio .03
Max Eigen value 3.05

neighborhood sustainability	environmental	economic	social	relative weight
environmental	1	1/3	1/3	0.14
economic	3	1	1/2	0.33
social	3	2	1	0.53

Neighborhood Life Survey indicators of environmental, economic, and social criteria

Fourteen indicators of economic, environmental, and social criteria for the goal of SoMa neighborhood sustainability were identified by content analysis of the responses to the “asset” and “change” prompts of the Neighborhood Life Survey using codes “dd” – “f2” of the coding framework. Table 4.33 summarizes the frequency of indicator codes, most frequent indicator themes, and most commonly co-occurring codes. Due to the short format of most of the responses, as well as their indirect nature, indicator codes were extrapolated based on criteria codes. For example, “a1” *increase mixed-used* criteria code was extrapolated to “d1” indicator code and *amount mixed-use*. Similar to criteria codes, social indicator codes were identified the most number of times, followed by environmental and economic indicators. The individual indicator codes that were identified most often were “d2” *greenspace and natural area indicators*, “e1” *transportation indictors*, and “e3” *complete neighborhood indicators*. The most frequently identified themes were access to greenspace, access to active transportation, and number of local businesses.

Table 4.33 Neighborhood Life Survey indicator content analysis results

Code	Code Count	Theme Count	Top 5 Most Frequent Themes	Co-occurrence Count	Top 5 Co-occurrence Code
dd All environmental indicators	0	n/a	n/a	n/a	n/a
d1 Land use indicators	0	n/a	n/a	n/a	n/a
d2 Greenspace and natural area indicators	2	*	*	*	*
d3 air and water indicators	0	n/a	n/a	n/a	n/a
ee All social indicators	0	n/a	n/a	n/a	n/a
e1 Transportation indicators	0	n/a	n/a	n/a	n/a
e2 Well-being indicators	0	n/a	n/a	n/a	n/a
e3 Complete neighborhood indicators	0	n/a	n/a	n/a	n/a
ff All economic indicators	0	n/a	n/a	n/a	n/a
f1 private sector economic indicators	0	n/a	n/a	n/a	n/a
f2 Public sector economic indicators	0	n/a	n/a	n/a	n/a
j Equity	0	n/a	n/a	n/a	n/a
k Partnership	0	n/a	n/a	n/a	n/a

* Theme only recorded once
n/a never observed

The highest weighted environmental indicator was *access to greenspace* (see table 4.34 for economic indicator matrix). Indicators of economic criteria focused on the *number of restaurants and food carts* (see table 4.35 for environmental indicator matrix). Indicators of social criteria focused primarily on the *amount of mixed-use development* (see table 4.36 for social indicator matrix). For example a response that indicated a location had, “too much brick and concrete. I'd like to see more greenery,” was translated from “a2” *increase greenspace* to “d2” *amount of greenspace*.

Table 4.34 Neighborhood Life Survey economic indicator decision matrix
Consistency Ratio .04
Max Eigen value 4.14

economic	retail	local businesses	restaurants/ food carts	PSU growth rate	relative weight
retail	1	1/3	1/3	1/2	0.11
local businesses	3	1	1/2	1/2	0.22
restaurants/ food carts	3	2	1	1	0.35
PSU growth rate/health	2	2	1	1	0.32

Table 4.35 Neighborhood Life Survey environmental indicator decision matrix
Consistency Ratio .07
Max Eigen value 4.21

environmental	access to greenspace	access to greenways	maintenance level of greenspace	eco-friendly retrofitting/new development	relative weight
access to greenspace	1	3	1	3	0.38
access to greenways	1/3	1	1	1	0.18
Maintenance level of greenspace	1	1	1	4	0.32
eco-friendly retrofitting/new development	1/3	1	1/4	1	0.12

Table 4.36 Neighborhood Life Survey social indicator decision matrix
Consistency Ratio .17
Max Eigen value 8.03

social	density	mixed use	access to transit	pedestrian safety	pedestrian infrastructure	public safety/ home-lessness	Neighborhood services and amenities	relative weight
density	1	1/3	1/3	1/3	1/3	1/3	1/3	0.05
mixed use	3	1	1	3	3	3	1	0.23
access to transit	3	1	1	1/2	1/2	3	1	0.16
pedestrian safety	3	1/3	2	1	2	1/3	1/2	0.12
pedestrian infrastructure	3	1/3	2	1/2	1	1/3	1/3	0.10
public safety/ homelessness	3	1/3	1/3	3	3	1	1/2	0.15
Neighbor-hood services and amenities	3	1	1	2	3	2	1	.19

Combined AHP Matrices

Combined matrices were created through the integration of all top-down and bottom-up documents mentioned above. The integration process was informed by within and between group comparisons of all the documents described above. I will begin by discussing top-down and bottom-up within group comparisons of AHP matrices and will conclude with a discussion of the AHP primarily informed by between group comparisons of top-down and bottom-up documents.

Top-Down within group comparisons of AHP matrices

Within the three top-down documents, environmental criteria were the top weighted aspect of sustainability with a cumulative weight of 1.37. Social criteria were weighted closely and had a cumulative weight of 1.12. Economic criteria were consistently ranked at the bottom, with a .51 cumulative weight. In general, all top-down plans place twice the importance on environmental and social criteria as compared to economic criteria.

Top weighted environmental indicators relate to *access to green space* (1.12 cumulative weight) and include a range of indicators including *distance to nearest park*, *tree canopy area*, *green space area*, and *green infrastructure*. The second highest weighted indicators pertain to *transportation mode split* (.73 cumulative weight) and include a range of indicators, such as *vehicle miles travelled* and *mode split*. *Green infrastructure*, including both *greenways* and *impervious surfaces*, rounded out the bottom of the environmental indicators with a cumulative weight of .61.

Top weighted social indicators unanimously supported *complete neighborhood index* with a cumulative weight of 1.08. However, it may be worth exploring this complex index by breaking it into two parts, neighborhood services and neighborhood amenities. A measure of housing diversity was supported, especially to highlight *affordable housing* (.35 cumulative weight). A measure of education was also supported (.26 cumulative weight).

The top weighted economic indicators present in all top-down plans were *measures of local businesses* (.59 cumulative weight). This included *number of* *neighborhood-based businesses*, *business leakage* (a measure of dollars spent outside of the neighborhood), *diversity of business types*, and *export value* (the value of goods being exported from the neighborhood). *Income distribution* and *jobs per household* indicators were strongly weighted (.81 cumulative weight) in both of the City scale plans but were suspiciously absent from the neighborhood scale West Quadrant Plan. Income distribution and percent of cost burdened homes were two popular indicators.

Bottom-Up within group comparisons of AHP matrices

Social criteria were the top weighted aspect of sustainability for all bottom-up documents (1.47 cumulative weight). Economic criteria were inconsistently weighted among bottom-up documents (.83 cumulative weight). Environmental criteria weights differed within bottom-up documents as well (.70 cumulative weight).

The top weighted social indicator for bottom-up documents was *multi-modal access* (.69 cumulative weight) and included a range of indicators from *access to transit*, *pedestrian safety*, and *infrastructure*. *Neighborhood services and amenities* (.86 cumulative weight) was another prominent social indicator among bottom-up documents. Concerns regarding *housing diversity* were mixed among bottom-up documents (.36 cumulative weight). Weights regarding levels of *mixed-use* properties differed among bottom-up documents (.37 cumulative weight). Weighting of *public safety* was also mixed (.23 cumulative weight). Economic indicator weights varied within bottom-up documents, but the highest weighted indicators overall dealt with *measures* *of local businesses* (.87 cumulative weight). *Measures of employment* (.62 cumulative weight) were also highly weighted. *Institutional growth* indicators were another common concern (.79 cumulative weight).

Regarding environmental indicators, all bottom-up documents weighted *measures of green space* highest (1.69 cumulative weight), although there was some variance in indicators preferred. Themes of environmental indicators could be broken into sub categories, including *access to green space* (.74 cumulative weight), *access to greenways* (.51 cumulative weight), and *amount of green infrastructure* (.62 cumulative weight).

Integrated matrix summary Top-Down/Bottom-Up between group comparisons

Regarding criteria, there was a strong mismatch in weighting of environmental criteria between top-down (highest weighted top-down criteria at 1.37 cumulative weight) and bottom-up documents (lowest weighted bottom-up criteria at .70 cumulative weight). Weighting of social criteria was more consistent between top-down (1.12 cumulative weight) than bottom-up sources (1.47 cumulative weight). Weighting of economic criteria was variable within and between top-down (.51 cumulative weight) and bottom-up (.83 cumulative weight) documents. These results support a slight priority of social criteria over environmental, and considerable priority of social criteria over economic criteria as shown in Table 4.37.

Table 4.37 Integrated criteria decision matrix
Consistency Ratio .03
Max Eigen value 3.05

Neighborhood sustainability	environmental	economic	social	relative weight	analysis unit
environmental	1.00	2.00	0.50	0.31	the sum of environmental indicators rate x weight
economic	0.50	1.00	0.50	0.20	the sum of economic indicators rate x weight
social	2.00	2.00	1.00	0.49	the sum of social indicators rate x weight

Despite the mixed environmental goal weights between top-down and bottom-up plans, there was general agreement on preferred indicator types and their weights. The unanimous favorite was *access to green space* and *measures of green infrastructure*, including *area of greenways* and *impervious surface area*. Top-down and bottom-up documents support measuring *transportation mode-split* in differing manners. Indicators identified from top-down documents suggest focusing on vehicle mode split indicators like *vehicle miles travelled*, *mode split*, *CO2 emission reduction levels*, and *amount of greenways*. In addition to prioritizing measures of *greenspace* and *greenways*, bottom-up documents approached this issue by focusing on social indicators like the *distribution of multi-modal infrastructure*, *pedestrian safety*, and *access to public transit*. Table 4.38 provides a complete breakdown of integrated environmental indicator weights.

Table 4.38 Integrated environmental indicator decision matrix
Consistency Ratio .03
Max Eigen value 4.08

Environmental	% within 1/2 mile of greenspace	area of green infrastructure	mode split	% CO2 reduction below 1990 levels	relative weight	Analysis Unit
% within 1/2 mile of greenspace	1.00	1.00	3.00	3.00	0.39	Distance to Parks
area of green infrastructure	1.00	1.00	2.00	2.00	0.32	Area - % of block with Green Infrastructure
mode split	0.33	0.50	1.00	2.00	0.17	percent taking alternative transportation
% CO2 reduction below 1990 levels	0.33	0.50	0.50	1.00	0.12	Block average gas use

The weighting of social indicators displayed some interesting divergences including approaches to measuring transportation, the importance of neighborhood services and amenities, and the importance of education indicators at the city scale relative to public safety at the local scale. As mentioned in the environmental section, bottom-up documents highlighted an alternative approach to measuring transportation from top-down sources. Instead, they focused on measurements of *access to transit*, *pedestrian safety*, and the *distribution of multi-modal infrastructure* (top weighted indicator at .73 cumulative weight). *A complete neighborhood index* as the highest weighted social indicator for top-down documents was unanimously and strongly supported (1.08 cumulative weight). Bottom-up sources favored *measures of neighborhood services and amenities* less so (.86 cumulative weight) but also placed importance on *levels of mixed-use properties* (.37 cumulative weight). There was agreement on all types of social indicators other than two. Measures of education were present in top-down documents but not at all in bottom up documents. Instead, bottom-up sources focus on issues of public safety and homelessness. One area of agreement was *housing diversity* (.35 top-down and .36 bottom-up cumulative weight) with a focus on affordable housing more evident at the city scale. These findings support a strong relative weight of *complete neighborhood index* and *multimodal access*. Table 4.39 presents full results of the integrated social indicator matrix.

Table 4.39 Integrated social indicator decision matrix
Consistency Ratio .05
Max Eigen value 5.20

Social	complete neighborhood index	multimodal access	public safety	public involvement	housing diversity	relative weight	Analysis Unit
complete neighborhood index	1.00	2.00	2.00	3.00	3.00	0.36	Mean index score
multimodal access	0.50	1.00	3.00	2.00	3.00	0.28	distance to frequent transit/ bike route/ trails
public safety	0.50	0.33	1.00	2.00	1.00	0.14	Crime incidence
public involvement	0.33	0.50	0.50	1.00	0.50	0.09	# of public-private partner-ships
housing		0.33	1.00	2.00	1.00	0.13	% cost burdened homes

Regarding economic indicators, both top-down and bottom-up documents suggested varying weights of income and employment indicators (.81 top-down and .62

bottom-up cumulative weights) and measures of local business (.59 top-down and .87 bottom-up cumulative weights). There was the most variability concerning type of income and employment. Top-down documents prefer many different indicators including, number of jobs, income distribution, jobs/household, and % cost burdened homes. Additionally, despite a central role in both city scale plans, this issue was not identified in the neighborhood scale West Quadrant Plan. Similarly, bottom-up documents show mixed support of employment indicators (job diversity and job growth) and ignore issues of income. *Measures of local business* were the highest ranked types of indicators present in all top-down (.59 cumulative weight) documents. However, the exact indicator varied among top-down documents including, *export value*, *business leakage*, *diversity of business types*, and *number of neighborhood-based businesses*. *Measures of local business* were weighted consistently by bottom-up (.87 cumulative weight) documents. Indicators varied slightly but focused on increasing the *density of local businesses*. Table 4.40 presents the relative weights of the integrated economic indicator decision matrix.

Table 4.40 Integrated economic indicator decision matrix
Consistency Ratio .04
Max Eigen value 5.15

Economic	income distribution	jobs/ household	diversity of local businesses	density of local businesses	university growth	relative weight	Analysis Unit
income distribution	1.00	2.00	1.00	1.00	3.00	0.25	Income Per Capita
jobs/ household	0.50	1.00	0.50	0.50	2.00	0.14	# of Jobs/HH
diversity of local businesses	1.00	2.00	1.00	0.33	2.00	0.19	# of NAICS codes
density of local businesses	1.00	2.00	3.00	1.00	3.00	0.33	density
university growth	0.33	0.50	0.50	0.33	1.00	0.09	Ratio of assignable space to building footprint

Intercoder Reliability Testing Results

Intercoder reliability coefficients were calculated for percent agreement, Scott's π, Cohen's κ, and Krippendorff's α using ReCal2, an online utility. Tables 4.41 – 4.43 report the results of the intercoder reliability testing for each document. Overall, the average percent agreement was 89.2%, average Scott's π was 87.3%, average Cohen's κ was 87.2%, and average Krippendorff's α was 87.4%. The highest percent agreement was 94.1% for The Portland Plan. The Lowest percent agreement was 84.8% for the Comprehensive Plan. Given these results, the intercoder reliability testing process supports the validity of the qualitative analysis.

Table 4.41 Intercoder reliability results for Comprehensive Plan

	Percent Agreement	Scott's Pi	Cohen's Kappa	Krippendorff's Alpha (nominal)	N Agreements	N Disagreements	N Cases	N Decisions
Intercoder reliability rate	0.848	0.821	0.821	0.823	39	7	46	92

Table 4.42 Intercoder reliability results for Portland Plan

	Percent Agreement	Scott's Pi	Cohen's Kappa	Krippendorff's Alpha (nominal)	N Agreements	N Disagreements	N Cases	N Decisions
Intercoder reliability rate	0.941	0.928	0.928	0.93	16	1	17	34

Table 4.43 Intercoder reliability results for West Quadrant Plan

	Percent Agreement	Scott's Pi	Cohen's Kappa	Krippendorff's Alpha (nominal)	N Agreements	N Disagreements	N Cases	N Decisions
Intercoder reliability rate	0.886	0.869	0.87	0.87	78	10	88	176

SOURCE Analysis Mapping Results

The SOURCE tool is a type of multi-criteria spatial analysis that identifies priority areas, through a series of suitability maps for neighborhood-scale sustainable development, based on shared public and private preferences for mitigation. The zonal statistics as table tool was used in combination with the weighted sum tool, to apply a relative weight derived by AHP, in order to create a total of eighteen suitability maps that identify the blocks with the lowest sustainability performance and the highest level of shared public and private interest. These maps can be quickly used to visually assess sustainability from a variety of scales (goal, criteria, and/or indicator performance) while considering the preferences of stakeholders.

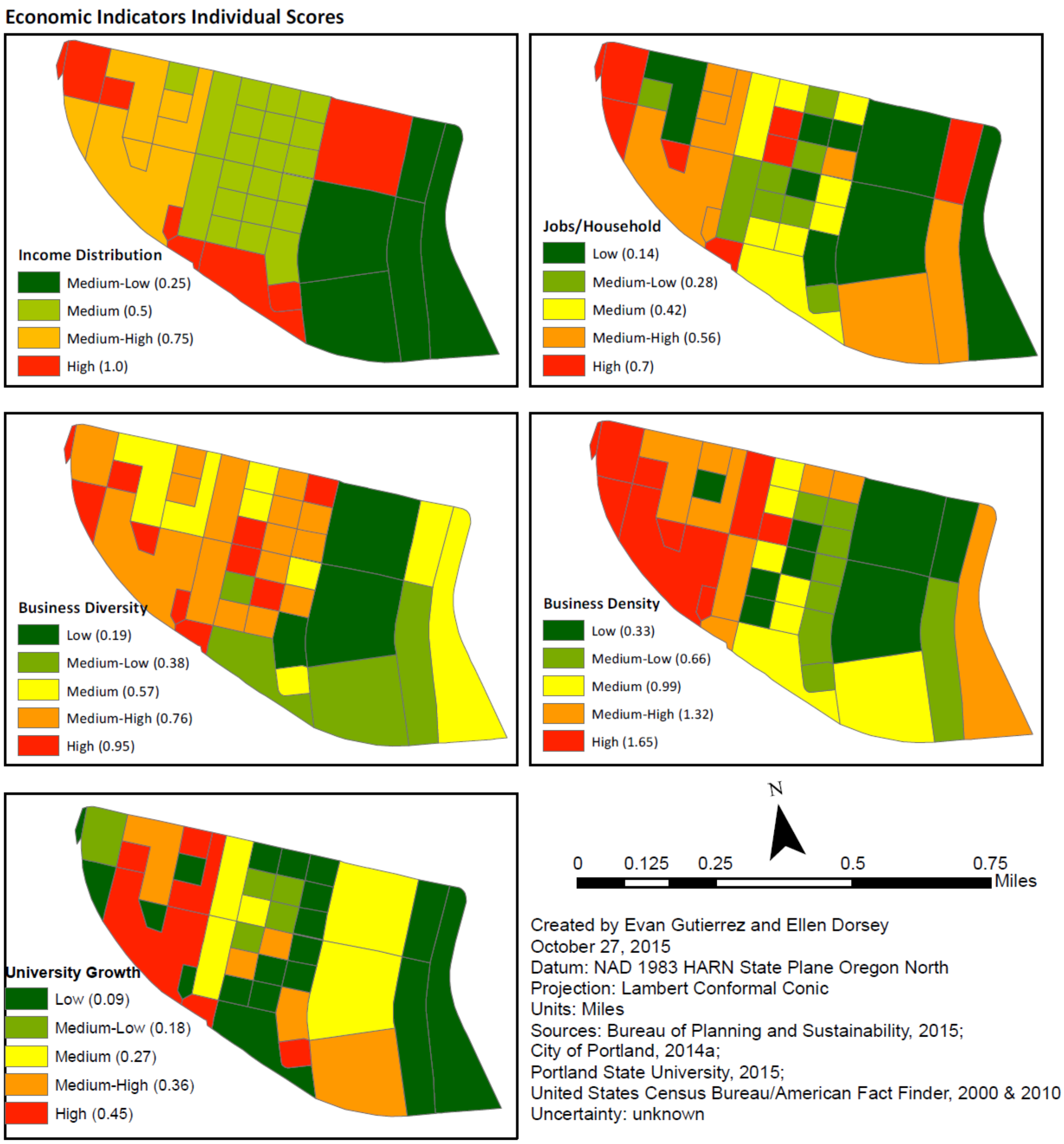
Three types of suitability maps were used to visualize areas of converging interests among stakeholder groups and a need for mitigation, including individual indicator score maps, composite criteria score maps, and a cumulative objective score map. An objective suitability map representing the cumulative weighted scores of all three criteria and 14 indicators was created (Figure 4.7) to serve as a quick visual assessment of shared sustainable development priorities in the study area. Two other types of suitability maps were also created, including 3 composite criteria maps (figures 4.4 – 4.6) and 14 individual indicator score maps (figures 4.1 – 4.3), which summarized the cumulative scores. They represent the weighted scores of the decision criteria and indicators and can be used to interpret performance of neighborhood sustainability at finer scales. Creating three types of suitability maps allows for quick visual analysis of neighborhood sustainability as well as the ability to provide a detailed analysis of performance and the priorities of decision makers. To apply the AHP method to each suitability map, a relative numerical score and chromatic scale were associated with the objective, criteria, and indicator suitability maps. In the graphic representation of the results, the color given to each block is related to each normalized score ranging from green to red and expresses the suitability (from low to high) for sustainable development projects given shared interests in a need for mitigation. The threshold applied to the suitability values to identify the most preferable areas for focusing sustainable development projects and partnerships was set for the top two quintiles. Next, I will present the individual indicator score maps, followed by the composite criteria score maps. I will end the section by exhibiting the map of cumulative scores for the overall objective, the sustainability of the SoMa neighborhood.

Individual Indicator Scores

Economic Indicators Individual Scores

Figure 4.1 shows the maps of individual scores for economic indicators obtained by the product of the normalized performance rate and the relative weight for each indicator. The range of suitability values of the five economic indicator individual scores maps generated was between .09 and 1.65. The thresholds applied to the suitability values to identify the most preferable areas were the upper 40%. The percentage of the area identified as most suitable for sustainable development projects was an average of 37.7% of the total area, varying between individual indicator score maps with a coefficient of variation of 4%. The maps of the most preferred sites based on economic indicator individual scores generated showed that the highest priority sites are scattered throughout the neighborhood depending on indicator. This highest weighted indicator, business density, identified the western portion of the district as the worst performing. Another highly weighted indicator, business diversity, focused on the western portion of the study area for the development of local businesses. As expected, income distribution and jobs per household tended to identify blocks with high student populations, however, jobs per household also impacted more residents of the study area. The lowest weighted indicator, university growth, identified the campus blocks with the least dense buildings on the west and south end of the study area.

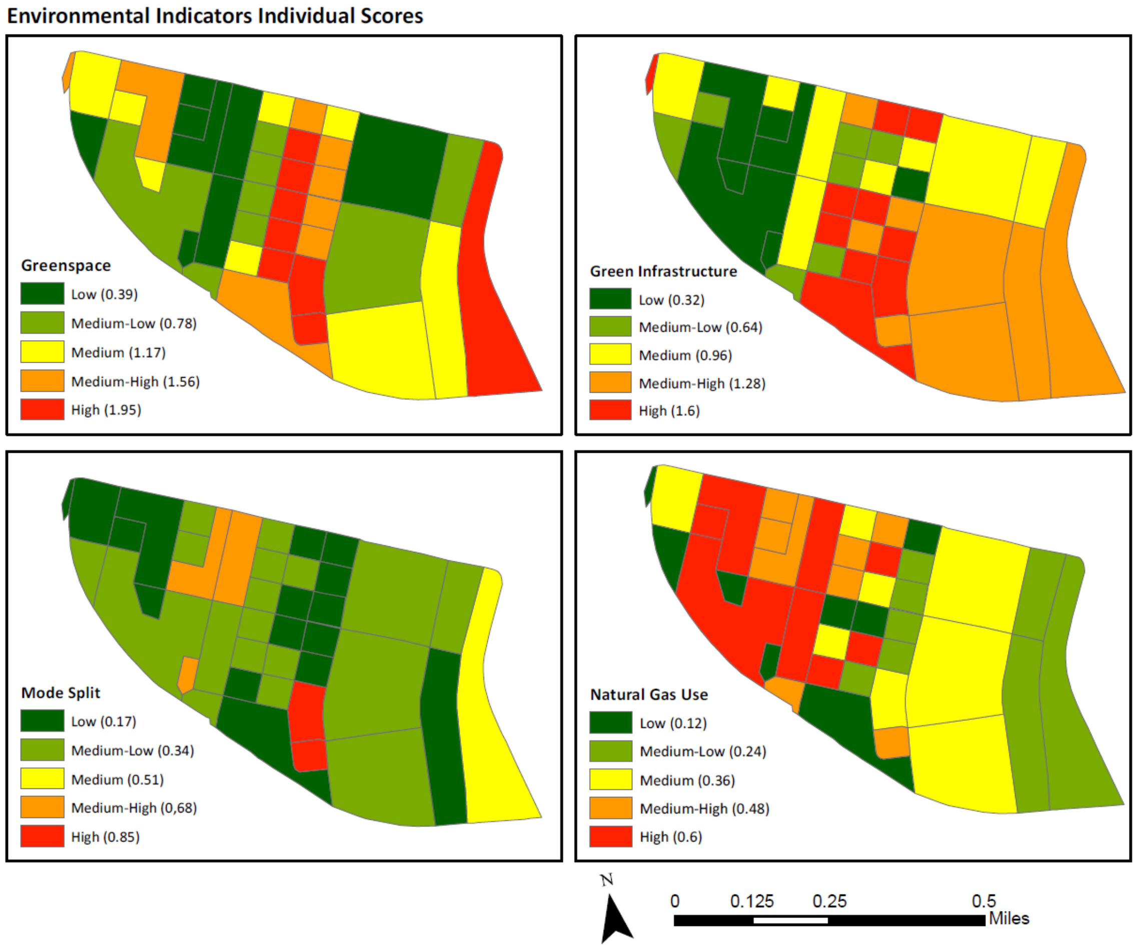
Figure 4.1 Maps of economic indicators individual scores



Environmental Indicators Individual Scores

Figure 4.2 shows the maps of individual scores for environmental indicators obtained by the product of the normalized performance rate and the relative weight for each indicator. The range of suitability values of the four environmental indicator individual scores maps generated was between .12 and 1.95. Given the threshold applied of the upper 40%, the percentage of the area identified as suitable for sustainable development projects was an average of 31% of the total area, varying between individual indicator score maps with a coefficient of variance of 17.4%. The maps of the most preferred sites based on environmental indicator individual scores generated showed that most of the preferable sites are found in the central portion of the neighborhood. The highest weighted indicators, access to greenspace and green infrastructure, both identified the core of the district as well as the riverfront as priority development areas. The mode split indicator identified only a handful of blocks to focus attention whereas the natural gas use indicator identified much of the campus area.

Figure 4.2 Maps of environmental indicators individual scores

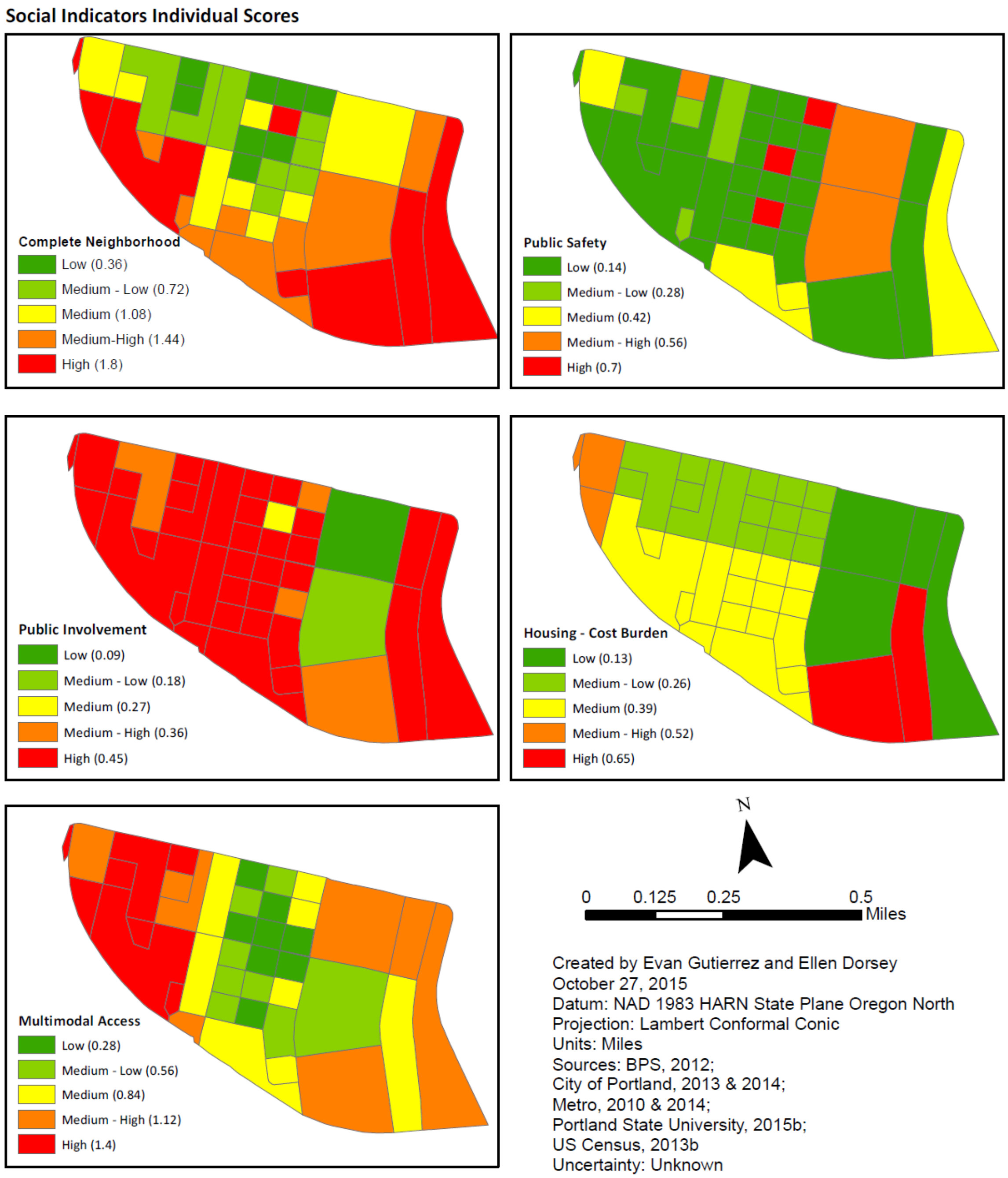


October 27, 2015
Datum: NAD 1983 HARN State Plane Oregon North
Projection: Lambert Conformal Conic
Units: Miles
Sources: City of Portland, 2010;
Customer Accounts, 2015;
Portland State University, 2015;
US Census, 2013a
Uncertainty: Unknown

Social Indicators Individual Scores

Figure 4.3 shows the maps of individual scores for social indicators obtained by the product of the normalized performance rate and the relative weight for each indicator. The range of suitability values of the five social indicator individual scores maps generated was between .09 and 1.8. Given a threshold applied of the upper 40%, the percentage of the area identified as suitable for sustainable development projects was an average of 44% of the total area, varying between individual indicator score maps with a coefficient of variance of 22%. The maps of the most preferred sites based on social indicator individual scores generated showed that most of the preferable sites are found throughout the neighborhood. The two highest weighted indicators, complete neighborhood and multi-modal access, identified a large amount of the periphery of the study area as most suitable for development projects. Both the public safety and housing cost burden indicators identified a few select blocks to focus development efforts. The lowest weighted indicator, public-private partnerships, displayed ample room for expansion of partnerships in the district.

Figure 4.3 Maps of social indicators individual scores



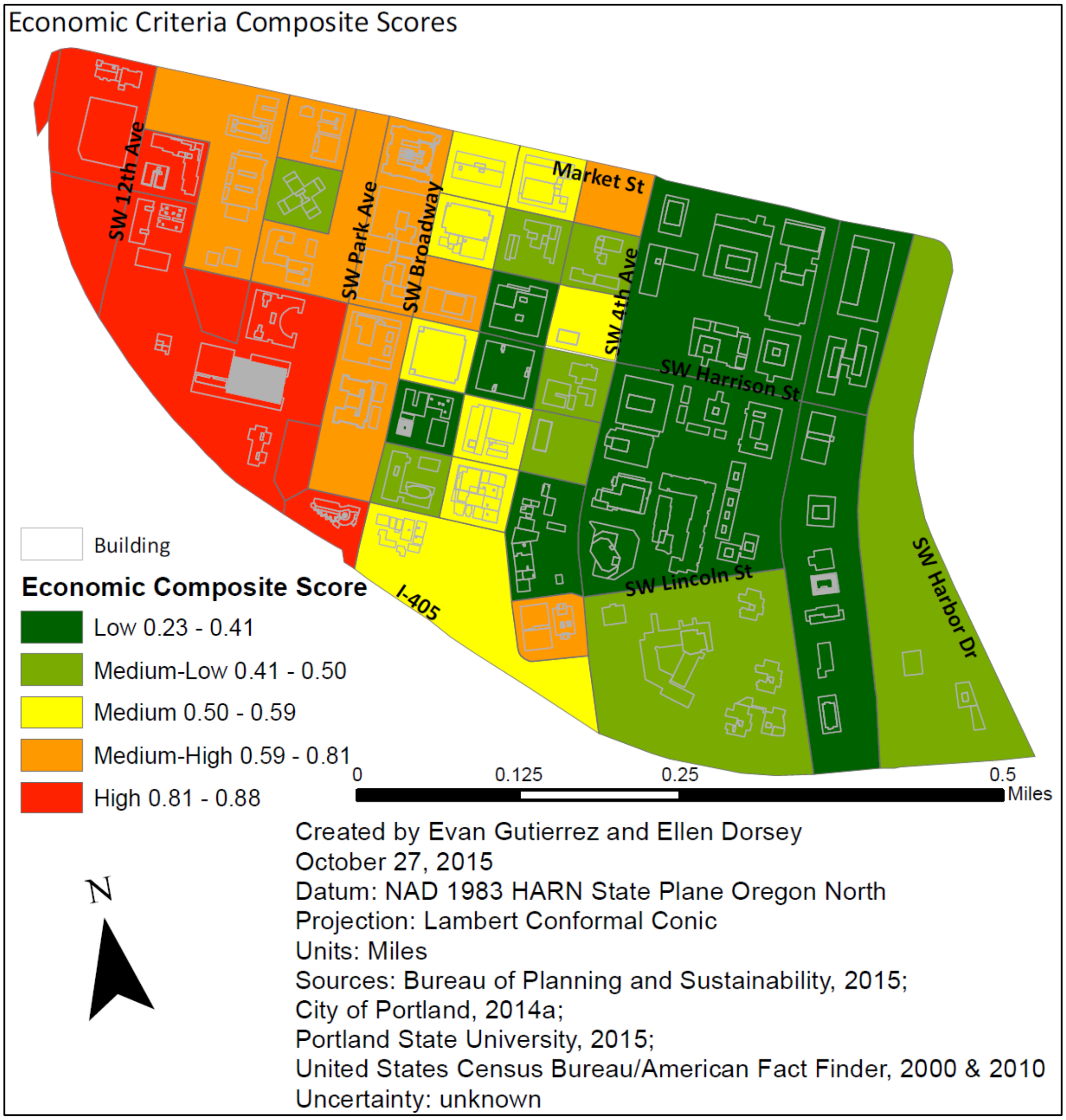
Composite Criteria Scores

In the following section I will present the maps of the composite scores for each criteria. On average, the composite criteria score maps identified 39% of the study area as in the medium-high, or high, suitability for sustainable development projects based on shared interests and need to increase performance. The amount of area identified by composite criteria scores varied by criteria with a coefficient of variance of 10%. I will begin by introducing the lowest weighted criteria, economic criteria, and finish with the highest weighted criteria, social criteria.

Economic Criteria Composite Scores

Figure 4.4 shows the maps of composite scores for economic criteria obtained by the product of the economic criteria weight and the sum of the individual economic indicator scores. The range of suitability values of the five economic criteria composite scores maps generated was between .22 and .95. Given a threshold of the upper 40%, the percentage of the area identified as suitable for development projects was an average of 30% of the total area. The map of the most preferred sites based on economic criteria composite scores generated showed that most of the preferable sites are found in the western and campus portions of the neighborhood.

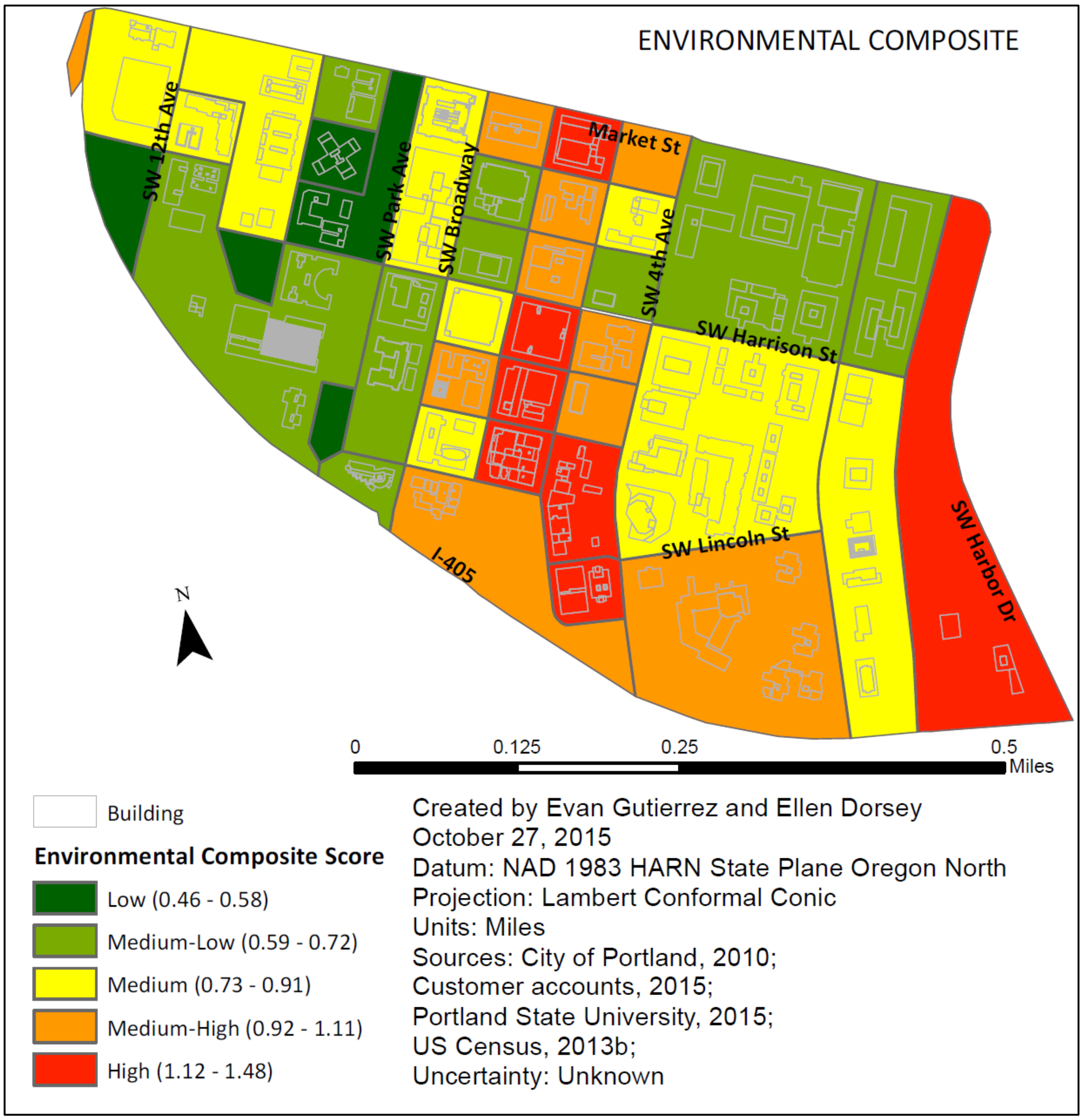
Figure 4.4 Map of economic criteria composite scores



Environmental Criteria Composite Scores

Figure 4.5 shows the maps of composite scores for environmental criteria obtained by the product of the environmental criteria weight and the sum of the individual environmental indicator scores. The range of suitability values of the four environmental criteria composite scores maps generated was between .46 and 1.48. Given a threshold of the upper 40%, the percentage of the area identified as suitable for sustainable development projects was an average of 37% of the total area. The map of the most preferred sites based on environmental criteria composite scores generated showed that most of the preferable sites are found in the central and eastern portion of the neighborhood.

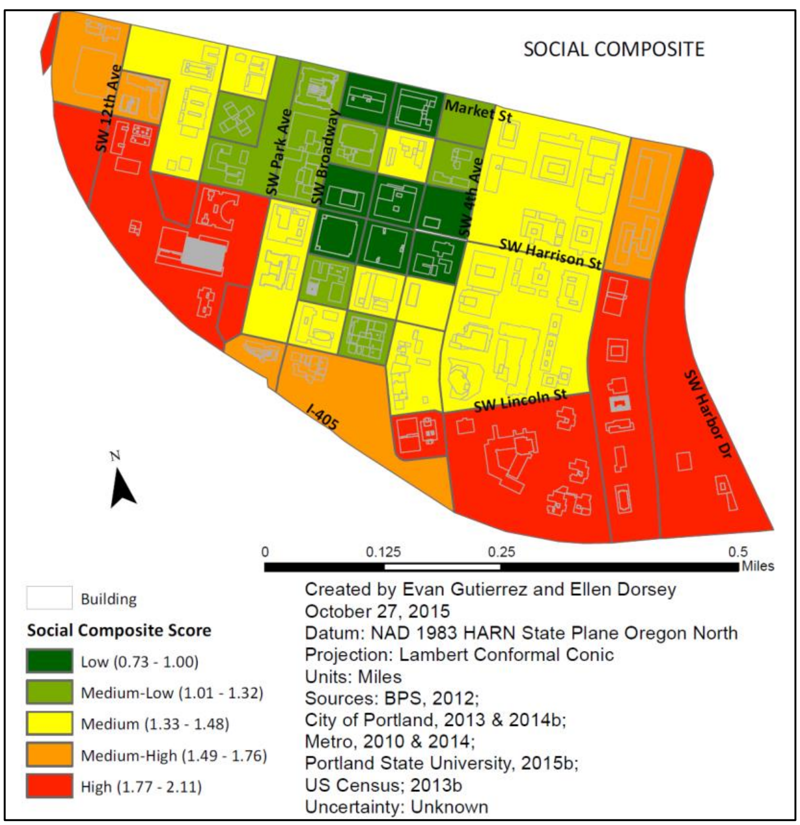
Figure 4.5 Map of environmental criteria composite scores



Social Criteria Composite Scores

Figure 4.6 shows the maps of composite scores for social criteria obtained by the product of the social criteria weight and the sum of the individual social indicator scores. The range of suitability values of the five social criteria composite scores maps generated was between .73 and 2.11. Given a threshold of the upper 40%, the percentage of the area identified as suitable for sustainable development projects was an average of 50% of the total area. The map of the most preferred sites based on social criteria composite scores generated showed that most of the preferable sites were found on the periphery of the neighborhood.

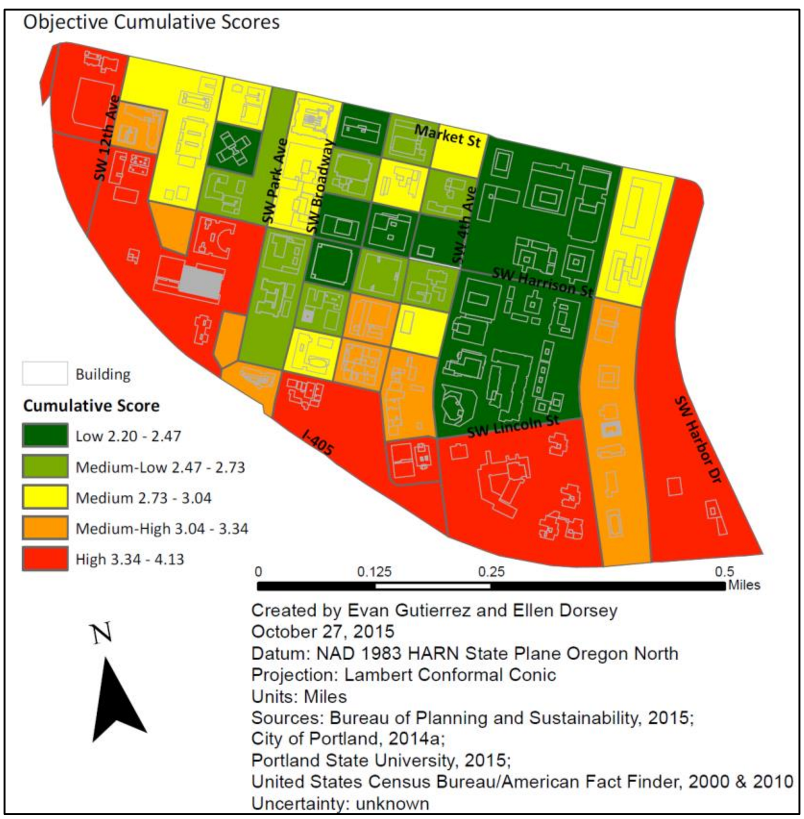
Figure 4.6 Map of social criteria composite scores



Objective Cumulative Scores

Figure 4.7 shows the maps of objective cumulative scores which optimize the objective function obtained by the sum of the criteria composite scores (see equation in figure 3.8). The range of suitability values of the cumulative score map generated was between 2.20 and 4.13 out of a possible 5. Given a threshold of the upper 40%, the percentage of the area identified as suitable for sustainable development projects was an average of 50% of the total area. Considering the high-scoring area represented only 19% of the total study area, while the remaining 31% of the area was in the medium-high score, the study area is performing well. The maps of the most preferred sites based on cumulative scores generated show that most of the suitable sites are found in

Figure 4.7 Map of objective cumulative scores



the periphery of the study area. The concept of optimization of indicators into composite criteria scores and individual cumulative objective score is shown in figure 4.8.

Figure 4.8 Conceptualization of spatial optimization of composite and cumulative scores

ENVIRONMENTAL COMPOSITE
Natural Gas Use
Low (0.12)
Medium-Low (0.24)
Medium (0.36)
Medium-High (0.48)
High (0.6)
Mode Split
Low (0.17)
Medium-Low (0.34)
Medium (0.51)
Medium-High (0.68)
High (0.85)
Green Infrastructure
Low (0.32)
Medium-Low (0.64)
Medium (0.96)
Medium-High (1.28)
High (1.6)
Greenspace
Low (0.39)
Medium-Low (0.78)
Medium (1.17)
Medium-High (1.56)
High (1.95)
SW 12th Ave
SW Park Ave
SW Broadway
Market St
SW 4th Ave
SW Harrison St
SW Lincoln St
I-405
SW Harbor Dr
Environmental Composite Score
Low (0.46 - 0.58)
Medium-Low (0.59 - 0.72)
Medium (0.73 - 0.91)
Medium-High (0.92 - 1.11)
High (1.12 - 1.48)

Economic composite
University Growth
Low (0.09)
Medium-Low (0.18)
Medium (0.27)
Medium-High (0.36)
High (0.45)
Business Density
Low (0.33)
Medium-Low (0.66)
Medium (0.99)
Medium-High (1.32)
High (1.65)
Business Diversity
Low (0.19)
Medium-Low (0.38)
Medium (0.57)
Medium-High (0.76)
High (0.95)
Jobs/Household
Low (0.14)
Medium-Low (0.28)
Medium (0.42)
Medium-High (0.56)
High (0.7)
Income Distribution
Medium-Low (0.25)
Medium (0.5)
Medium-High (0.75)
High (1.0)
SW 12th Ave
SW Park Ave
SW Broadway
Market St
SW 4th Ave
SW Harrison St
SW Lincoln St
I-405
SW Harbor Dr
Building
Economic Composite Score
Low 0.23 - 0.41
Medium-Low 0.41 - 0.50
Medium 0.50 - 0.59
Medium-High 0.59 - 0.81
High 0.81 - 0.88
0
0.125
0.25
0.5
Miles

Indicator Quality Assessment

I assessed indicator quality following the indicator assessment protocol developed by Coalition for a Livable Future, as discussed in the methods section (table 3.6). Any indicator with a score 17 of 21 (~81%) and above meets the standards for this investigation. Those with lower scores should be further developed. The average indicator quality score was 17.7 (84%). Overall, the high score for individual indicators was 21 (100%) and there was a low score of 9 (43%). Combined, economic indicators received the highest average quality score with 17.8 (84.8%) and social indicators received the lowest average quality score with 17.6 (83.8). Table 4.44 presents the results of the individual economic indicators quality assessment. Of the economic indicators, income distribution, as measured by income per capita, received the highest quality score (90%) and university growth, as measured by assignable space to footprint ratio, received the lowest quality score (76%). Table 4.45 presents the results of the individual environmental indicators quality assessment. Of the environmental indicators, access to greenspace and amount of green infrastructure both had the highest quality assessment scores (90%). Unexpectedly, CO2 reduction data, as measured by average natural gas consumption, received the lowest quality assessment rating (76%) due to the privacy of the data. Table 4.46 presents the results of the individual social indicators quality assessment. Of the social indicators, public safety, as measured by the density of crimes reported, received the highest quality assessment score (100%). As expected, the public involvement indicator, as measured by the density of partnerships, received the lowest assessment quality score due to the fact that this indicator previously lacked a robust dataset and needed to be created ad-hoc.

Table 4.44 Economic indicator quality assessment results

Economic indicator (unit)	collection	processing	updates	resolution	accuracy	extent	consistency	sum
income distribution (income per capita)	3	3	3	2	2	3	3	19
jobs (# jobs/household)	3	3	1	3	2	3	3	18
business diversity (# of NAICS codes/block)	3	3	1	3	2	3	3	18
business density (density of business/block)	3	3	1	3	2	3	3	18
university growth (footprint : assignable space ratio)	3	2	3	2	1	3	3	16

Table 4.45 Environmental indicator quality assessment results

Environ. indicator (unit)	collection	processing	updates	resolution	accuracy	extent	consistency	sum
access to greenspace (% within 1/2 mi of greenspace)	3	3	2	3	2	3	3	19
amount of green infrastructure (area)	3	3	1	3	3	3	3	19
mode split (% take alt. transport)	3	3	2	2	1	3	3	17
CO2 reduction (PSU total EUI)	1	2	3	2	2	3	3	16

Table 4.46 Social indicator quality assessment results

Social indicator (unit)	collection	processing	updates	resolution	accuracy	extent	consistency	sum
complete neighborhood index (block mean index score)	3	3	2	3	3	3	3	20
Multi-modal access (distance to alt. transit)	3	3	1	3	3	3	3	19
public safety (block density)	3	3	3	3	3	3	3	21
public involvement (block density)	1	1	1	3	1	1	1	9
housing diversity (% housing cost burdened)	3	3	2	3	2	3	3	19

Chapter 5 Discussion

Optimization of sustainability performance and public-private preferences as measured by composite and individual suitability scores has led to a series of recommended sustainable development projects to address poor SOURCE scores and guide the SoMa neighborhood's development. These projects will be discussed in the following section. A series of Neighborhood Life Corridors, or suites of sustainable development projects, represent the application of the SOURCE tool's synthesis of data types and stakeholder preferences. Neighborhood Life Corridors are a type of multi-functional green infrastructure designed to meet concurrent development needs within a single space. I begin the following section by briefly discussing the role of green infrastructure as an urban renewal strategy to address multiple aspects of sustainability and achieve synergistic effects. Then, I dissect the priority zones identified by the SOURCE analysis to inform the details of suggested Neighborhood Life Corridors. I conclude the section by reviewing the quality of indicators used.

Integrating Multi-functional Green Infrastructure with Sustainable Urban Renewal

Mell (2009) explored the use of green infrastructure to promote urban sustainability. Developing green infrastructure in urban areas addresses multiple facets of sustainability. Ecologically, green infrastructure can provide spaces to intercept rainfall, absorb solar radiation, and reduce urban heat island effects locally. On a broader scale, green infrastructure can act as a buffer to climate change by increasing biodiversity and habitats, as well as a creating a buffer for flooding and maintaining healthy hydrologic and carbon cycles. Socially, green infrastructure has also been used to increase sense of community, create public gathering and recreation spaces, and address issues of equity. Green infrastructure also plays a role in economic renewal through the role landscape plays in attracting business and residents to a region. Attractive and well-designed spaces are able to attract business because people want to live in such areas (Mell, 2009). Given the ability of green infrastructure to address each aspect of sustainability, it is a robust sustainable urban renewal tool that can be developed in conjunction with transportation, business, and other urban infrastructures to form a complete neighborhood that connects mixed-use, accessible spaces, which offer a range of services and amenities.

Newell and colleagues (2012) explored the use of green alley programs as an innovative emerging urban renewal strategy to achieve a variety of sustainability and public health goals. Revitalizing urban alleys by developing green infrastructure can promote sustainability through management of ecologic systems such as runoff management, groundwater recharge, heat island reduction, increased habitat, as well as through the management of social systems, for example, increased pedestrian activity, recreational opportunities, connectivity, and safety. Table 5.1 displays an array of objectives and features of alley greening programs throughout the United States. While most objectives and features focus on stormwater capture and infiltration, some projects clearly focus on economic development and social equity goals. Envisioning green pedestrian alleys as a destination for locals and tourists, creating public open space for recreation and food production, and facilitating outdoor dining opportunities are a few examples of urban renewal projects that embrace social and economic goals along with stormwater.

Table 5.1 Objectives and features of green alley programs (Newell et al., 2012)

Objective	Features
Stormwater management	Permeable asphalt, concrete or pavers
Harvest rainwater	Impermeable asphalt, concrete or pavers
Urban heat island mitigation	Collar to hold pavers in place
Light pollution mitigation	Pitched surfaces
Energy conservation	Subsurface drainage pipe
Empower stakeholders	Subsurface gravel/rock/sand layer
Beautification	Concrete drainage channel
Enhance Safety	Dry well
Expand Greenspace	Grease interceptor
Alternative Transportation	Bioswale
Recreation	Infiltration trench
Connectivity	High albedo pavement
Build community	Recycled construction materials
Environmental education	Dark sky compliant light fixtures
Access to greenspace	Energy efficient light fixtures
Access to food	Native plantings
Enhance well-being	Benches or chairs
Public open spaces	Pedestrian walkway
Commercial spaces	Lighting for pedestrian use
	Gates
	Leasing agreements
	Locally sourced construction materials
	Murals
	Fitness equipment
	Interpretive or educational signage
	Community gardens, fruit trees, and/or edible landscaping

Within the SoMa EcoDistrict, the city of Portland has already implemented the Montgomery Green Street as part of their climate mitigation and adaptation strategy, which recognizes that value of multi-functional green infrastructure (Chang & House-Peters, 2010). Green streets use vegetated facilities to manage stormwater runoff and cool air temperature, as well as other constructed features to enhance neighborhood livability and strengthen the local economy. The Montgomery Green Street is characterized by several key attributes; water, an existing string of fountains provide a unifying element, as well as passive channels, a variety of planters, and permeable pavers to convey stormwater; placemaking, providing unique spaces for gathering or resting, room for outdoor business expansion, wildlife habitat, providing flexible space for events, and fostering of the urban ecosystem; and mobility, promote movement through the neighborhood on foot, bike, street car, and cars as well as balanced parking amenities (City of Portland, 2009).

A similar type of multi-functional green infrastructure, a Neighborhood Life Corridor, could be developed along the periphery of SoMa to address issues identified by the SOURCE analysis. Neighborhood Life Corridors are corridors that connect people and places, foster healthy ecosystems, lifestyles, local businesses, and diverse partnerships, as well as direct stormwater and solar energy by integrating a variety of multi-functional green infrastructures within public and private spaces. Developing seemingly less important areas of SoMa by creating diverse partnerships may hold the key to bridging barriers to sustainability in the neighborhood. The strategy of SOURCE is to optimize the location of neighborhood sustainable development projects and the identification of partnerships that could benefit most from community-driven stewardship. Expanding on the framework of Portland's Community Watershed Stewardship Program, Neighborhood Life Corridors are essentially non-traditional stewardship efforts that encompass multiple aspects of sustainability.

Similarly, Neighborhood Life Corridors rely on identifying a diversity of partnerships to involve stakeholders in the restoration of their neighborhood, with a mix of technical expertise and community capacity. Watershed stewardship partnerships will be a focus of the SoMa Neighborhood Life Corridor. Typical watershed partnerships might include maintenance and development of green streets, bioswales, and greenspaces. Local business partnerships will be another focus to promote mixed-use development, pop-up events, and retail partnerships. Partnerships with public and non-profit organizations will also play a key role in Neighborhood Life Corridor implementation, particularly Portland State University, Portland Development Commission, and SOLVE Oregon.

With existing pedestrian trails in place, there is an opportunity to connect under-utilized spaces with some of the more vibrant areas in SoMa and unite the area in new ways. A truly vital community needs to be more than a simple matrix of high performing buildings, but a resilient, interconnected community, supported by multi-functional greenspaces and diverse partnerships. Neighborhood Life Corridors would serve to facilitate stakeholder interactions, improve sustainability performance, and increase physical connectivity throughout the district. This is achieved by connecting high performing buildings, spaces, and businesses with a vibrant series of pedestrian walkways and public gathering spaces. Currently, the South Park Blocks serve as the main green space and pedestrian route and the Halprin Blocks secondarily in the east side of SoMa. Using these Neighborhood Life Corridors as conduits, there lies an opportunity to electrify the rest of the SoMa community by tapping into the energy of the South Park and Halprin Blocks.

The best locations for these Neighborhood Life Corridors were identified through the SOURCE analysis. The SOURCE tool indicated which of the numerous possible sustainable development project locations and components would yield the highest environmental, social, and economic returns given the current performance regime and preference structure. Neighborhood Life Corridors aim to alleviate shared stakeholder concerns (complete neighborhood green space, mobility, greenspace, and local business), address block level sustainability performance, as well as connect the disjointed district by increasing the flow of stakeholders throughout the district; thereby improving their chances for interaction and opportunities to negotiate resource use and allocation. If implemented correctly, these Neighborhood Life Corridors are capable of accomplishing several urban renewal goals simultaneously. By their very nature, Neighborhood Life Corridors improve sustainability performance by increasing connectivity, fostering local businesses and destination gathering places, and expanding green infrastructure. In the following section, I will discuss potential Neighborhood Life Corridor configurations to address the sustainability performance issues and shared interests captured by the SOURCE analysis.

Optimization of Cumulative Scores and Sustainable Development Projects

Neighborhood Life Corridor Zone 1 SoMa's Southwest Side

Based on the results of the SOURCE optimization analysis, specifically the objective cumulative score map, criteria composite score maps, and indicator individual score maps, two zones were selected to have the greatest chance of success for a proposed Neighborhood Life Corridor within the study area. The objective cumulative score map identified the western, southern, and eastern periphery as the worst performing blocks with a high potential for public-private partnership based on shared interests in increasing sustainability performance. Once the locations of the Neighborhood Life Corridor were optimized by highest cumulative score, the nuances of project specifics were crafted using the data in the criteria composite score and indicator individual score maps. Basically, the cumulative score gives users a quick, simplified, assessment of overall sustainability performance by block. For more information regarding the specifics of what constitutes that cumulative score, criteria and indicator scores must be consulted to determine which types of projects would be best suited for the areas.

The SOURCE tool determined that five of the nine highest scoring blocks, including the highest scoring block, were located in SoMa's southwest side (see figure 5.1), which will be referred to Neighborhood Life Corridor zone 1.

Figure 5.1 Map of Neighborhood Life Corridor Zone 1

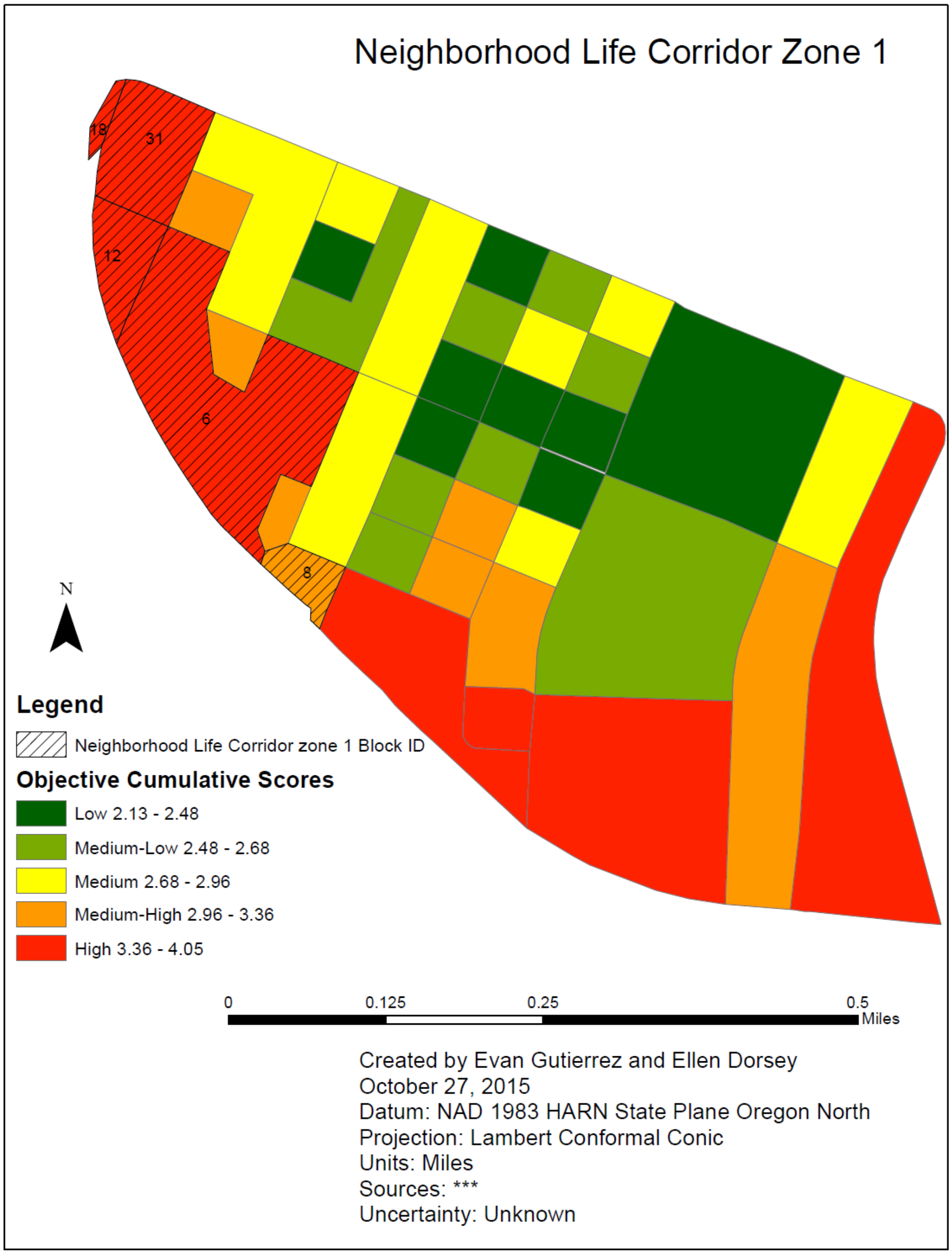


Table 5.2 Neighborhood Life Corridor Zone 1 Criteria Composite Scores and Objective Cumulative Scores

Block ID	Environmental Criteria Composite Score	Economic Criteria Composite Score	Social Criteria Composite Score	Objective Cumulative Score
6	0.63	0.83	2.05	3.51
8	0.69	0.88	1.73	3.31
12	0.46	0.83	2.11	3.40
18	1.07	0.88	2.11	4.06
31	0.82	0.86	1.76	3.44
Average	0.74	0.86	1.95	3.55

Further analysis of SOURCE composite criteria scores for these blocks revealed that the west side of SoMa could benefit most from sustainable development projects focused primarily on the social aspects (1.95 average composite score) of sustainability, followed by economic (.86 average composite score) and environmental aspects (.74 average composite score). Examination of individual indicator scores for Neighborhood Life Corridor 1 blocks, given the relative weights of the criteria (overall weight), allowed for comparative assessment of each indicator and determination of project component priorities (see Tables 5.3 – 5.5).

Table 5.3 Neighborhood Life Corridor Zone 1 Economic Indicators Individual Scores, Average Individual Scores, and Overall Average Weighted Individual Scores

Block ID	Income	Jobs	Business Diversity	Business Density	University Growth	Economic Composite Score	Objective Cumulative Score
6	0.75	0.56	0.76	1.65	0.45	0.83	3.51
8	1.00	0.70	0.95	1.32	0.45	0.88	3.31
12	0.75	0.70	0.95	1.65	0.09	0.83	3.40
18	1.00	0.70	0.95	1.65	0.09	0.88	4.06
31	1.00	0.70	0.76	1.65	0.18	0.86	3.44
Average	0.90	0.67	0.87	1.58	0.25	0.86	3.55
Overall average weighted individual score [x]	0.18	0.13	0.17	0.32	0.05		

[x] average * criteria weight

Table 5.4 Neighborhood Life Corridor Zone 1 Environmental Indicators Individual Scores, Average Individual Scores, and Overall Average Weighted Individual Scores

Block ID	Green Space	Green Infrastructure	Mode Split	CO2	Environmental Composite Score	Objective Cumulative Score
6	0.78	0.32	0.34	0.6	0.63	3.51
8	0.78	0.64	0.34	0.48	0.69	3.31
12	0.39	0.64	0.34	0.12	0.46	3.40
18	1.56	1.6	0.17	0.12	1.07	4.06
31	1.17	0.96	0.17	0.36	0.82	3.44
Average	0.94	0.83	0.27	0.34	0.74	3.55
Overall average weighted individual score [x]	0.29	0.26	0.08	0.10		

[x] average * criteria weight

Table 5.5 Neighborhood Life Corridor Zone 1 Social Indicators Individual Scores, Average Individual Scores, and Overall Average Weighted Individual Scores

Block ID	Complete Neighborhood	Multi-Modal Access	Public Safety	Public-Private Partnerships	Housing Cost Burden	Social Composite Score	Objective Cumulative Score
6	1.8	1.4	0.14	0.45	0.39	2.05	3.51
8	1.44	1.12	0.14	0.45	0.39	1.73	3.31
12	1.8	1.4	0.14	0.45	0.52	2.11	3.40
18	1.8	1.4	0.14	0.45	0.52	2.11	4.06
31	1.08	1.12	0.42	0.45	0.52	1.76	3.44
Average	1.58	1.29	0.20	0.45	0.47	1.95	3.55
Overall average weighted individual score [x]	0.78	0.63	0.10	0.22	0.23		

[x] average * criteria weight

For example, the two highest scoring indicators for Neighborhood Life Corridor zone 1 blocks were *complete neighborhood index* and *multi-modal access* with an average score of 1.58 and 1.29 respectively. By considering the relative weight of social criteria (.49), an overall average weighted individual score was calculated for each indicator (.77 and .63). Visualizing the weights of the indicators in this manner makes it is possible to see the impact of a single indicator on the overall decision, as well as to compare indicators directly. The next highest overall average weighted individual scores of Neighborhood Life Corridor 1 blocks were business density (.32), access to greenspace (.29), and distance to green infrastructure (.26).

Given the considerations raised by the SOURCE analysis results as discussed above, I am recommending a suite of projects within Neighborhood Life Corridor zone 1 that focuses on building partnerships which increase multi-modal access, healthy food, commercial services, greenspace, and green infrastructure to achieve a more complete neighborhood. Neighborhood Life Corridor zone 1 starts in the northwest corner of the SoMa District on SW 13th between Market and Montgomery Streets. It continues east on SW Market Street towards the beginning of the Montgomery Green Street from SW 11th to SW 10th Ave. From there, the Neighborhood Life corridor moves south down SW 10th Ave. between the community fields and the PSU library, where it connects to the south end of the Park Blocks via SW Harrison St. The Neighborhood Life Corridor continues south, down the Park Blocks, where it meets with SW Jackson Street, and then heads east where it continues into Neighborhood Life Corridor zone 2.

Overall, the SoMa Neighborhood Life Corridor aims to activate the periphery of the neighborhood by taking advantage of partnerships at a few key locations with various local businesses, non-profits, and community groups, as well as governmental and educational organizations. Along that route, I recommend several sustainable development projects for strengthening new and existing infrastructure, building partnerships and creating an active and sustainable corridor through the periphery of campus based on SOURCE scores. Such a suite of projects aims to positively impact local multi-modal accessibility, greenspace and green infrastructure, housing cost burden, business diversity, income distribution, as well as public safety.

1. The beginning of the Neighborhood Life Corridor zone 1 should focus on the entrance to the SoMa neighborhood from SW 13th at Market. The block on the east side of SW 13th Ave. contains a large above ground parking structure as well as the Helen Gordon Child Development Center. On the west side of SW 13th Ave. there is a small vacant block that borders the Interstate 405. On a recent visit to the area, the vacant block was covered in trash, the tents of two different homeless people were occupying the space between the tall trees, and the sidewalk was not well maintained (see figures 5.2). Across the street it was a much different story (figure 5.3), as the sidewalk was well maintained and lined with planters, and the parking structure had several plants growing on it. I propose balancing the character

Figure 5.2 Unmaintained entrance to SoMa

Figure 5.3 Well-maintained entrance to SoMa

of the two disparate blocks by developing multi-functional green infrastructure on an otherwise undeveloped block. For example, the space could be transformed by updating the sidewalk, adding green infrastructure, and creating a place for gathering. Potential partners include the community garden down the street, the child development center, and food carts/retail carts near the gathering spaces. These types of project would address low multimodal access, green infrastructure, and complete neighborhood scores of blocks 18 and 31.

2. The gateway to campus should feature more pop-up events similar to children's events (see figure 5.4) held more regularly and with more local vendors, including the Metro Coffee house (SW 11th and Montgomery). The community garden and orchard across the street can play a role in supplying healthy food to campus events, eateries, and food carts. Gathering spaces and green infrastructure should be

Figure 5.4 Children's pop-up event

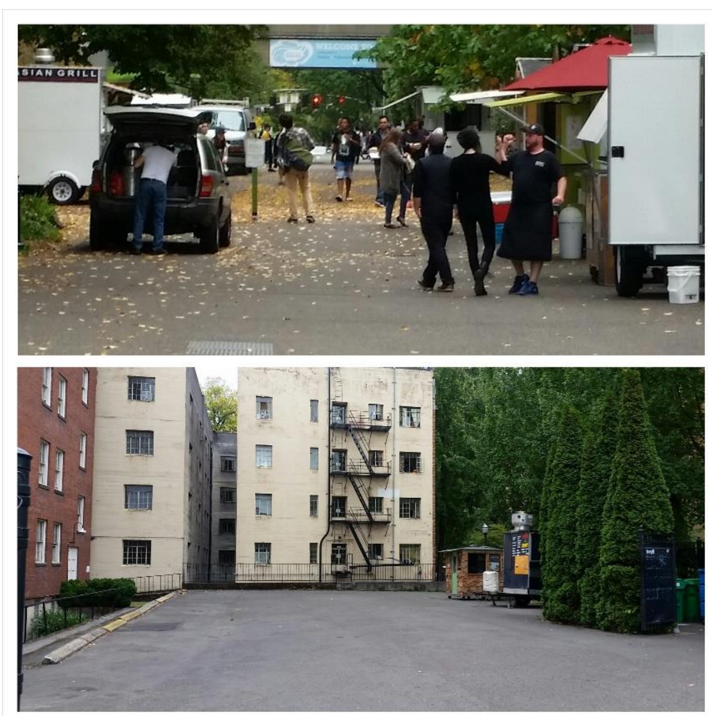
enhanced to extend the existing Montgomery Green Street west to the edge of the neighborhood. A good start, for example, is the recently restored oak savannah and canoe carving pop-up class, which is just beginning to transform what was until recently, a fenced parking lot (see figure 5.5). This is a perfect example of how to transform seemingly un-usable spaces into multi-functioning assets of the community and to address poor complete neighborhood, business density and diversity, green space and green infrastructure scores.

Figure 5.5 Transformation of parking lot to oak savannah outdoor classroom

3. The vacant parking lot at Harrison and SW 10th Avenue could be used as a more permanent food and retail cart pod and potentially extended into a cart pod corridor

along SW Harrison where a few carts have started setting up during lunchtime (see Figure 5.6). In addition to traditional food carts, I would recommend including retail carts and covered seating amenities (similar to those seen in the SE Division pod “Tidbits”). This pod could also service and coordinate community activities on the Peter W. Stott Community Field and Recreation Center. The area could team with PSU’s business accelerator program to form a cart pod accelerator program or incubator to train students and even community members to form sustainable cart-based businesses and address poor complete business diversity and density scores. Additionally, the program could offer pop-up and event training using the south end of the park blocks as a type of recurring and evolving gathering space, outdoor event venue, and community classroom to build social capital in the neighborhood.

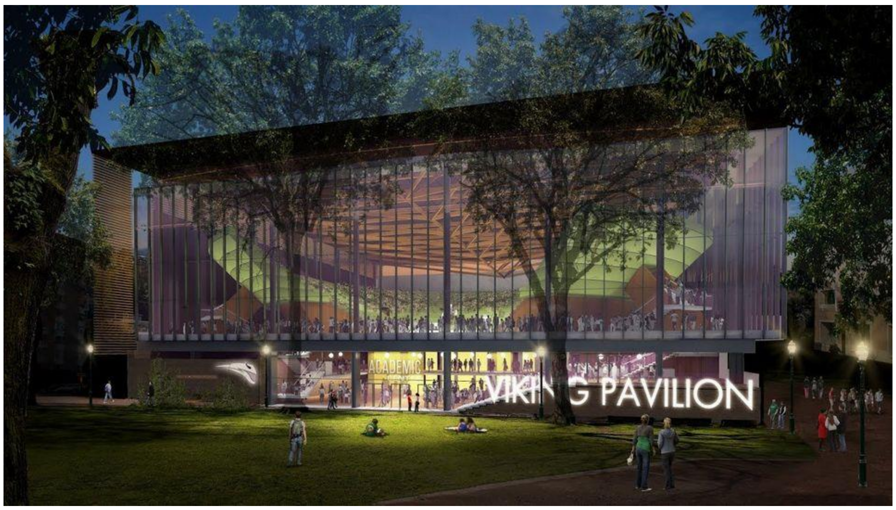
Figure 5.6 Potential food and retail cart pod site



4. Continuing the Neighborhood Life Corridor though the southern end of the Park Blocks can revitalize the South Park Blocks by tapping into their energy and potential as an outdoor venue and community gathering space. Part of what defines the SoMa neighborhood is the impermanent, fleeting quality of many events, stakeholders, and even locations. Neighborhood Life Corridors are particularly well suited to adapt to multiple, quickly evolving uses. Similar to the popular Portland Farmers Market model, the south end of the Park Blocks could host a series of regular rotating events such as outdoor concerts, local arts and crafts markets, cultural and food events, as well as community-led green infrastructure maintenance workshops. The workshops could potentially augment existing green infrastructure and welcoming features at the southern entrance to the neighborhood where SW Park Avenue crosses I-405 next to the Native American Student and Community Center. Potential partnerships include the Native American Student and Community Center, the Park Plaza Apartment residents, PSU food cart and pop-up incubator program, and local businesses and artists. The partners could work together to host a diversity of community events and address poor SOURCE scores. The Native American community center could also be used to host more cultural and community events and workshops.

Another huge opportunity exists in leveraging the upcoming renovation of the Peter W. Stott Recreation Center beginning January 2016; expected to be completed by spring 2018. (see figure 5.7).

Figure 5.7 Future Viking Pavilion



Once completed, the newly proposed "Viking Pavilion" will be a multi-purpose venue for PSU and OHSU, with seating for up to 5,000. The completely upgraded recreation center will host PSU sporting events, university functions, academic symposiums, concerts, seminars, conferences, commencements, and a variety of other events. It will also contain a student academic center, advising facilities, classrooms, athletic facilities, and gathering and study space. The future Viking Pavilion is a strong potential partner to anchor the Neighborhood Life Corridor in the south Park Blocks by drawing more people to that part of the neighborhood and providing them with new services and wonderful greenspace and green infrastructure. An important part in developing these spaces is continuing to involve stakeholders in the process and partnering with local businesses and organizations. The SOURCE tool provides a mechanism to scaffold this collaborative process.

Figure 5.8 Notice of public hearing

Neighborhood Life Corridor Zone 2 SoMa's Southeast Side

The SOURCE analysis produced another group of high scoring blocks clustered around the southern and eastern edges of SoMa (see figure 5.9), which will be referred to as Neighborhood Life Corridor zone 2.

Figure 5.9 Map of Neighborhood Life Corridor Zone 2

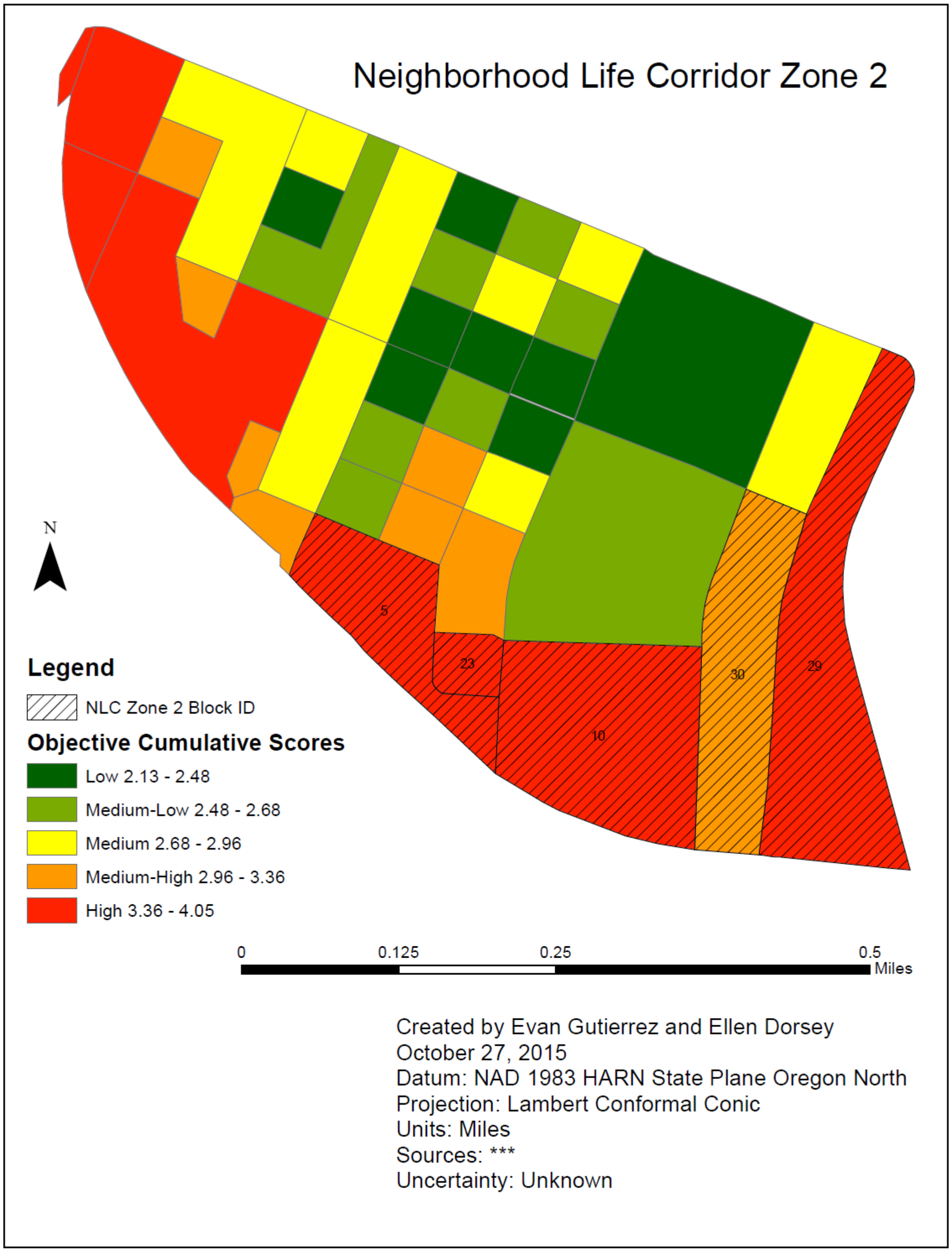


Table 5.6 NLC Zone 2 Criteria Composite Scores and Objective Cumulative Scores

Block ID	Environmental Criteria Composite Score	Economic Criteria Composite Score	Social Criteria Composite Score	Objective Cumulative Score
5	1.07	0.58	1.73	3.38
10	0.98	0.51	1.99	3.48
23	1.41	0.59	1.91	3.92
29	1.23	0.47	1.92	3.63
30	0.89	0.39	1.90	3.18
Average	1.12	0.51	1.89	3.52

Table 5.7 NLC Zone 2 Economic Indicators Individual Scores, Average Individual Scores, and Overall Average Weighted Individual Scores

Block ID	Income	Jobs	Business Diversity	Business Density	University Growth	Economic Composite Score	Objective Cumulative Score
5	1	0.4	0.38	0.99	0.09	0.58	3.38
10	0.25	0.6	0.38	0.99	0.36	0.51	3.48
23	1	0.3	0.57	0.66	0.45	0.59	3.92
29	0.25	0.1	0.57	1.32	0.09	0.47	3.63
30	0.25	0.6	0.38	0.66	0.09	0.39	3.18
average	0.55	0.39	0.46	0.92	0.22	0.51	3.52
overall average weighted individual score [x]	0.11	0.08	0.09	0.18	0.04		

[x] average * criteria weight

Table 5.8 NLC Zone 2 Environmental Indicators Individual Scores, Average Individual Scores, and Overall Average Weighted Individual Scores

Block ID	Green Space	Green Infrastructure	Mode Split	CO2 emissions	Environmental Composite Score	Objective Cumulative Score
5	1.56	1.6	0.17	0.12	1.07	3.38
10	1.17	1.28	0.34	0.36	0.98	3.48
23	1.95	1.28	0.85	0.48	1.41	3.92
29	1.95	1.28	0.51	0.24	1.23	3.63
30	1.17	1.28	0.17	0.24	0.89	3.18
average	1.56	1.34	0.41	0.29	1.12	3.52
overall average weighted individual score [x]	0.48	0.42	0.13	0.09		

[x] average * criteria weight

Table 5.9 NLC Zone 2 Social Indicators Individual Scores, Average Individual Scores, and Overall Average Weighted Individual Scores

Block ID	Complete Neighborhood	Multi-Modal Access	Public Safety	Public-Private Partnerships	Housing Cost Burden	Social Composite Score	Objective Cumulative Score
5	1.44	0.84	0.42	0.45	0.39	1.73	3.38
10	1.8	1.12	0.14	0.36	0.65	1.99	3.48
23	1.8	0.84	0.42	0.45	0.39	1.91	3.92
29	1.8	1.12	0.42	0.45	0.13	1.92	3.63
30	1.8	0.84	0.14	0.45	0.65	1.90	3.18
average	1.73	0.95	0.31	0.43	0.44	1.89	3.52
overall average weighted individual score [x]	0.85	0.47	0.15	0.21	0.22		

[x] average * criteria weight

Further analysis of the SOURCE composite scores (tables 5.6 5.9) showed that planning of this area should focus on development projects that target a mix of social (1.89 average composite score) and environmental (1.12 average composite score) outcomes. The highest overall average weighted individual scores within zone 2 were complete neighborhood index (.85), access to greenspace (.48), multi-modal access (.47), green infrastructure (.41), and housing cost burden (.22).

Given the considerations raised by the SOURCE analysis results as discussed above, I am recommending a suite of projects within Neighborhood Life Corridor zone 2 that focuses on building partnerships which increase greenspace, multi-modal access, green infrastructure, safety, commercial services, access to healthy food and lower housing cost burden to achieve a more complete neighborhood. Neighborhood Life Corridor zone 2 joins zone 1 on SW Jackson Street at Broadway where it continues east down to SW 5th Avenue. It then stagers half a bock south, to continue east down SW

Lincoln Street to SW Naito Parkway. The Neighborhood Life Corridor ends by connecting SW Naito Parkway with SW River Parkway, and the Riverplace/North Mcadam neighborhood through the currently undeveloped greenspace south of SW Lincoln Street between SW Naito Parkway and SW Harbor Drive. (See figure 5.9 for Neighborhood Life Corridor Zone 2 Map). Along that route, I recommend neighborhood life corridor projects to strengthen new and existing infrastructure, building partnerships and creating an active and sustainable corridor through the periphery of campus to address poor SOURCE scores.

1. The transition between Neighborhood Life Corridor zone 1 and 2 will focus on developing pedestrian and bicycle infrastructure. This will be focused on the crossings at the heavily trafficked SW Broadway, 6th, and 5th Avenues to better connect the western and eastern portions of campus along SW Jackson between Broadway and SW 5th to improve multimodal access scores. In addition to accessibility upgrades, this area should continue to increase the green infrastructure around the Jackson Street cul-de-sac between SW 5th and SW 6th. A green infrastructure project was recently started just south of the MAX light rail stop at SW Jackson and SW 6th Avenue that includes bio swales, permeable paving, and benches for gathering (figure 5.10). Additionally, there is a large solar panel array located on the block that could benefit from addition green infrastructure surrounding it (figure 5.11). Potential partnerships could include TriMet, Portland General Electric, and PSU’s art building across the street to design outdoor art exhibitions for the space

Figure 5.10 Green infrastructure cul-de-sac

Figure 5.11 Solar panel in need of green infrastructure

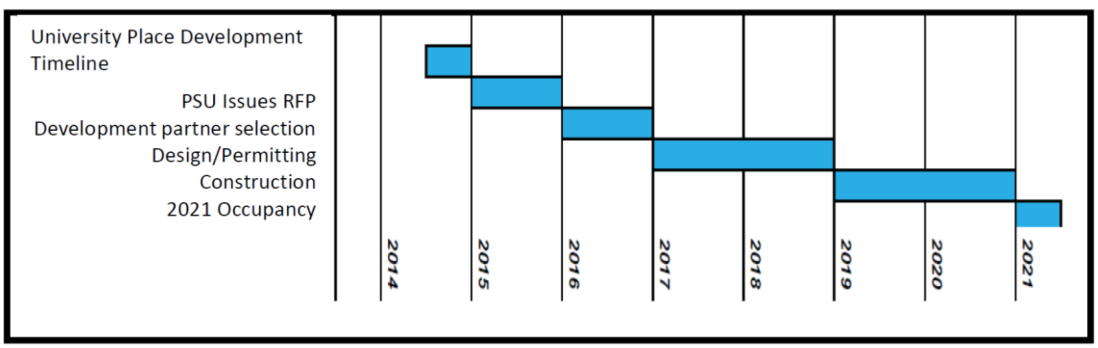
based on their shared interests in green infrastructure, active transit and complete neighborhoods.

2. The Neighborhood Life Corridor continues east down SW Lincoln Street, past the site of the current University Place Hotel and Conference Center, along the newly installed Tri-Met "Orange Line transit mall" as part of the city's MAX light rail system. The SOURCE analysis identified the block south of SW Lincoln between SW 4th and SW 1st as a top priority for hosting sustainable development projects due to poor scores in several indicators corresponding with high degrees of shared interest, including complete neighborhood index, multi-modal access, university growth, greenspace and green infrastructure, jobs per household, business density, public-private partnerships, and cost burdened homes. Large-scale, coordinated redevelopment efforts are needed in order to address the magnitude of the issues identified by the SOURCE analysis. A good format to conceptualize such complex and lofty redevelopment aspirations is a neighborhood Life Corridor that focuses on redeveloping University Place as a dense, mixed-use, multipurpose, community space, where private enterprises can be encouraged to locate in conjunction with higher education facilities in a "living-learning village." This could be supported by a partnership between PSU and Portland Development Commission, as well as other local partners including businesses and non-profits.

Since 2004, when PSU acquired the 3.86-acre property from Red Lion Inns, the university and city have been planning to redevelop the area within five to ten years. As of December, 2014, Portland State University and the Portland Development Commission officially entered into a deposition and development agreement for the redevelopment of multiple properties within the University District, including the

University Place site as part of the amended North Mcadam Urban Renewal Area funded by tax increment financing (TIF). The University Place project is very much in its infancy, as the initial formal request for proposals to redevelop the area only just recently closed as of May 4, 2015. Furthermore, the development partner selection process will occur throughout 2016, before the design and permitting phase starting in 2017, and the eventual completion in 2021 (see figure 5.10 for timeline).

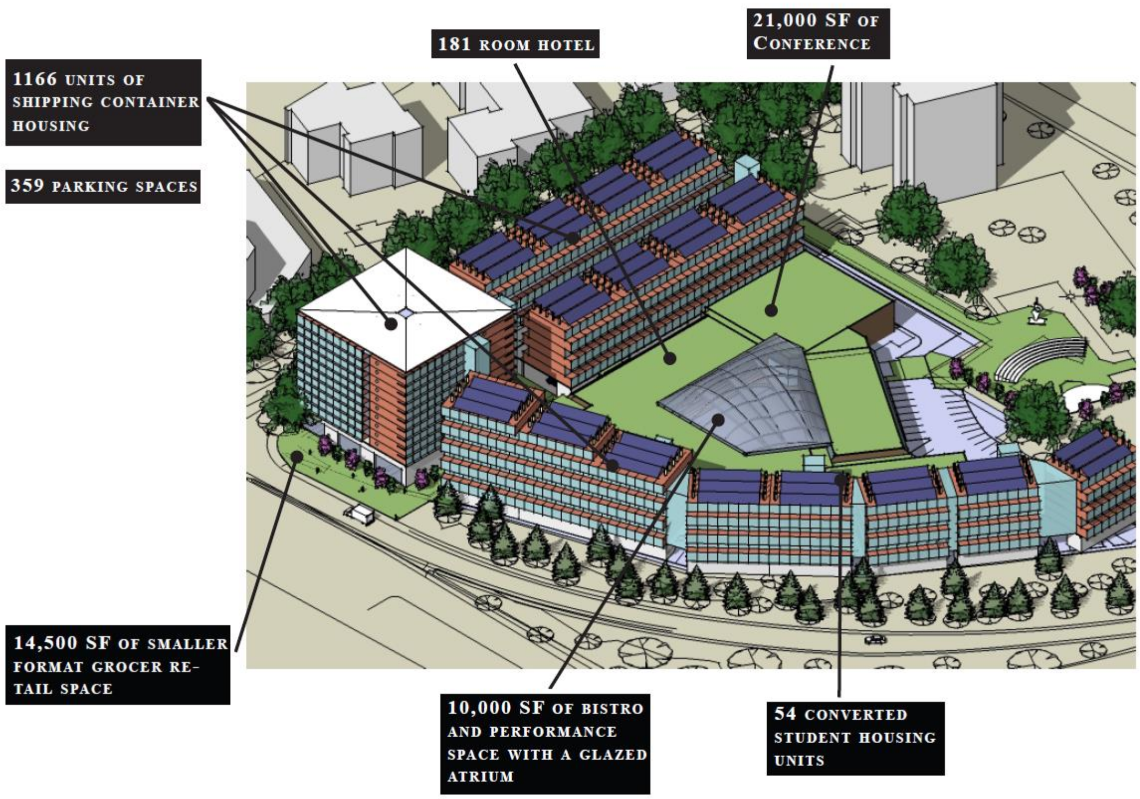
Figure 5.12 Proposed Timeline for the development of University Place (Portland Development Commission, 2014)



By partnering with Portland Development Commission, PSU wishes to attract development partners interested in a dense, mixed use development of the site that meets PSU's priorities and supports the growth of PSU and the University District, pursuant to the objectives outlined in the University District Framework Plan and aligning with City and PDC's Urban Renewal Plan and Comprehensive Plan policy priorities (Portland Development Commission, 2014). The University Place Project aims to provide a higher density of mixed uses, including new housing and commercial uses adjacent to the Portland-Milwaukie light rail transit center. The University Place project aims to create taxable real estate for the purposes of serving shared interests that will help support the goals of the SoMa EcoDistrict and the North Macadam Urban Renewal Area.

In 2007, the Portland State University Center for Real Estate Development Workshop produced a sustainable development plan for the University Place site. Led by Professor Will Macht, researchers formed a real estate development team and produced an original development plan, including the development concept, the market analysis, the conceptual design, economic analysis, capital and operations budget, and management plan for University Place. The development team envisioned what could be the cornerstone of the SoMa Neighborhood Life Corridor as a living-learning village at the current University Place site. Their vision completely redevelops the block by increasing the density of development to include more housing, commercial, and institution services (See figure 5.11 for design concept). The development team's visionary design included 1166 high efficiency, affordable housing units, retail, commercial, and grocery space, a 181 room hotel, and a 21,000 square foot conference center with performance atrium and restaurant bistro. In addition, the plan incorporated accessible greenspaces, green infrastructure, and multi-modal transit options (Macht et al., 2007). Such a high-performing living-learning village is exactly the type of development project and partnership model that should be considered by the PSU Portland Development Commission in their deposition and development agreement process to anchor the SoMa Neighborhood Life Corridor. These are exactly the types of sustainable development projects supported by complete neighborhood, multimodal assess, business density and diversity, green infrastructure, and housing cost burden SOURCE scores.

Figure 5.13 University Place design concept (Macht et al., 2007).



3. The Neighborhood Life Corridor continues east on SW Lincoln where it meets the next major project zone at the greenspace between SW Naito and SW Harbor Drive, immediately south of SW Lincoln, extending to the International School on SW Sherman. By ending the Neighborhood Life Corridor there, this under-developed greenspace could serve as a small neighborhood park and improve the connection with the North Mcadam neighborhood and within SoMa. Additionally, at this location, there are multiple opportunities for partnerships with nearby non-profits.

Currently, the south end of SW Naito Parkway feels disconnected and undeveloped in comparison to the rest of the SoMa Neighborhood, with multiple un-developed green spaces. The largest of these greenspaces (figure 5.14) immediately south of the SW Harbor Viaduct could anchor the eastern edge of the SoMa Neighborhood Life Corridor through the creation of an official park, complete with open gathering spaces, recreation opportunities, upgraded pedestrian and bicycle infrastructure, and green infrastructure. Recently, while documenting the site in question, I noted the presence of multiple homeless camps scattered throughout the greenspace

Figure 5.14 Underdeveloped greenspace

directly adjacent to a K-5 school, and I was even physically threatened by one of its members. Also, I noted a substandard quality of pedestrian infrastructure, especially regarding the footpath between SW Naito and SW Harbor (see figure 5.15).

Figure 5.15 Opportunity to improve active transportation infrastructure

The site could be transformed into a vibrant neighborhood park through a partnership between the city of Portland and thee immediately adjacent local non-profits including SOLVE Oregon, the Boy Scouts of America, and the International School K-5 elementary school by focusing on poor SOURCE scores. With a mission of brining Oregonians together to improve the environment and build a legacy of stewardship, SOLVE mobilizes over 35,000 volunteers and organizes over 1,000 cleanup and restoration projects throughout Oregon. Surely, SOLVE can partner with the city and other local organizations like CH2mHill engineering firm, TriMet, or ZGF Architects to redevelop this greenspace into a vibrant gathering, recreation, and high-performing urban ecosystem informed by SOURCE scores.

This greenspace also holds potential as a gathering and recreation space with amazing public-transit accessibility. One example of an appropriate use of the space would be to host a small public transit-oriented music festival, similar to the Streetcar Mobile Music Festival. The Streetcar Mobile Music Festival was a partnership between the City of Portland, Portland Bureau of Transportation, Globe Sherpa, Portland Streetcar, TriMet, Ch2mHill, ZGF Architects, New Rail Visionaries, and Advancing Women in Transportation. The event brought together 15 local bands to celebrate public transportation in Portland in a new and exciting way. With the recent addition of the Orange MAX line a block and a half away from the greenspace in question, the potential to host a MAX mobile music festival is high. Hosting temporary gatherings like this can add to the daily benefits of a well-planned, accessible, greenspace and green infrastructure, and also fits with the goals of the Neighborhood Life Corridor.

Neighborhood Life Corridor Recap

The above mentioned projects within Neighborhood Life Corridor zones 1 and 2 serve as an introduction to the concept of designing Neighborhood Life Corridors as a sustainable urban renewal tool. In addition to the major projects mentioned above, the entire Neighborhood Life Corridor would implement as many green streets and multi-functional green infrastructures as possible along the corridor to create a sense of continuity, as well as to address performance goals. Of course, the exact details of the SoMa Neighborhood Life Corridor require further exploration and design consideration before implementation can occur. SOURCE suitability maps should be used to seed further discussion and selection of project alternatives. Another iteration of GIS-AHP could be run with additional stakeholders to systematically select between these types of well-defined project alternatives.

The basic tenants of the Neighborhood Life Corridor concept have been illustrated with the SoMa Neighborhood Life Corridor examples I have described above. However, I would like to expand on the potential of the Neighborhood Life Corridor concept. In addition to the more tangible sustainable development projects I mentioned, Neighborhood Life Corridors have the potential to effect some of the more abstract projects that occur throughout the district, to address SOURCE scores. Neighborhood Life Corridors are great venues to raise awareness about a diversity of district-wide efforts, for example, signage, information, and opportunities to participate in the existing efforts such as the kilowatt-crackdown as well as to form similar efforts to voluntarily reduce car trips, water use, heat use, or even weight. Examples of similar partnerships are Seoul, Korea’s “Eco-Milage System” voluntary energy reduction program or Dubai, United Arab Emirates’ “Your Child’s Weight in Gold” voluntary family weight reduction campaign. Neighborhoods Life Corridor also can serve as venues for local organizations, businesses, and agencies to interact with and serve the greater community. District-wide sustainable development project focused on social criteria, such as local businesses, local food production, and community sharing programs can advertise and recruit within Neighborhood Life Corridors to build awareness. In short, Neighborhood Life Corridors connect people and places, foster healthy ecosystems, lifestyles, local businesses, and diverse partnerships, as well as direct stormwater and solar-energy by integrating a variety of multi-functional green infrastructures within public and private spaces. Neighborhood Life Corridors as designed based on the results of the SOURCE analysis.

Discussion of Indicator Quality

The analysis of indicator quality based on the ability to capture neighborhood-scale sustainably performance as measured by the Coalition for a Livable Future's checklist produced mixed results. As a group, economic indicators were the highest quality for neighborhood-scale sustainability assessment. This does not surprise me due to the availability of comprehensive census data. However, even the highest quality economic indicators have lower accuracy at small scales (block-level). Overall, Indicators of income distribution, jobs per household, and business diversity and density are particularly robust at the neighborhood scale. The one exception was an indicator of university growth. This could be due to differences in university record keeping versus the dynamic nature of academic programs. As a group, social indicator were the lowest quality for neighborhood-scale sustainability assessment. This was primarily due to an extremely low quality score for an indicator of public involvement as measured by the number of public-private partnerships. While extremely relevant to the neighborhood scale, information regarding public-private partnerships is often difficult to uncover. The remaining social indicators, complete neighborhood index, multimodal access, public safety, and housing cost burden were robust indicators of neighborhood-scale sustainability performance due to their extremely developed datasets. Similarly, the environmental indicators of access to greenspace, access to green infrastructure, and mode split proved to be robust at the neighborhood scale due to extensive datasets. However, CO2 reduction as measured by average natural gas consumption had low quality scores due to privacy issues related to public utilities.

Chapter 6 Conclusions

This chapter restates the basic conclusions I have drawn about the extent to which a spatial AHP method (SOURCE) can optimize locations for the implementation of sustainable development projects through public-private partnerships at the neighborhood scale, as well as about the capacity of existing urban sustainability indicators to capture neighborhood sustainability performance. Then, I discuss limitations of the study and provide insight for future research directions. Finally, I consider broader implications and discuss potential applications of GIS-AHP in collaborative neighborhood-scale sustainability assessment and planning.

Summary of Findings

Integration of AHP and GIS for collaborative neighborhood-scale sustainability assessment and planning has allowed me to draw three conclusions. First, the present application of a spatial AHP (SOURCE) allowed for the identification of competing priorities of the entire spectrum of stakeholders from diverse data types and the location of and potential design of sustainable development projects. Ultimately, a tangible suitability map of areas (blocks) represents the highest priority sites to implement sustainable development projects at the neighborhood scale based on consensual public and private values as well as a need to increase sustainability performance. GIS-AHP effectively supported an extremely complex decision making process by collaboratively and systematically defining a decision problem and producing tangible maps of priority locations to focus sustainable development efforts. This case study also stimulated the concept of designing Neighborhood Life Corridors, suites of sustainable development projects, to meet a neighborhood's concurrent and dynamic needs. GIS-AHP was instrumental in locating and designing Neighborhood Life Corridors in a systematic, collaborative, and equitable manner.

Second, using AHP within a GIS environment appears to be a helpful tool in collaborative neighborhood sustainability assessment based on its capabilities to deal with multiple conflicting criteria, spatially optimize sustainable development projects given the preferences of stakeholders, generate maps and design considerations, identify potential partnerships, and serve as a discussion tool. Thus, SOURCE fills a gap in the collaborative neighborhood-scale sustainability assessment toolbox. It is important to note that the final cumulative score map is not meant to be the only solution, but rather the most suitable according to a particular set of value judgments, or weights. The AHP and cumulative suitability score map are useful tools for defining problems and continuing negotiations between stakeholders, and are adaptable to a diversity of contexts.

Third, development of specific neighborhood-scale datasets is needed for a more certain implementation of GIS-AHP techniques in the assessment and management of neighborhood-scale sustainable development. Specifically, indicator quality analysis indicates a need for development of neighborhood-scale datasets that can serve as indicators of university growth, utilities usages and CO_2 emissions, as well as public-private partnership and involvement opportunities. The certainty of the SOURCE analysis is directly influenced by the quality of indicators used. The mixed results of neighborhood-scale sustainability indicator quality could be improved by a variety of factors. Addressing shortcomings in each of the seven indicator quality assessment categories is a concrete starting point to address indicator quality as well as uncertainty. Generally, quality could be improved through expansion of existing datasets and increased accessibility. For example, increased utility data accessibility could be achieved through implementation of real-time web-based applications such as energy use dashboards.

Limitations of the Study and Direction for Future Study

Certainly there are limitations of this study that need to be acknowledged. In general, these limitations relate to the research design and the quality of indicators used for analysis. I will reflect on both of these limitations and offer suggestions for future research in the following sections.

Research Design Limitations

In terms of research design, one limitation of this study is that the AHP was modified using secondary sources and data from convenience samples. While the sample of secondary sources was representative of the target stakeholder groups I was interested in studying, the AHP process had to be modified through the use of qualitative coding of the secondary sources to elucidate the hierarchical structure of the decision problem and assign relative priority values to decision elements. In order to complete this process, I had to choose which documents to code from a very small selection of plans, reports, workshop summaries, surveys, and charrettes directly related to the study area. Ideally, I would have liked to have organized stakeholders in a series of AHP workshops to engage them more directly, but without funding, I made the best of the available data, which turned out to be extremely detailed and relevant to the SoMa EcoDistrict.

In future research situations, when a similarly modified AHP is required, researchers could follow the tradition of scenario planning in urban planning and environmental resource management to compare various priority structures of decision hierarchies. For example, they could propose a hierarchy of a decision problem based on qualitative coding of secondary data, just like my study. After the initial relative priority weights are assigned, more conservative and or more liberal scenarios could be tested using different priority structures on the same decision hierarchy. This would allow for comparison of the effects that different priority structures have on the outcome of the decision hierarchy and recommended development projects. With or without the opportunity to collect primary data, there is value in dissecting the structure of a decision problem to distill indicator priorities and recommend development projects in a systematic manner.

A limitation related to the data analysis procedure was the validity of qualitative coding of such large amounts of data by a single individual and validity of intercoder reliability testing performed by moderately trained coders. Since I was the sole coder of the data, there is the possibility of subjectivity and other errors affecting the themes identified in the documents, the structure of the decision hierarchies created, and the relative priority weights assigned to decision elements. While employing expertly trained coders and establishing a higher rate of intercoder reliability is a more desirable method, due to lack of resources, employing a team of expert coders was not feasible. To mitigate coding errors and to aid in reproducibility, it is important to note that I followed a detailed set of coding guidelines made available in the methods section, as well as to the two other coders trained to test selections of the data.

Indicator Quality Limitations

The quality of the SOURCE assessment is directly limited by the quality of the indicators used as calculated by a function of the collection, processing, age, resolution, accuracy, extent, and consistency of the spatial datasets. The analysis is only as good as the data used to calculate the results. Running the assessment of indicator quality developed by non-profit Coalition for a Livable Future on the set of indicators used in the SOURCE analysis showed that most spatial datasets used were robust indicators for the neighborhood-scale assessment, while a few showed considerable room for improvement. The need for a more reliable neighborhood-scale spatial dataset regarding university growth, C02 reduction, and public-private partnerships indicators is evident from poor quality assessment scores.

Effectively capturing the concept of university growth with a single spatial indicator was particularly difficult due to the scale of analysis (block) versus the scales of available data (university or building), as well as the dynamics of academic program space needs and allocation. Portland State University keeps meticulous records of

Table 6.1 University space needs (Portland State University, 2010b)

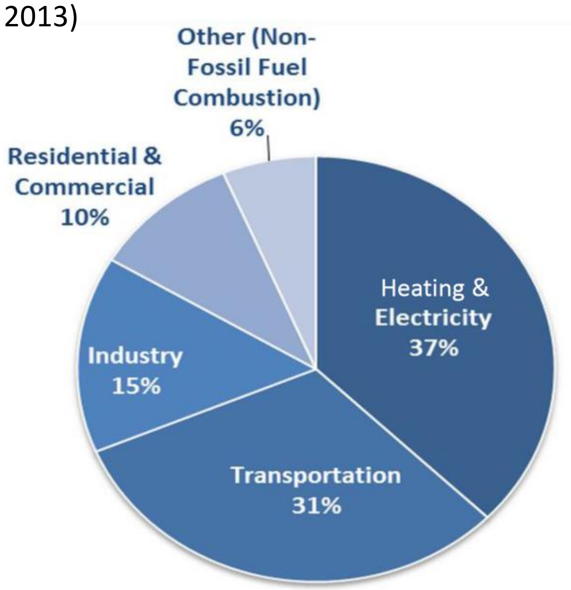
HEGIS CODE	USE	EXISTING FLOOR AREA (NASF)	TOTAL SPACE NEED (NASF)	SURPLUS/ (SHORTFALL) (NASF)
100	Classroom Space	155,841	173,066	(17,224)
200	Laboratory Space	134,360	124,755	9,605
250	Research Laboratory	128,705	160,881	(32,176)
300	Office Space	343,273	403,377	(60,104)
400	Library. Study, Media Space	102,569	171,232	(68,663)
500	Recreation & Athletics	91,177	137,930	(46,773)
600	General Use	170,457	409,295	(238,838)
700	Support Space	97,069	79,027	18,042
800	Health Space	3,723	17,225	(13,502)
900	Residential Space	464,235	443,925	20,130
		1,691,409	2,120,712	(429,503)

available building space and space needs at multiple scales, mainly on building-scale or university-scale (see table 6.1). However, compared to the scales of the data presented by PSU, the reality of academic program space dynamics made it impossible to track the growth in space needs of individual buildings or departments, as departments often occupy more than one building and change the use of space regularly. While the amount of square footage, assignable space and other details were available by building, the usage of building space by department was simply not accounted for, therefore making it impossible to measure how much space individual university departments were occupying, as well as individual building or department space needs.

After numerous discussions with various PSU staff, I spoke with Jason Franklin, director of campus planning and design, and he pointed me in another direction. Essential to the 2010 University District Framework Plan was a fundamental restructuring of how the campus should develop. While previous models focused on building a low density, sprawling, more exclusively university district, the 2010 framework plan emphasized a dense, compact, mixed-use campus development strategy to meet sustainability goals, attract more diverse partners, and increase local tax revenue. In light of these goals, I was inspired to create an indicator of university growth based on a ratio of the building footprint to the amount of assignable space that identified these low density, sprawling, university owned buildings. In the case of the University Place site, there exists a great potential to transform a low density, university-owned portion of the neighborhood into the type of sustainable urban renewal partnership the University District Framework Plan and others suggest.

Although CO2 reduction has long been the cornerstone of many sustainability indicator regimes, I found it particularly difficult to operationalize at the neighborhood scale without additional financial support. According to the Environmental Protection Agency, the primary greenhouse gas emitted through human activities, carbon dioxide (CO_2), results principally from the combustion of fossil fuels for electricity and heating as well as transportation (see figure 6.1). Given that the study area lacks major production industries, it is safe to assume its share of CO_2 resulting from electricity, heating, and transportation is even higher than national averages. Since transportation emissions were indirectly measured through mode split and multi-modal access, I decided to focus on the largest component of CO_2 generation-electricity and heat production from public utilities. The two public utilities responsible for providing electricity and heat within the study area are Portland General Electric and Northwest Natural Gas. Due to privacy issues surrounding public utility data, collecting building-level or even block-level energy profiles was impossible without institutional sanction and the permission of utility customers. Through correspondence with Northwest Natural Gas, I was able to piece together annual average natural gas consumption by block, along with a PSU utility spatial dataset. While perhaps not the most accurate or easily accessible, average gas consumption by block was preferable compared to the logistical and financial feasibility of calculating an accurate measure of the neighborhood's total CO_2 emissions. With cooperation of public utilities and utility customers, a higher quality spatial dataset could be created for a more realistic indicator of neighborhood-scale CO_2 emissions.

Figure 6.1 US Carbon Dioxide Emissions by source (Environmental Protection Agency, 2013)



A high need for establishing a spatial dataset of public-private partnerships and involvement in the study area and Portland Metro region was a primary finding of the indicator quality assessment. The partnership model has become ubiquitous in several aspects of sustainable urban renewal, although there is no formal public database for keeping track of such interactions and collaborations. Instead, currently, each individual project and/or organization maintains a list of partners that is not sufficiently publicized. Portland State University's Office of Strategic Partnerships was established in 2011 to elevate the university's role as a civic and economic partner throughout the metro region. In just a few years, the Office of Strategic Partnerships has led and managed key partnerships with companies and organizations including Intel, Portland General Electric, Oregon Health and Science University, Technology Association of Oregon, Oregon Inc., Greater Portland Inc., City of Portland, Port of Portland, Multnomah County, Metro, and Oregon Museum of Science and Industry. The office of Strategic Partnership also coordinates university-wide economic development programs including the PSU center for Entrepreneurship, the PSU Business Accelerator, and industry cluster initiatives. The Office of Strategic Partnerships facilitates clear communication, information sharing, and assessment of partnership goals and agendas through the PSU Partnership council. Such a resource should curate a more complete spatial database of public-private partnerships and involvement, but at least it is a start in the right direction.

In general, the quality of neighborhood-scale sustainability indicators has significant room for improvement to catch up with the quality of broader scale sustainability indicators. Much of the data relied on US Census and American Community Survey data, which are notorious for high levels of uncertainly at small scales, but none-the-less remain the industry standard source for several social and economic indicators including income distribution, jobs per household, mode split, and housing cost burden. Also, measuring greenspace and green infrastructure accurately at high resolutions can be extremely difficult. Most land use datasets rely on national-scale classifications, which are usually based on 30-meter resolution, resulting in the entire study area simply designated as “urban.” The City of Portland maintains a higher resolution (3-meter) dataset, which is a more accurate representation of the city’s greenspace and green infrastructure than 30-meter land use classification data would have one believe. Not all cities are fortunate enough to have high resolution land use classification databases along with other specialized spatial data bases where the scale of landscape classification variation is much higher than non-urbanized areas. I have come to appreciate, through this exercise of neighborhood-scale sustainability assessment, how the quality of indicators drives the assessment process and overall interpretation of results.

Directions for Future Research and Broader Implications

Given the timing of multiple planning efforts (Comprehensive Plan Update, West Quadrant Plan, and the Education and Mcadam Urban Renewal Plans), the results from the SOURCE analysis should immediately be used to create more detailed SoMa

Neighborhood Life Corridor design plans and solidify concrete partnerships for Neighborhood Life Corridor development in the SoMa EcoDistrict. The Portland Development Commission or Portland State University could take the lead in spearheading a variety of initiatives to entice local business and stakeholders to engage in collaborative efforts. Additionally, the SOURCE analysis should be replicated in the study area using alternative indicator weighting scenarios. By taking a scenario planning approach, future researchers could model more conservative or more liberal weighting of the same decision hierarchy. These alternative scenarios could also be used along with the original project designs to seed discussions about project selection alternatives. Specifically, the AHP could be repeated with the goal of project selection instead of site selection. Project selection differs from site selection by adding another layer to the decision hierarchy that represents alternative project options. Decision makers of project selection problems weight project alternatives with regard to indicator and criteria weights. Using project design ideas as concrete, tangible, and measureable discussion points may have a positive impact on the pairwise comparison process of sustainability project alternatives. Eventually, the SOURCE analysis process should be replicated using higher quality indicators in another location, engaging with actual stakeholders and experts in the AHP, instead of coding secondary data.

Given the need for collaborative neighborhood-scale sustainability assessment tools in urban planning, this study provides broader implications for sustainability decision support at multiple scales. At the neighborhood scale, SOURCE can be used to justify the selection of projects and make difficult funding allocation decisions- a pressing issue the Portland Development Commission is currently facing. Urban Renewal Area (URA) tax increment financing (TIF) is the source of Portland Development Commission project funds and is awarded to the highest priority projects within the urban renewal area. Currently, the priority of such projects is determined by the project's ability to generate new TIF revenue within the URA. This process of assessing priority to assign TIF to projects within the study area could be improved by expanding the assessment of priority to include the concepts embodied by SOURCE. By integrating these concepts into an evaluation of priority, not only is taxable revenue considered, but also issues of sustainability performance, shared values, and equity. The integration of GIS-AHP allows decision-makers to better understand the performance of key neighborhood sustainability indicators more clearly, given the values of diverse stakeholders and to identify areas for public-private partnerships for sustainable development. The integration of GIS and AHP provides a mechanism from which complex issues can be thoroughly and equitably explored and prioritized to inform a sustainable land use decision-making process.

From a comprehensive planning perspective, this study supports the validity of a neighborhood-scale approach to reach citywide goals. This study demonstrates how a neighborhood approach to urban planning of cities is capable of optimizing the complexities of sustainability given competing values. SOURCE meets a critical need for a tool capable of optimizing multiple criteria necessary to meet the dynamic goals of neighborhood, city, and metro-area sustainability. The integration of GIS and AHP provides a mechanism from which complex issues can be thoroughly and equitably explored to inform a sustainable land decision-making process.

This study also has implications for sustainability assessment and planning at broader scales. In general, sustainability is thought to be primarily based on environmental criteria, but this study demonstrates the importance of considering other dimensions as well. AHP is a powerful tool for solving complex problems with multiple objectives. It is useful to hierarchically model a large, multi-criteria system, calculate the relative priority of decision elements through pairwise comparison, and compare elements through comprehensive scores. GIS can be used to manage and analyze large amounts of spatial data from a variety of sources to reveal the most suitable sites for project development. Together, GIS-AHP can optimize the entire spectrum of sustainability criteria (environmental, economic, and social). The decision-making process modeled by SOURCE demonstrates how GIS combined with AHP can optimize complex spatial data using a diversity of data types and sources. This results in a more inclusive and flexible analysis method that is capable of handling multiple criteria, and simple to understand and to communicate given the scope and complexity of neighborhood and citywide sustainability. To stop sustainable development from becoming a meaningless buzzword that divides groups, it must be used to unite disparate interests in the stewardship of common interests.

Final Thoughts

Cities and neighborhoods struggle to select and site appropriate sustainable urban renewal projects due to the difficulties in measuring available resources as well as divergent stakeholder values. This paper supports the use of GIS-AHP to facilitate such decision-making situations. By focusing on the structure of the decision problem and weights of individual decision elements, AHP is an effective tool to provide a tangible solution for decision makers based on a clear definition of the problem and creation of a series of maps. By integrating GIS and AHP, relative importance of the sustainable development objective, criteria, and indicators can be identified. The tangible map of cumulative SOURCE suitability scores is useful for assessing the priority and impact of potential sustainable development projects.

This investigation also supports the ability of GIS-AHP to identify public-private sustainability partnerships at the neighborhood scale. This finding complements the research that sustainability optimization frameworks for GIS-AHP based assessment have shown to support sustainable development and facilitate stakeholder interaction in the planning process at larger scales. It remains to be further explored whether or not stakeholders' joint efforts and pooling of resources during AHP-based collaborative planning tasks can indeed positively impact their collaborative development beyond the identification of sustainable development projects. Given the complexity and cost of higher density and mixed use development projects, planning and zoning alone often fails to stimulate the private investments needed to build dynamic and accessible communities. SOURCE can help to overcome these barriers by identifying potential investments in public private partnerships to build projects in areas where the market is not yet strong enough to support these higher cost development forms. Strategies such as land acquisition, working with developers on public-private partnership projects, site planning and technical assistance to local jurisdictions, and identifying and removing barriers to compact development need to be explored using urban renewal area funding and other local agencies to implement neighborhood life corridors.

The current study has extended the body of empirical research on GIS-AHP based neighborhood scale sustainability assessment. Primarily, that GIS-AHP can contribute to the identification of sustainable development projects and partnerships within a collaborative neighborhood-scale urban renewal framework. This case study supports further implementation of GIS-AHP as a tool for collaborative neighborhood-scale sustainability assessment and planning, as well as further development of certain sustainability indicators at the neighborhood scale. In this instance, GIS-AHP was instrumental in overcoming ambiguities associated with operationalizing neighborhood-scale sustainability by providing systematic and equitable assessment to support collaborative decision-making of complex spatial problems involving diverse stakeholders and data types.

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Appendix A SoMa Research Group SoMa EcoDistrict in-depth characterization

SoMa EcoDistrict
Energy Summary

Energy Demand

Development	2010	2015
Existing Commercial	297,200	297,200
Existing Residential	153,875	153,875
Existing Industrial	0	0
Existing Open Space	137	137
Existing ROW	424	424
New Commercial	0	58,696
New Residential	0	29,348
New Industrial	0	0
New Open Space	0	0
New ROW	0	0
Total	**451,636**	**539,680**
COM	**297,200**	**355,896**
RES	**153,875**	**183,222**
IND	**0**	**0**
Open Space	**137**	**137**
ROW	**424**	**424**
Existing	451,636	451,636
New	0	88,044

Carbon Emissions

Development	2010	2015
Existing Commercial	45,764	45,764
Existing Residential	23,694	23,694
Existing Industrial	0	0
Existing Open Space	28	28
Existing ROW	87	87
New Commercial	0	9,038
New Residential	0	4,519
New Industrial	0	0
New Open Space	0	0
New ROW	0	0
Total	**69,573**	**83,130**
COM	**45,764**	**54,802**
RES	**23,694**	**28,213**
IND	**0**	**0**
Open Space	**28**	**28**
ROW	**87**	**87**
Existing	69,573	69,573
New	0	13,557

Energy Costs

Development	2010	2015
Existing Commercial	$5,579,343	$5,579,343
Existing Residential	$3,206,128	$3,206,128
Existing Industrial	$0	$0
Existing Open Space	$2,418	$2,418
Existing ROW	$7,449	$7,449
New Commercial	$0	$1,101,897
New Residential	$0	$611,492
New Industrial	$0	$0
New Open Space	$0	$0
New ROW	$0	$0
Total	**$8,795,337**	**$10,508,726**
COM	**$5,579,343**	**$6,681,240**
RES	**$3,206,128**	**$3,817,619**
IND	**$0**	**$0**
Open Space	**$2,418**	**$2,418**
ROW	**$7,449**	**$7,449**
Existing	$8,795,337	$8,795,337
New	$0	$1,713,389

Note:
Note: Note rate escalation assumed for electricity or natural gas.

SoMa EcoDistrict
Water Assessment

Water Demand

Development	2010	2015
Existing Commercial	85,321,666	85,321,666
Existing Residential	44,175,061	44,175,061
Existing Industrial	0	0
Existing Open Space	0	0
Existing ROW	0	0
New Commercial	0	16,850,673
New Residential	0	8,425,327
New Industrial	0	0
New Open Space	0	0
New ROW	0	0
Total	**129,496,727**	**154,772,727**
COM	**85,321,666**	**102,172,338**
RES	**44,175,061**	**52,600,388**
IND	**0**	**0**
Open Space	**0**	**0**
ROW	**0**	**0**
	2010	**2015**
Existing	129,496,727	129,496,727
New	0	25,276,000

Carbon Emissions

Development	2010	2015
Existing Commercial	0	0
Existing Residential	0	0
Existing Industrial	0	0
Existing Open Space	0	0
Existing ROW	0	0
New Commercial	0	0
New Residential	0	0
New Industrial	0	0
New Open Space	0	0
New ROW	0	0
Total	**0**	**0**
Total Commercial	**0**	**0**
Total Residential	**0**	**0**
Total Industrial	**0**	**0**
Total Open Space	**0**	**0**
Total ROW	**0**	**0**
Existing	0	0
New	0	0

Water Costs

Development	2010	2015
Existing Commercial	$2,633,027	$2,633,027
Existing Residential	$1,363,242	$1,363,242
Existing Industrial	$0	$0
Existing Open Space	$0	$0
Existing ROW	$0	$0
New Commercial	$0	$520,012
New Residential	$0	$260,006
New Industrial	$0	$0
New Open Space	$0	$0
New ROW	$0	$0
Total	**$3,996,269**	**$4,776,286**
Total Commercial	**$2,633,027**	**$3,153,038**
Total Residential	**$1,363,242**	**$1,623,248**
Total Industrial	**$0**	**$0**
Total Open Space	**$0**	**$0**
Total ROW	**$0**	**$0**
Existing	$3,996,269	$3,996,269
New	$0	$780,017

Note:
No escalation assumed for water, sanitary and stormwater rates.

Development Assumptions

Land Use Type	Ownership	Area Acre	Area %	2010 SF	2010 %	2015 SF	2015 %
Existing Development							
Commercial	Private	63.0	36%	4,793,352	66%	4,793,352	66%
Residential	Private	16.0	9%	2,481,745	34%	2,481,745	34%
Industrial	Private	0.0	0%	0	0%	0	0%
Open Space	Public	37.0	21%	0	0%	0	0%
Right of Way	Public	57.0	33%	0	0%	0	0%
Total		**173.0**	**100%**	**7,275,097**	**100%**	**7,275,097**	**100%**
New Development							
Commercial	Private	63.0	36%	0	0%	946,667	67%
Residential	Private	16.0	9%	0	0%	473,333	33%
Industrial	Private	0.0	0%	0	0%	0	0%
Open Space	Public	37.0	21%	0	0%	0	0%
Right of Way	Public	57.0	33%	0	0%	0	0%
Total		**173.0**	**100%**	**0**	**0%**	**1,420,000**	**100%**
Development Summary							
Commercial	Private	63.0	36%	4,793,352	66%	5,740,019	66%
Residential	Private	16.0	9%	2,481,745	34%	2,955,078	34%
Industrial	Private	0.0	0%	0	0%	0	0%
Open Space	Public	37.0	21%	0	0%	0	0%
Right of Way	Private	57.0	33%	0	0%	0	0%
Total		**173.0**	**100%**	**7,275,097**	**100%**	**8,695,097**	**100%**

Notes:
1. Existing development assumptions based on Metro RLIS and PSU data.
2. Future development assumptions based on PSU Framework Plan.

Table 1: Comparison of Canopy, Non-Canopy Vegetation, and Impervious Surface as a Percentage of Total Landscape between the four study areas (NoMa, SoMa, Downtown and Portland)

Area Name	Total Area (sqft)	Canopy % of landscape	Non-canopy veg % of landscape	Impervious surface % of landscape
SoMa	7,525,093	28.3%	5.3%	62.8%
NoMa	16,206,228	15.2%	5.3%	80.5%
Downtown	23,731,321	19.3%	5.3%	74.9%
Portland*	2,919,431,923	32.2%	23.9%	43.4%

*Portland statistics include whole city minus the Downtown area (i.e. SoMa and NoMa).
Data Source: LIDAR data (remote sensing), Metro, 2007

Table 2: Comparison of Population Size, Racial Composition, Income Levels and Household Status between 4 Comparison Study Areas (SoMa, NoMa, Downtown and Portland)

Population Group	Population	RACE (%) White	RACE (%) Hispanic	RACE (%) Black Pop	RACE (%) Asian	INCOME (IN 2000 DOLLARS) Median household income	INCOME (IN 2000 DOLLARS) Per capita income	HOUSEHOLD STATUS % Households renter occupied
SoMa residents	3,590	79	4	3	12	$22,170	$22,630	91
NoMa residents	6,360	78	6	8	5	$14,380	$13,280	96
Downtown residents	9,950	78	5	6	8	$17,190	$17,630	94
Portland*residents	452,821	78	6	7	6	$39,850	$28,480	51

*Portland statistics include whole city minus the Downtown area (i.e. SoMa and NoMa).
Data Source: U.S. Census 2000

Table 3: Comparison of Gender Composition, Age Composition and Educational Attainment between 4 comparison Study Areas (SoMa, NoMa, Downtown and Portland)

		GENDER (%)		AGE GROUP (%)				HIGHEST LEVEL OF EDUCATION (%)				
Population Group	Population	Male	Female	17 & under	18-44	45-60	61+	High School	Some College	Assoc. Degree	Bachelor's Degree	Graduate Degree +
SoMa residents	3,590	51	49	3	59	16	23	17	25	15	30	37
NoMa residents	6,360	68	32	3	55	25	16	19	27	5	16	6
Downtown residents	9,950	61	39	3	57	22	19	18	26	8	21	17
Portland* residents	452,821	50	50	17	50	19	14	10	25	6	24	12

*Portland statistics include whole city minus the Downtown area (i.e. SoMa and NoMa).
Data Source: U.S. Census 2000

Table 4: Comparison of Total Area, Multi-Family Residential, Single Family Residential, Commercial and Industrial Land Use patterns, as well as Road-to-Block Area ratio, between the 4 Study Areas (NoMa, SoMa, Downtown and Portland)

Area Name	Block Area (Foot Prints, Million SqFt)	MFR % (Building Footprint)	MFR FAR (Built-up Density)	SFR % (Building Footprint)	SFR FAR (Built-Up Density)	COM % (Building Footprint)	COM FAR (Built-up Density)	IND % (Building Footprint)	IND FAR (Built-up Density)	Road Area:Block Area
SoMa	7.5	8.9	3.7	0.6	0.6	36.3	1.8	0.0	N/A	0.33
NoMa	16.2	8.0	3.7	0.0	1.3	37.4	4.3	0.2	0.0	0.38
Downtown	23.7	8.5	3.7	0.2	0.7	37.0	3.5	0.2	0.0	0.36
Portland*	2,919.4	2.7	0.7	34.6	0.2	13.5	0.3	5.8	0.3	0.21

*Portland statistics include whole city minus the Downtown area (i.e. SoMa and NoMa).
Data Source: Regional Land Use Information System (RLIS), November 2011

Appendix B Inter-coder reliability testing raw data

ICR Comp Plan Update Intercoder reliability raw data

Coding Instance	Secondary Coder	Primary Coder
1	13	13
2	43	43
3	12	12
4	13	13
5	11	11
6	12	12
7	43	43
8	7	7
9	13	13
10	8	8
11	13	12
12	13	13
13	22	22
14	13	13
15	43	43
16	12	12
17	42	42
18	12	12
19	13	13

20	12	12
21	32	32
22	62	62
23	32	32
24	62	62
25	7	99
26	11	11
27	99	12
28	13	13
29	12	12
30	11	11
31	12	12
32	12	12
33	32	32
34	8	8
35	99	12
36	99	22
37	13	13
38	43	43
39	7	7
40	13	13
41	13	13
42	7	7
43	12	12
44	42	32
45	12	12
46	13	99

The Portland Plan Intercoder reliability raw data

Coding Instance	Secondary Coder	Primary Coder
1	61	61
2	52	52
3	52	52
4	53	53
5	52	52
6	61	99
7	61	61
8	61	61
9	62	62
10	51	51
11	43	43
12	53	53

13	52	52
14	52	52
15	43	43
16	43	43
17	42	42

West Quadrant Plan Intercoder reliability raw data

Coding Instance	Secondary Coder	Primary Coder
1	21	21
2	12	12
3	31	31
4	21	21
5	21	13
6	32	32
7	8	8
8	8	8
9	31	31
10	11	11
11	8	8
12	41	41
13	41	41
14	41	11
15	8	8
16	11	11
17	41	41
18	21	41
19	43	43
20	43	43
21	11	12
22	41	42
23	13	13
24	43	43
25	11	22
26	11	11
27	11	11
28	31	31
29	23	23
30	53	53
31	22	22
32	52	52
33	11	22
34	31	31

35	32	32
36	62	62
37	53	53
38	21	21
39	21	21
40	22	22
41	21	21
42	12	12
43	21	21
44	11	11
45	21	21
46	21	21
47	21	21
48	21	21
49	21	21
50	51	51
51	11	11
52	21	21
53	21	21
54	12	12
55	21	21
56	12	12
57	21	21
58	11	11
59	11	11
60	41	41
61	11	23
62	21	21
63	11	11
64	41	41
65	13	13
66	21	11
67	13	13
68	43	43
69	12	12
70	21	21
71	12	12
72	21	21
73	42	42
74	51	51
75	11	21
76	12	12
77	42	42
78	13	13

79	11	11
80	12	12
81	12	12
82	11	11
83	21	21
84	11	11
85	41	41
86	11	11
87	8	8
88	11	11