Are Dense Neighborhoods More Equitable?

Evidence from King County, Washington

by

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ABSTRACT

The aims of the study are to investigate the relationship between density and social equity. Social equity is an important social goal with regard to urban development, especially smart growth and sustainable development; however, a definition of the concept of social equity from an urban planning perspective was still lacking. In response to these deficiencies, the study used quantitative and qualitative methods and synthesized multiple social and spatial perspectives to provide guidance for density and social equity planning, community design, and public policy. This study used data for the area of King County, Washington to explore the empirical relationship between density and social equity at the neighborhood level. In examining access to several facilities, this study found that distances to parks and grocery stores were shorter than those to other facilities, such as the library, hospital, police station, and fire station. In terms of the relationship between density and accessibility, the results show that higher density is associated with better accessibility in neighborhoods. Density is also positively associated with both income diversity and affordable housing for low-income families. In terms of the relationship between density and crime, density is positively associated with violent crime, while density is negatively associated with property crime. The findings of this study can aid in the development and evaluation of urban policy and density planning aimed at promoting social benefits in urban space. Therefore, this study is useful to a range of stakeholders, including urban planners, policy makers, residents, and social science researchers across different disciplines.

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CHAPTER 1

INTRODUCTION

Background

The term "compact city" emerged as an alternative to "urban sprawl" some decades ago. Sprawl is a form of development with low-density, separated land uses, and automobile dominance (Gillham, 2002; Hayden, 2003). Recently, a growing body of urban studies has suggested that sprawl generates high social costs, such as climate change, for example, (Ewing et al., 2007; Younger et al., 2008; Stone et al., 2010) and public health issues pertaining to food (Morland and Wing, 2007), obesity, and a lack of physical activity (Frank & Engelke, 2001; Ewing et al., 2003; Nelson et al., 2006). The compact city is commonly defined as an urban form with high density and a pattern of mixed-use development (Rice, 2010). The pattern is considered to be effective in retrofitting urban sprawl by concentrating activity and services in urban areas and reducing dependency on the automobile (Lin and Yang, 2006). Therefore, the compact city is a popular paradigm for enhancing sustainability (Williams et al., 2000; Holden & Norland, 2005).

Many scholars have reviewed empirical data regarding whether or not compact development can rectify suburban problems and whether or not compact cities are sustainable. Some studies provide inconclusive evidence that a compact urban form provides sustainable benefits (Breheny, 1992; Williams et al., 2000; Neuman, 2005); however, many other studies have shown that economic, environmental, and social benefits along with sustainability can be derived from the urban design of living smaller and closer and driving less (Schlossberg et al., 2006; Ewing and Rong, 2008; Talen, 2011b; Zook et al., 2012).

One of the social implications is social equity, which is one principle for sustainability (Campbell, 1996) and one of the social goals of smart growth (Talen, 2002). Recent urban

studies have shown that the equity issue is a prominent social problem in cities. Dempsey et al. (2009) defined social equity as the absence of "exclusionary or discriminatory practices hindering individuals from participating economically, socially, and politically in society" (p.292). Therefore, the meaning of social equity in the context of the physical design of urban planning relates to a fair distribution of resources and the avoidance of exclusionary practices, which allows all residents to be engaged in a community socially, economically, and politically.

Urbanism theories, such as those proposed by Jacobs (1961), and the New Urbanists theory have suggested a set of ideas to improve social life through physical design. For instance, positioning buildings with porches, stoops, and windows close to the street or other public spaces promotes surveillance of the surrounding neighborhood and also allows neighbors to look out for one another (Congress for the New Urbanism, 2000). The physical design can act as a mechanism to promote resident interaction and can influence social behavior (Talen, 1999). New Urbanism proponents have also been interested in the research that identifies the relationship between design factors and social environment. There is a critical opinion that their focus on the physical environment masks the deeper issues of social problems (Milgrom, 2002; Grant, 2006) however, many planners believe that improved design can improve social life (Talen, 1999).

This dissertation explores the link between dense urban form and social equity. Density is one of the key aspects because it can be associated with other urban features, such as land use, housing, and transportation. In recent studies of urban planning, particular attention has been given to the issue of density in the context of the compact city versus sprawl debate (Bramley & Power, 2009) because it is the most important criterion to distinguish between the two (Galster et al., 2001; Burton, 2002; Tsai, 2005). This dissertation aims to provide a better understanding of urban density and the phenomenon of social equity and empirically analyzes the association

between the two. The relationship between density and social equity have been discussed in previous studies regarding the compact city (Burton, 2003; Lin and Yang, 2006; Bramley and Power, 2009; Raman 2010); however, the compact city is beyond the density issue even though it is commonly identified as having a high density (Lin and Yang, 2006). In recent research, "the compact city" tends to be defined in an abstract sense and can be described as a moderately-sized and self-contained city (Burton 2002). Therefore, the concept of the compact city has a broader delimitation than density. For example, literature about the compact city emphasizes concentration and development and is connected with land use and the process of development as well as density (Tsai, 2005; Lin and Yang, 2006). Therefore, this study focuses on the effect of density on social equity and excludes other effects, such as land use, transportation systems, and development patterns.

The recent empirical literature is not consistent regarding the influence of density on social equity. For instance, some empirical studies of segregation suggest that density is positively correlated with income segregation (Pendall & Carruthers, 2003), while other studies claim that density is likely to decrease social segregation (Burton, 2000, 2003). In terms of affordable housing, some studies suggest that high-density is likely to increase housing prices and lower affordability (Carruthers, 2002; Anthony, 2003, 2006), but other studies provide evidence that high-density or central downtown areas have a great quantity of affordable homes (Aurand, 2010; Mukherjee, 2012). Thus, whether or not high-density does indeed provide benefits for social equity is still a matter of debate.

Social equity can have many different meanings and can be interpreted in various ways. Thus, social equity must be evaluated using various criteria. There has been ample theoretical discussion, but there is still not enough empirical evidence regarding the connection between density and the various dimensions of social equity. Lynch (1981) suggested that the concept of

justices is “a way in which benefits and costs of any one kind are distributed between persons” (p.225). Therefore, this study will provide a better understanding of the relationship between density and social equity by examining the various advantages and disadvantages of density that affect social equity.

Many previous studies of the relationship between density and social equity did not consider spatial dimensions in the analyses (Burton 2000, 2003; Bramley & Power, 2009; Dempsey et al. 2012). Current research in urban planning includes “spatial thinking” because it is useful in detecting patterns and understanding significance in a “spatial context” (Goodchild, 2010, pp.379-382). In a spatial analysis, a scale or analysis unit is important because a phenomenon in the actual world does not occur uniformly at any scale and a specific pattern can change according to the spatial scale. Previous studies of the relationship between density and social equity observed at the city or the metropolitan level (Burton 2000, 2003; Lin and Yang, 2006). This study will explore the relationship between them at the neighborhood level because dense urban form may be connected to the social atmosphere in a neighborhood through local activities.

Research Questions

The following questions are explored in this dissertation:

What is the relationship between urban density and social equity? Does the achievement of social equity vary by density if all else is equal?

In what ways and to what extent is social equity compromised by density?

Which density level is more equitable: low, medium, or high density?

How can these findings be applied to communities for enhancing social equity, and what are the implications for public policy?

To answer these questions, quantified, empirical data was used to assess the association between density and social equity. In establishing a conceptual framework, it is important to first define and understand the varied meanings of density and social equity. Discussions of urban density and social equity have long been central to theories relating urban form to city life; however, the understanding and the measure of the concepts is not easy due to the complexity that stems from the multitude of definitions of the term in different disciplines. There is no consensus regarding what constitutes the concepts of density and social equity, and they have been defined according to many different dimensions. Therefore, this study first proposes how to measure each concept in order to determine the relationship between them. Subordinate research questions tackled from this perspective include:

What is an appropriate definition of urban density?

What dimensions of urban density need to be defined?

How can urban density be measured?

How is the concept of social equity used in urban planning?

What dimensions exist in the concept of social equity?

How can social equity be measured?

Research Purpose

This dissertation examines the relationships between urban density and social equity. The purpose of this dissertation is to empirically investigate the association between urban density and social equity using several indicators and to suggest implications for public policy. The study of social equity at the neighborhood level will not only provide effective and desirable urban forms in a practical way for urban planners but will also contribute to consolidating and expanding the social equity implications for urban design. Therefore, this empirical research will

provide a more nuanced understanding of density and social equity in community development. This information will assist urban planners in understanding what a good urban environment is and how they can create it. In summary, the goal of this study is to shed light on the relationship between density and social equity so that urban planners can develop appropriate policy responses.

Organization of the Study

This dissertation includes seven chapters. Chapter 1 introduces the research problem, the research questions, and the research purpose. Following this introductory chapter, Chapter 2 reviews density, social equity, and the relationship between them. The chapter examines the density concept and provides a comprehensive understanding of social equity through planning history, geographical perspectives, and sociological theories, particularly in geospatial terms. Chapter 2 also includes a discussion of the significant body of literature regarding density and social equity and a review of the previous theoretical research on the relationship between urban form and equity. In addition, chapter 2 provides a conceptual framework for the study, examines that relationship by reviewing previous empirical research, and develops hypotheses for the study.

In chapter 3, the research methods for the dissertation are outlined. The chapter introduces the location of the study (King County, Washington) and some measurements of density and social equity used in this study. This chapter suggests how to analyze the association between density and social equity and how to measure density and social equity as well.

In Chapter 4, the proposed measurement of density from Chapter 3 is applied to King County, Washington. King County has communities with a variety of density levels, and the

county can be evaluated to show spatial distribution by a density index. The purpose of the chapter is to explain the density in King County in geospatial terms.

Chapter 5 evaluates the aspects of social equity under examination in the context of King County, Washington using the measurement of social equity suggested in Chapter 3. This chapter presents results showing the differences between the communities and the spatial patterns in King County in terms of social equity.

The focus of Chapter 6 is the examination of the relationship between density and social equity. This chapter investigates the manner in which density is associated with social equity by using a statistical analysis. The results of the analysis are presented, which focus on the influence that density may or may not have on social equity. This chapter ends with a discussion regarding the association between density and social equity in King County.

Chapter 7 applies geospatial and statistical methods to explore the relationship between density and crime in Seattle. This chapter examines whether there is a significant difference between violent and property crimes in terms of their relationship to urban density.

Finally, Chapter 8 provides an opportunity to review the results from the analyses and examine how these results contribute to the hypotheses this study presents. The final chapter concludes the dissertation by summarizing the findings, linking the results to previous literature, suggesting policy implications based on the findings, and making suggestions for future research.

CHAPTER 2

LITERATURE REVIEW

Urban Density

Defining density. The concept of density derives originally from physics as a quantity of mass per unit volume, and urban density is technically defined as the ratio between the volume of a certain urban activity and the given physical area (Frenkel & Ashkenazi, 2008). Plenty of studies on urban planning use population density and/or housing density (Burton, 2000; Forsyth et al., 2007; Frenkel & Ashkenazi, 2008; Terzi & Kaya, 2011), so density seems to be easy to calculate because population and housing density can be obtained by dividing the number of persons by the number of square miles, and the number of housing units by the number of acres, respectively. It is, however, not enough to evaluate urban density only by population and housing because urban density also needs to take into account the variety of activities, such as street and transport, which can influence urban form. There are a great number of urban activities, and plenty of densities can be obtained from these activities, for example, job density, vehicle density, and street density. In the field of urban planning, the most appropriate approach for deciding which density measure to use is often based on the purpose for using the density measure, the particular characteristics of the development, and the surrounding area (Department of the Environment, Transport & the Regions, 1998; Boyko & Cooper, 2011).

As applied within urban studies, density applies to certain quantities per unit area. According to Dovey and Pafka (2014, p.67), widely used density measures in geography and planning are “dwelling density” (dwellings/area), “residential density” (residents/area), and “job density” (jobs/area). All of these measures may either be net or gross—net density being

calculated within a development site and gross density incorporating the broader network of public space. In terms of measurement scale, there is also an understood distinction between the "external density" at the neighborhood scale and the "internal density" of people per room. All these conceptions of density are quantifiable and collectively referred to as "measured density." This is distinguished from "perceived density," which has been a focus of environmental psychology and the analysis of perceptions of crowding (Dovey & Pafka, 2014, p.67). "Social density" is also difficult to quantify because it is hard to determine 1) whether a specific high density is a function of large numbers of people and 2) whether it will make a difference in people's reactions to that density (Churchman, 1999, p.390).

Generally, the term "density" is considered as objective, quantitative, and neutral (Churchman, 1999). It is usually represented as the number of people in a given space, and people cannot judge immediately whether a given level of density is positive or negative. Thus, density is different from the concept of "crowding." Crowding is the subjective perception that the number of people is too high. Crowding cannot be measured objectively and generally refers to people's psychological responses, usually distress and unwanted interaction, whereas the term density has no positive or negative connotation (Gray, 2001). There are, however, studies that include the perception of density as a measurement of density.

Recent studies have suggested the concept of perceived density (Ramen, 2010; Cheng, 2010; Dempsey et al., 2010; Dave, 2011). The evaluation of density can be objective, spatially based, and can measure the number of resources in a given area; density can be also assessed subjectively (Dempsey et al., 2010). The perception of density can be changed through urban design and layout. In the case of perceived density, the most important issue is how to quantify the perception of density. Dave (2011) provides that perceived density can be measured through perception of external crowding (perception of a neighborhood) and internal crowding

(perception of the size of a home) by interview. A more recent study focuses on the perception of residential density and suggests that the stakeholders' perception of density is strongly influenced by physical urban environments (Sivam et al., 2012). The human perception of density, however, is very difficult to represent in physical measures (Raman, 2010). Cheng (2010) argues that perceived density is "subjective as it relies on individual apprehension, but it is neutral as it does not involve any personal evaluation or judgment" (p. 13).

There have been a number of attempts to explore various density types with the aim of listing and clarifying definitions of density (Cheng, 2010; Boyko & Cooper, 2011). The typical list would include dwelling density, people density, residential density, job density, net density, gross density, physical density, measured density, perceived density, internal density, spatial density, and social density (Dovey & Pafka, 2014). These studies provide exemplary definitions of density, focusing on measurable spatial densities rather than social and perceived densities.

High density has received attention by scholars because most urban studies on sustainability and smart growth have dealt with compact development. Compact development is the opposite of sprawl in terms of a development pattern, and high density can match up with land use mix and transit-oriented development (TOD) for compact development. That is, density is closely associated with other elements of urban form such as land use and transportation. Density is also connected to the quality of urban life through urban services provision and availability of public and private space; therefore, recent planning policy in many countries has attempted to increase the density of new urban development (Dempsey et al., 2010). Thus, urban density needs to be understood in a more holistic and integrated way rather than in a one-dimensional way due to the complexity of current urban environments (Boyko & Cooper, 2011).

Spatial understanding of density. Urban scholars believe that an approach to density that is both well-designed and strategic can foster more holistic communities, which include improved transportation, affordable housing, a strong economy, and energy efficiency, however critics have argued that density may be problematic to define because it is dependent on what kind of density is being explored and how that density is defined, conceptualized, and assessed (Boyko & Cooper, 2011). Furthermore, there appears to be an over-emphasis on dwelling density as the principle density type mentioned in policy (Boyko & Cooper, 2011). Recent research on density suggests the concept of spatial density. Spatial density can be related to the perception of density as follows: "[the] relationship among spatial elements such as height, spacing and juxtaposition, and high-spatial density is related to environmental qualities, such as intricacy of spaces and high activity levels (Cheng, 2010, p. 12)." When urban density is evaluated, spatial form can be also considered through the concept of spatial density. Jacobs (1961) discussed the relationship between residential density and street life. She suggested density is a key condition for urban diversity, claiming that small blocks can increase safety and diversity. In other words, Jacobs (1961) emphasized high density in small blocks for urban diversity. Jacobs (1961) was also an advocate of high levels of site coverage-in her opinion, high-density low-rise morphologies produce greater variety than a modernist tower typology. Urban development of the same density can exhibit very different urban forms, for example, multi-story towers, medium-rise buildings, and parallel rows of single-story houses (Cheng, 2010). Thus, urban density has a complicated relationship with urban morphology, and it plays an important role in the shaping of urban form.

In addition, when showing the density level of certain areas, spatial analysis, including visualization, can be adopted. Spatial patterns and visualization of density are helpful to identify high-, medium-, and low-density areas. There is no standard for which level is high-density or

low-density because density has various measurements and density level is understood within different cultural contexts and development types. For example, Asian cities have different density standards than American cities in terms of density level, i.e., high and low density, and the cities can be compared visually through maps and Google images. Thus, it is difficult to have a universal standard so that the identification of high or low density can be relevantly understood within a regional context. For this reason, visualization of density can be useful to examine which areas are high-, medium-, or low-density; further, how the areas vary across space will suggest relevant insights with policy implications.

Definition for the study. Urban scholars have been discussing and studying density for decades; however, there is no consistent definition. From the literature, the dissertation is based on two dimensions to help untangle the complexity of density: 1) the concentration of individuals or physical structures in the given physical area, and 2) urban features to make people perceive a dense urban form. The first dimension is related to physical density and the second dimension can be connected to spatial density (Table 1). Physical density means "the concentration of individuals or physical structures within a given geographical unit" (Cheng, 2010, p. 3). Spatial characteristics to shape urban form are important in the perception of density in that the density is from "the interaction between the individual and the environment"(Cheng, 2010, p. 12) and relies on perceptual, associational-symbolic, and physical aspects of the environment (Churchman, 1999). The importance of the concept of perceived density is how physical design can be manipulated to increase the probability of either a heightened or lessened perception of density (Jacobs & Appleyard, 1987). Therefore, to understand more nuanced urban density, this dissertation focuses not only on the quantitative concentration of urban resources, but also on spatial characteristics to make dense urban form,

as density should be considered an integral part of urban environment, including both "hard" (i.e., quantitative) and "soft" (i.e., qualitative and contextual) elements (Churchman, 1999).

Table 1

Two Dimensions of Measurable Density

Dimension	Explanation	Examples
Physical density[1]	-numerical measures of the concentration of individuals, resources or physical structures within a given geographical unit -the numerators are the volume of activities, and the denominators represent the area of land that is available for the corresponding activities	-people density -building density -job density -car density
Spatial density	-the interaction between individuals and built environments -be associated with the built form and certain urban features	-size of buildings -space between buildings -street width -block lengths -street intersection -building height -space openness -number of street signs -space complexity

Sources: Cheng (2010), Bramley and Power (2009), and Lin and Yang (2006)

[1] Mitrany (2005) suggests 'objective density' instead of 'physical density'. The terms are used in the same sense, and this dissertation uses the term of physical density.

Table 2

Definition of Urban Density for This Study

Definition of urban density
1) Ratio between the volume of a certain activity and the given physical area (*physical density*), and 2) measurement of urban features to promote built environment that make people perceive as dense urban form (*spatial density*)

Social Equity

The ideas of social equity. There are many different interpretations of equity, but the one that is perhaps the most relevant to the case of urban planning is the notion of distributive justice. In *A Theory of Justice* (1971), John Rawls proposes to solve the problem of distributive justice with his two principles of justice: the liberty principle (aka, the first principle of justice) and the difference principle (aka, the second principle of justice). Rawls' first principle is "each person is to have an equal right to the most extensive basic liberty compatible with a similar liberty for others" (p.60), and the second principle, in other words the difference principle, is "social and economic inequalities are to be arranged so that they are to be of the greatest benefit of the least-advantaged members of society" (p.83), and "all social primary goods—liberty and opportunity, income and wealth, and the bases of self-respect—are to be distributed equally unless an unequal distribution of any or all of these goods is to the advantage of the least favored" (Rawls 1971, p.303). Rawls's idea highlights the fair distribution of social, political, and economic goods and services.

A number of studies on social equity in the fields of geography and urban planning are based on Harvey's concept of distributive justice (Mennis et al., 2005; Omer, 2006, Delmelle and Casas, 2012). Harvey suggests the concept of "needs" to formulate a principle of territorial distributive justice. Needs can be defined with respect to a number of different categories of

activity; Harvey (1973) lists nine needs: food, housing, medical care, education, social and environmental services, consumer goods, recreational opportunities, neighborhood amenities, and transport facilities. The needs provide a hypothetical figure for the allocation of resources to a region, and a measure of social equity can be devised by correlating the actual allocation of resources with the hypothetical allocations (Harvey 1973, p.101). According to Harvey, a just way of determining both the boundaries of territories and the means of allocating resources is socially established for the realization of social equity.

The realization of equity in the distribution of urban resources is an important mission for planners. Social equity is a critical issue to planners in that they should decide how to design urban spaces and allocate resources in cities. Many different definitions of equity can be used in defining social equity. However, the basic concept of social equity refers to the degree to which services or resources are distributed in an equal way (Omer, 2006). Social equity examines the association between amenity distribution and the population's need for amenities (Smoyer-Tomic et al., 2004). Social equity also can be defined as equal access to basic public facilities measured in distances (Kunzmann, 1998). When social equality is considered, the needs of special groups, such as the low-income population, children, and the elderly, should not be neglected. There are plenty of residents and a variety of minorities in cities, and most tasks have addressed social equity within the urban environment (Talen, 2001; Smoyer-Tomic et al., 2004; Omer, 2006).

In terms of social justice issues in cities, a number of sociological studies have focused on the "underclass" in inner-city neighborhoods. In the past several decades, economic conditions in many inner-city neighborhoods have dramatically declined. The loss of low-skill manufacturing jobs during the 1970s and the shift toward jobs that require more education and higher skill levels produced a sharp rise in the concentration of poverty in many inner-city

neighborhoods (Rankin et al., 2000). Moreover, this economic shift had acute unemployment effects on segregated African-American communities, as a significant proportion of that population worked in low-skilled manufacturing trades (Wilson, 1996). Wilson's study (1996) uses the term "underclass" to refer to the urban poor. Specifically, Wilson's hypothesis (1996) on urban research is that the formation of the underclass is caused by the economic shift from industrial to post-industrial societies from the 1970s onwards, and the underclass is characterized by the absence of employment opportunities. The underclass often suffers from the absence of societal support, as well as low economic status (Wilson, 1996). Therefore, the concept of equity can be considered as an approach intended to provide a certain social environment in which people, especially the disadvantaged, are not excluded from the activities of society. For this reason, social diversity in a community can be linked to social equity. Social diversity is equitable because a certain class, especially the disadvantaged, are not ruled out and "it ensures better access to resources for all social groups" (Talen, 2008, p. 40). In addition, a socially mixed population is "the ultimate basis of a better, more creative, more tolerant, more peaceful and stable world" (Talen ,2008, p. 40).

Many studies on urban social problems have agreed on the view that diversity in communities is an important factor in terms of equity because "social divisions are manifested in spaces and landscapes that reflect separation, and in turn these spaces and landscapes further reinforce social division" (Talen, 2010, p.490). Social scholars are mostly united in agreeing that the spatial dimensions of segregation are needed to capture the shifting dynamics of inequality in modern America. A lot of social researchers have studied spatial segregation in terms of race and income (Massey & Denton, 1989; Reardon et al., 2008; Reardon & Bischoff, 2011). Many sociological studies on segregation support the idea that socially mixed communities are connected to social equity. Segregation is the uneven geographic distribution of income and/or

groups within a community (Reardon & Bischoff, 2011), and it means a community that is not socially mixed. Massey (1990) argues that the concentration of poverty in minority neighborhoods is the most pernicious result of contemporary residential segregation. The poverty concentration is associated with other social problems, such as high crime, poor schools, and excessive mortality (Massey, 1990). In addition to race segregation, sociologists are also interested in income segregation because income segregation may lead to inequality in social outcomes (Reardon & Bischoff, 2011). Income segregation can be characterized by the spatial segregation of poverty and/or the spatial segregation of affluence. For example, high-and low-income households are likely to be spatially far from one another; that is, they are likely to be in economically homogeneous neighborhoods (Reardon et al., 2008). Research of residential segregation shows that "spatial boundaries strengthen social divisions, making it easier for the privileged to monopolize their resources in a form of social closure and reinforcing the social exclusion of the disadvantaged" (Dwyer, 2010, p.114). For this reason, social diversity in communities can alleviate the social closure and the social exclusion of the disadvantaged.

Social diversity does not eliminate group differences, but it makes a society more equal and makes the society's members "mutually respect one another in socially differentiated groups" (Young, 1990, p.163).Young (1990) defines social justice as "the fair distribution of benefits and burdens among society's members in urban space" (p.15). This idea of justice is linked to reducing the gap between the advantaged and the disadvantaged and ameliorating the effects of poverty and race. When they are located in different communities or in different parts of a community, it is difficult to contact with each other and share urban resources, even if they live in the same municipality (Dwyer, 2010).

Young (1990) also highlights what makes a social condition just. To have a just social condition, "the society must enable all to meet their needs and exercise their freedom, and

justice requires that all be able to express their needs" (Young, 1990, p.34). The primary role of equity planning is to provide the disadvantaged opportunities to express their needs. Equity planning sees a city as “a location of conflict over the distribution of resources, of services, and of opportunity” (Campbell, 1996, p.298). Davidoff (1965) argues that different groups in society have different needs that result in fundamentally different plans, if they are recognized. Davidoff claims that wealthy and powerful groups have the skill and resources to shape urban planning to include their interests, but poor and powerless people do not have these opportunities. Thus, there should be planners acting as advocates articulating their interests in the same way that lawyers represent their clients. “The advocate planner would be above all a planner. He would be responsible for his client” (Davidoff, 1965, p.333). Davidoff's view of planning profoundly influenced the activist planners of the 1960s and 1970s, many of whom defined themselves as advocacy planners; they developed plans to meet underrepresented groups, and advocated for their interests.

Spatial understanding of social equity. The power of visualization can be an effective tool for addressing issues of social justice (Talen, 2011a). In urban planning research, spatial analysis for social equity has been widely used because spatial equity communicates a fundamental concept in relatively straightforward, easily recognized terms- who has access to things and who does not (Talen, 2011a). Spatial analysis of social equity, including visualization, can show the physical urban pattern of which areas are more spatially segregated and unequal. A wide range of ongoing urban studies have found increasing or decreasing physical accessibility, and the visualization of the patterns have suggested explicit policy implications for social equity (Smoyer-Tomic et al., 2004; Tsou et al., 2005; Delbosc & Currie, 2011). Access in terms of spatial equity is defined as the ability to reach a given destination based on geographic distance.

The geovisualization of these varying patterns of access gets at the key implication of spatial equity. The spatial pattern contributes to the public discussion of resource distribution issues; how access changes when the inputted variables change; and what those variations mean for economic, social, and environmental health.

The fair distribution of resources is an achievement of social equity. Determining the distribution of benefits and costs is something policymakers have a great deal of control over as they attempt to allocate scarce public resources (Talen, 2011a). Social equity includes considering need, justice, and fairness in the inequality of distribution (Talen et al., 1998). Geographers and urban planners focus on equity from a spatial perspective, and the objective of social equity research is to examine whether the distribution of services is equitable and correlates with observed socio-economic spatial patterns (Talen & Anselin, 1998). That is, in the context of geography and urban planning, equity is related to a just spatial distribution of people and resources (Talen, 2002), and many empirical studies have dealt with the issue, especially regarding minority and low-income populations (Omer, 2006).

Definition for the study. From the above review of the literature, the dissertation employs two overarching concepts at the core of the notion of social equity: fair equality and just distribution. The concepts can be aligned with the fair equality of opportunity principle and the difference principle, which are derived from Rawls's second principle of justice. The study of Wang et al. (2012) differentiates between social equity and spatial equity and defines them: Social equity is "equity between different groups of people living broadly in the same location" and spatial equity is "equity between people living in different regions" (Wang et al., 2012, pp.66-67). In the strict sense, social equity in this dissertation follows the definition of spatial equity according to the study of Wang et al. (2012); however, this dissertation uses the term

"social equity" and social equity in this study focuses on the geographic access and locational distribution of facilities and people (Talen, 2005).Therefore, the dissertation focuses on the spatial distribution of people and urban services, and employs a spatial analytical perspective to evaluate suitability or urban facilities in assessing whether or not, or to what degree, the distribution of urban facilities equitable. Harvey (1973, p.13) argues that "the problem of proper conceptualization of space is resolved through human practice with respect to it." When this basic idea is translated into physical principles for community planning, it indicates that where people live must be equitably proximal to what they need, regardless of any socioeconomic conditions (Talen, 2005). Thus, this dissertation defines social equity for urban planning as just distribution to fulfill what people need, and it means just spatial distribution of people and resources.

Table 3 *Definition of Social Equity for the Dissertation*

Definition of social equity
Fair equality of opportunity to fulfill what people need, that is, just spatial distribution of people and resources

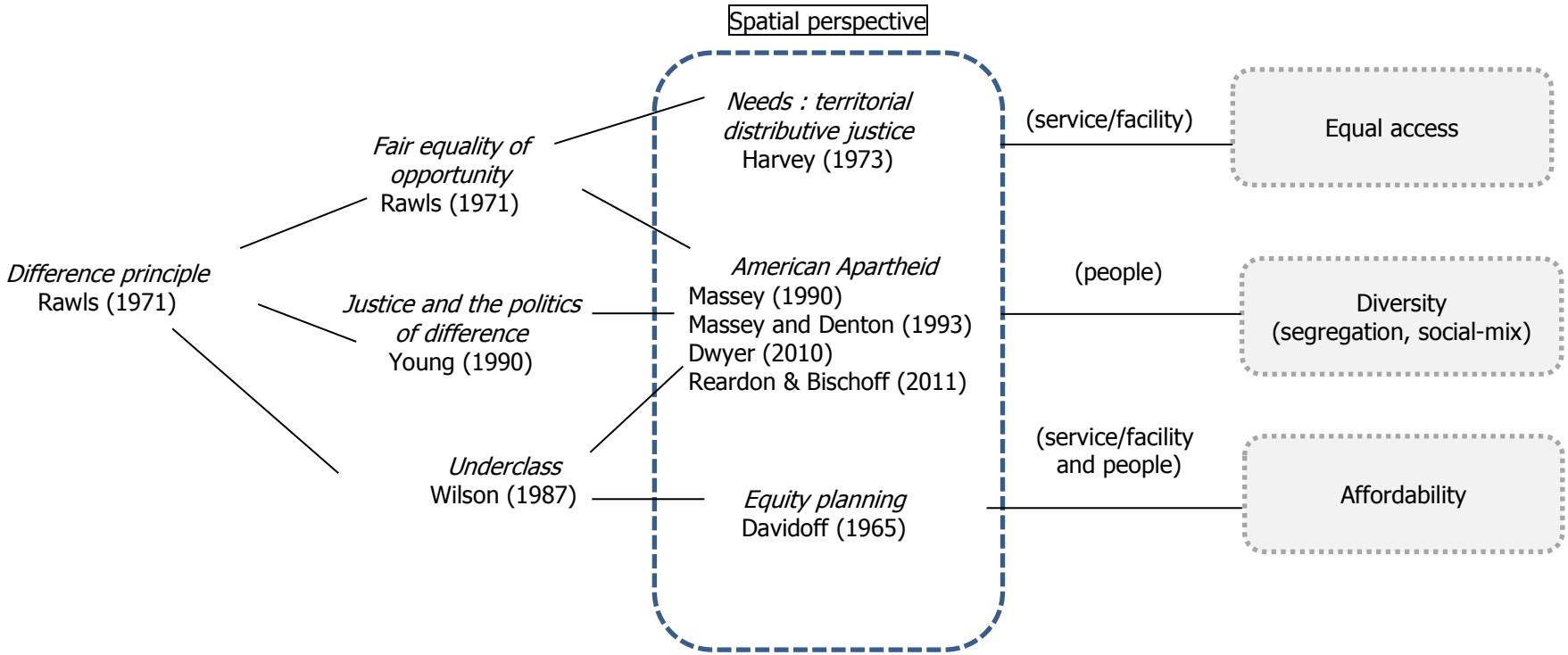


Figure 1. *Spatial Dimensions of Social* Equity

Dense Urban Form and Social Equity

Built environments can be connected to enhance social environments. High-quality spaces can increase social inclusion and socially cohesive behavior, while a decline in the quality of cities can encourage anti-social behavior (Dempsey, 2008). A compact urban form can help balance the competing interests of the environment, economy, and quality of life (Bhatta, 2010). This concept is similar to the ideas of the early planning theorist Ebenezer Howard, who aims to use spatial relations to create a close-knit social community that facilitates the interaction of diverse elements (Fainstein, 2000).

Howard's garden city contributed greatly to the theory and practice of, 20th-century urban planning (Parson, 2002). Howard (1902) identifies real social injustice as arising from industrialization and believes that real social injustice can be best addressed at the local level. In his book Garden Cities of To-morrow (1902), Howard posits that town and county alike can attain benefits through cooperation, beauty, green parks, social opportunities, high wages, low rents, and low pollution. The creation of an environment that embodies the characteristics of both the town and the county is hardly new, but the garden city movement expands it to be accessible to low-income households (Parson, 2002). Therefore, Howard's garden cities can be achieved by socially mixed communities and by good community facilities, and consequently, the concept of the garden cities is known not only to provide a solution to the problem of poor-quality housing but also to serve as a means to solve the social and health problems of the industrial city (Dempsey et al., 2012). The principle of social mixing has been embraced in planned communities with people of different socioeconomic classes (Talen, 2010). For example, Forest Hills Garden, a model suburb developed in New York, was designed for a mix of incomes, with apartment houses, attached houses, and detached houses of various sizes (Barnett, 1986).

Hull House, located in the middle of a poor, immigrant community in Chicago and co-founded in 1889 by Jane Addams and Ellen Gates Starr, is a famous example of a neighborhood for low-income people. The objective of Hull House was to integrate immigrants into the city in three ways: individual moral example, moral coercion, and systemic upgrading of the urban environment through parks and playgrounds (Hall, 2002). Basic services at the neighborhood level, such as parks and playgrounds, are valuable, and the Hull House program was focused not only on neighborhood improvement but also on social mixing and social diversity (Talen, 2005). In communities, poverty and racial and class discrimination are not only the most important problems but are also the major causes of the low quality of urban life (Keating et al., 1991).

Contemporary planners attempt to incorporate the principles of justice into community development. In particular, New Urbanists view the value of justice as a social goal they should achieve (Talen, 2002). Although generally design centered, New Urbanism encompasses a complex social agenda (Brain, 2005). New Urbanists try to achieve the principles of justice through community design. Take, for example, their concern with social mixing within a community. According to their view, low-density development patterns aggravate racial and income segregation, and therefore, dense communities will have better socioeconomic integration (Pendall & Carruthers, 2003).

In addition, the Smart Growth Network Subgroup of Affordable Housing, a coalition of organizations and government agencies which includes the American Planning Association, Fannie Mae, and Urban Land Institute, defines smart growth as “that which invests time, attention, and resources in restoring community and vitality to center cities and older, inner suburbs. Smart growth in new developments is more town centered, transit and pedestrian oriented, and has a greater mix of housing, commercial, and retail uses” (Arigoni,

2001, cited in Pendall & Carruthers, 2003, p.543). Smart growth development combined with high density can promote socioeconomic desegregation through mixed-income communities that distribute affordable housing. However, smart growth development can also result in new construction to support mass transit use and pedestrian activities, and some might be willing to pay a premium to live in such communities (Song & Knaap, 2003). Thus, those who have difficulty paying high housing costs might have to leave these communities. For these reasons, the relationship between density and social segregation is not simple. An empirical study by Pendall & Carruthers (2003) using a national dataset of metropolitan areas from, 1980 to, 2000 illustrates that the relationship between density and income segregation follows a quadratic function; that is, first rising, then falling, and changing density increases, decreases, and then increases segregation in metropolitan areas.

Nevertheless, it is still suggested that density can be connected to the development of housing for low-income families. High-density development promotes a large number of multi-unit structures such as condominiums, townhomes, and apartment buildings relative to the number of detached single family homes. A high-density of multi-unit residential structures can increase the quantity of affordable units for low-income households in two ways: First is through the effect of the housing supply and demand on prices in general, and second, high-density housing is more likely to be found in affordable sub-markets than unaffordable ones (Aurand, 2010).

The density of urban development has the potential to have social impacts and implications. The social effects in communities involve a range of social behaviors: social interaction between community residents, levels of trust across the community, and a positive sense of identification with and pride in the community (Forrest & Kearns, 2001; Dempsey et al., 2012). One of the greatest benefits of dense communities is that they bring

people within walking distance of each other, close enough that they can interact without traveling (Campoli et al., 2007). For example, a higher density might mean that people are more likely to meet each other on the street than in low-density areas (Duany & Plater-Zyberk, 2001). In contrast, lower densities tend to decrease the potential for spontaneous interaction in communities because people are likely to rely on car travel (Transit Cooperative Research Program, 1998). The lifestyle in high-density areas that facilitates face-to-face interaction can be connected to a sense of community (Nasar & Julian, 1995). Jacobs (1961) views the essential spirit of nature as one of dynamic creativity, rather than one of tranquility. For Jacobs (1961), therefore, a successful urban street is a complex blend of neighbors and strangers and a constantly changing "urban ballet" (Fishman, 2000, p. 9). Jacobs (1961) argues that a major part of the success of communities depends on their "overlapping" and "interweaving" (p. 120). However, dense communities can also stimulate crime due to significant levels of physical contract and psychological pressure (Lin and Yang, 2006). Burton (2000, 2003) empirically confirmed a positive relationship between density and crime. This negative influence was also found by Lin and Yang (2006), who suggest strategies to reduce the negative influence of density on crime. For example, urban facilities and adequate security need to be supplied to limit the rate of crime in high-density areas. On the other hand, some studies, such as that by Elkin et al. (1991), have argued that compactness promotes personal safety by putting eyes on the street to deter wrongdoing.

High-density development can increase access to urban services and facilities and enhance social justice in communities. Accessibility can be discussed in terms of transport and mobility and thus is related to urban density (Carmona et al., 2003). As access to facilities and services increases, transport costs become lower. For example, the presence of women and low-income groups tends to reduce travel costs, and the higher the accessibility

of urban services and facilities, the greater are their benefits. The greater the access to such opportunities, the lower the transport costs are. In addition, accessibility achieves justice by allocating facilities and services for basic needs within a walkable distance for those who do not own a car or cannot drive. Therefore, a dense, urban form can improve the disadvantaged's access to resources. Particularly, access to public resources is likely to depend on each individual's income, and the spatial distribution of urban resources directly affects the distribution of welfare of communities (Harvey, 1973). In particular, access to public spaces such as parks might be more severely limited by social and cultural boundaries than physical ones (Mitchell, 2003). Cities are loci where "rights not only are contested, but also are actively produced by struggles over rights" (Mitchell, 2003, p. 81). For example, disempowered groups are denied access to public spaces because property rights imply power (Mitchell, 2003).

The principles of justice can be incorporated into community development, which embraces urban forms that are accessible and available to all people, especially certain social groups such as the poor, minorities, and the elderly. Planners need to incorporate their interests into community design and to guarantee their right to a public place. Unfortunately, disempowered groups seem to be denied access to public places because of property rights, which imply power and violence (Mitchell, 2003). Communities, as public places, have not only physical but also social dimensions. They are an arena for diverse groups of people to engage in debates and oppositional struggles, and they need to be accessible to and used by all (Ellin, 1996). In terms of community design, "it is not just a question of building more, higher density housing in towns, but also of creating really attractive living environments within easy reach of a range of facilities (including jobs) and of tackling some of the main disadvantages associated with urban living" (Urbanism, Environment & Design and The

Bartiett School of Planning, University of College London, 2000, as cited in Burton, 2003, p. 559).

Table 4

Previous Studies for Relationships between Dense Urban Form and Social Aspects

Researcher	Density variable	Social equity variable	Study area	Analysis unit	Result (association)
Burton (2003)	-population density -household density	-access to superstores -access to green space -crime rate -social segregation -affordable housing	25 cities in the UK	city	higher density – better access to superstore, higher density – worse access to green space higher density – higher crime rate, higher density – less social segregation, higher density - less affordable housing
Pendall & Carruthers (2003)	-population density -job density	-income segregation	318 metropolitan regions in the US	Metropolitan region	higher density – higher income segregation
Kaido (2005)	-population density	-access to local facilities (community center, park, rail station, hospital/clinic, banking facility/post office, day care center for older people, and food convenience store)	Japan (housing and land survey of Japan)	city	density – day care, local community center, park : no association, density – railway station, banking facility/post office, hospital/clinic : moderate association, density – convenience store: strong association
Lin and Yang (2006)	-residential density (residents/area) -building density -employment density	-public service -crime rate -housing affordability	92 cities/towns in Taiwan	city	higher density – higher crime rate, higher density – lower housing affordability

Table 4

Previous Studies for Relationships between Density and Social equity (Continued)

Researcher	Density variable	Social equity variable	Study area	Analysis unit	Result (association)
Bramley & Power (2009)	-residential density (dwellings per hectare)	-satisfaction with area -access to three local services (convenience store, post office, doctor)	Census output area in the UK (The Survey of English Housing)	block	higher density – lower satisfaction with area, higher density – higher accessibility
Aurand (2010)	-residential density (housing density)	-affordable rental units	Portland (n=273), Seattle (n=405)	neighborhood	higher density – more affordable rental units
Dave (2011)	-physical density (residential density, population density, floor area per person) -perceived density (perception on external and internal crowding)	-access to facilities and amenities (school, health facility, park) -health of the inhabitants -community spirit and social interaction -sense of safety -satisfaction with neighborhood	Mumbai Metropolitan Authority, India (interviews for 259 residents)	neighborhood	higher physical density – higher accessibility and better health of the inhabitants, higher perceived density – lower community spirit, lower sense of safety, higher social interaction, and lower satisfaction with the neighborhood
Dempsey et al. (2012)	-perception of density	-access to facilities/green space -unsafety -social interaction	UK cities	qualitative study (interview, self-reported)	higher density – better access to facilities, higher density – lower, accessibility to green space, higher density – higher unsafety, higher density – less social interaction

Research Hypotheses

This study investigates the relationship between density and social equity in geospatial dimensions, based on the idea that built environments can be linked to social goals. Figure 2 shows a conceptual framework to guide the study.

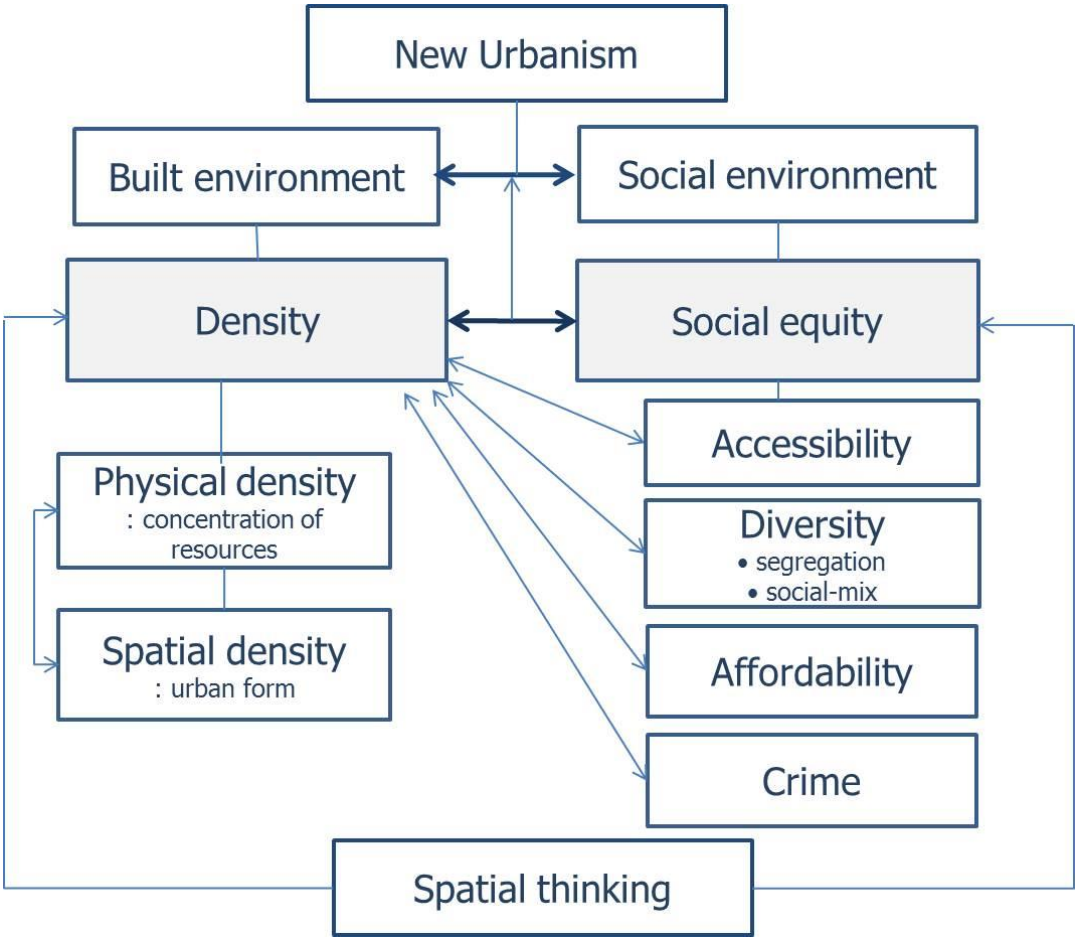


Figure 2. *Conceptual Framework for the Study*

Density and accessibility. New Urbanism proponents present accessibility, known as "import replacement," as a smart growth strategy (Duany et al., 2010, p. 3.7). When neighborhoods satisfy their needs for goods and services nearby, they become self-sufficient enough to develop local economies, retain wealth, and save energy for sustainability (Duany et al., 2010). Access to urban resources and services is one of the criteria to shape a good urban environment (Lynch, 1981; Jacobs & Appleyard, 1987; Ellin, 1996).

Current research evaluates accessibility focusing on daily life in local areas, for example, in grocery stores (Tsou et al., 2005), parks (Talen & Anselin, 1998 ; Wolch et al., 2002; Tsou et al., 2005), and medical facilities (Rosero-Bixby, 2004; Kadaliri et al., 2011; Harada et al., 2012). Harvey (1973) lists needs based on daily activities, as follows: food, housing, medical care, education, social and environmental services, consumer goods, and recreational opportunities. Moreover, previous studies on accessibility have discussed the influence of density. Most studies have concluded that high-density development can promote access to local facilities (Burton, 2000, 2003; Bramley & Power, 2009; Dave, 2011), but in terms of access to parks, the results have not been consistent. Some studies provide evidence that high density tends to decrease the amount of green space and accessibility to green areas (Burton, 2000, 2003). The distance to a park in a neighborhood is connected to transport modes; for example, small parks tend to be located within walking distance, while the distance to the park can be greater when residents have access to a car or an affordable transit system (Garcia &White, 2006). New Urbanists suggest that facilities relevant to daily needs such as parks and grocery stores can be located within walking distance of high-density developments (Duany et al., 2010). Therefore, the following hypotheses on the relationship between density and accessibility can be proposed:

H1. Density is positively correlated with access to urban services.

H2. Density has a strong relationship with access to daily activity services such as grocery stores and parks.

Density and diversity. Many scholars have been interested in diversity in urban spaces. Jacobs (1961) identified diversity as the most important condition for a healthy city. Jacobs and Appleyard (1987) wrote a widely cited manifesto in which they argued that diversity and the integration of activities were necessary parts of the fabric of urban life. The social equity dimension of place diversity involves the idea that social mixing in one place is more equitable because it ensures better access to resources for all social groups (Talen, 2006).

Dense areas such as inner cities are attractive to poor people in that it is easy to find a job there. Shipler (2004) mentions that the poor are likely to have difficulty finding and holding jobs due to their lack of access to an automobile. Those who are not able to afford a car may prefer dense urban areas with public transit networks than suburbs characterized by car dependency. Most impoverished people are not the unemployed, but rather the working poor who have unskilled job such as fast food jobs (Newman, 2009). For this reason, poor people seem to populate high-density, central areas. Some studies suggested that density tends to reinforce social segregation (Radberg, 1996; DETR, 1998, as cited in Churchman, 1999). Huie and Frisbie (2000) also examined whether density is connected to racial segregation in the 58 largest American metropolitan regions, and their results suggest that densely populated areas exhibit greater segregation of black and white people.

Scholars, however, have suggested that high-density developments can increase diversity and alleviate social segregation. New Urbanists argues that compact development can reduce segregation, especially with respect to income (Talen, 2002). Smart growth is more town centered, transit and pedestrian oriented, and has a greater mix of housing, commercial, and retail uses" (Arigoni, 2001, p.9), and socioeconomic segregation can be reduced by way of mixed-income community. High-density neighborhoods can include a variety of housing types, such as apartments and townhomes, and accommodate a wider range of income than those consisting only of single-family homes on large lots (Pendall & Carruthers, 2003). In addition, in terms of economy of scale, high-density can make it financially feasible for developers to produce multi-family homes (Speir & Stephenson, 2002; Carruthers & Ulfarsson, 2003).

Social-mixed neighborhood plays important role in promoting social equity. Most urban redevelopments geared towards improving poor communities in inner cities through vouchers or new subsidies have failed (Downs, 1999). Higher-income social groups are unlikely to be attracted to places with poor physical conditions, and this could result in segregation. Thus, building up diversity using various social-mixing programs in communities is a better way to improve poverty communities (Talen, 2010). A city needs to be the place where "life is a being together of strangers, diverse and overlapping neighbors" (Young, 1990, p. 240). As such, city politics must "take account of and provide voice for the different groups that dwell together in the city" (Young, 1990, p. 227). Jacobs (1961) argues that "close-grained diversity" is the result not of great plans, but of all the little plans of ordinary people that alone can generate the diversity that is the true glory of a great city (Fishman, 2000, p. 19). For the relationship between density and diversity, the following hypotheses can be proposed:

H3. Density is positively correlated with social diversity.

H4. Density is negatively correlated with social segregation.

Density and affordable housing. Equity in the distribution of urban resources can be according to need, termed "compensatory equity" by Crompton and Lue (1992, p.230). Lucy (1981) refers to this as "unequal treatment of unequals," which is based on poverty and minority. The Congress for the New Urbanism (2000) states that "within neighborhoods, a broad range of housing types and price levels can bring people of diverse ages, races and incomes into daily interaction, strengthening the personal and civic bonds essential to an authentic community" (p. 89). New Urbanists believe that affordability can be promoted through urban design to meet the diversity principle (Talen, 2010). In addition, affordability can be linked to the principle of accessibility. The opportunity for residents to carry out daily activities, such as shopping or going to school, without needing a car, may make life more affordable and accessible for low-income families (Johnson &Talen, 2008).

The relationship between housing affordability and smart growth is intricate. Many smart growth strategies are designed to promote affordability by increasing density, providing diversified housing options other than single-family units, and promoting better design with a balanced distribution of work and residence (DETR, 1998; Alexander & Tomalty, 2002). At the same time, in order to maintain environmental quality, many smart growth practices limit growth and reduce the supply of developable land (Downs, 2005). These practices have the potential to increase housing prices and reduce housing affordability. Burton (2000, 2003) argues that higher density communities are likely to lack of affordable housing, and Lin and

Yang (2006) support these findings with evidence that density is negatively associated with housing affordability. However, more recent research has provided empirical evidence that communities with higher residential densities have a greater quantity of affordable units for very-low-income renters (Aurand, 2010). Aurand's (2010) study provides empirical evidence that communities with a high density and greater variety of housing types are likely to have more affordable units than low-density communities consisting exclusively of single-family homes. There are also some studies that high density significantly improves housing choices and enables affordability for all residents (Downs, 2001; Alexander & Tomalty, 2002). Thus, the following hypothesis about the relationship between density and affordable housing can be proposed:

H5. Density is positively correlated with affordable housing.

Density and crime. Research on sustainable development suggests that urban density has the potential to decrease crime (Burton, 2000). Jane Jacobs argued in her book The Death and Life of Great American Cities (1961) that the presence of "eyes on the street" prevents crime and enhances safety. Thus, high density can play the role of informal social control, and may have conditional effects on crime (Stucky & Ottensmann, 2009), because a dense urban environment may "create opportunities for natural surveillance by residents, neighbors, and bystanders" (Anderson et al. 2013, p.712). However, empirical research shows inconsistent results regarding the idea that density decreases crime. For example, Lin and Yang's (2006) study shows that density is positively associated with crime rates in Taiwanese cities, and

Burton (2000, 2003) analyzes the data from twenty-five British cities using correlation analysis, finding that higher density tends to be associated with higher crime rates. In contrast, however, a recent study found no difference between population density and either property or violent crime (Harries, 2006), while another provided ambiguous results regarding the relationship between crime and a built environment (Stucky & Ottensmann, 2009). Based on Jacobs's (1961) concepts, this study hypothesizes the following:

H6. Density is negatively correlated with violent crime.

H7. Density is negatively correlated with property crime.

CHAPTER 3

RESEARCH METHODS

This chapter outlines the methodology commonly used to explore the three research topics of the dissertation: measuring density, evaluating social equity, and exploring the relationship between density and social equity in the case of King County, Washington. The first section in this chapter introduces the study area for the research. The second section summarizes methods used to measure urban density, and the second section explains how to measure social equity. Finally, methods to analyze the relationship between density and social equity are introduced in this chapter.

Study Area

The dissertation uses the King County, Washington as a study area. Seattle, which is the county seat, is a medium-large town with progressive housing policies and a strong sense of sustainability, and the county has good representation of density and non-density and equity conditions. This study analyzes a sample consisting of the census tracts from King County in Washington, based on the 2010 census. King County's population is over 1.9 million and it is the 14th most populous county in the United States (U.S. Census 2010). King County has 39 cities, ranging in size from Seattle, with more than 608,000 people as of 2011, to Skykomish and Beaux Arts, with fewer than 350 each. Other large cities in King County are Bellevue, Auburn, Federal Way and Renton.

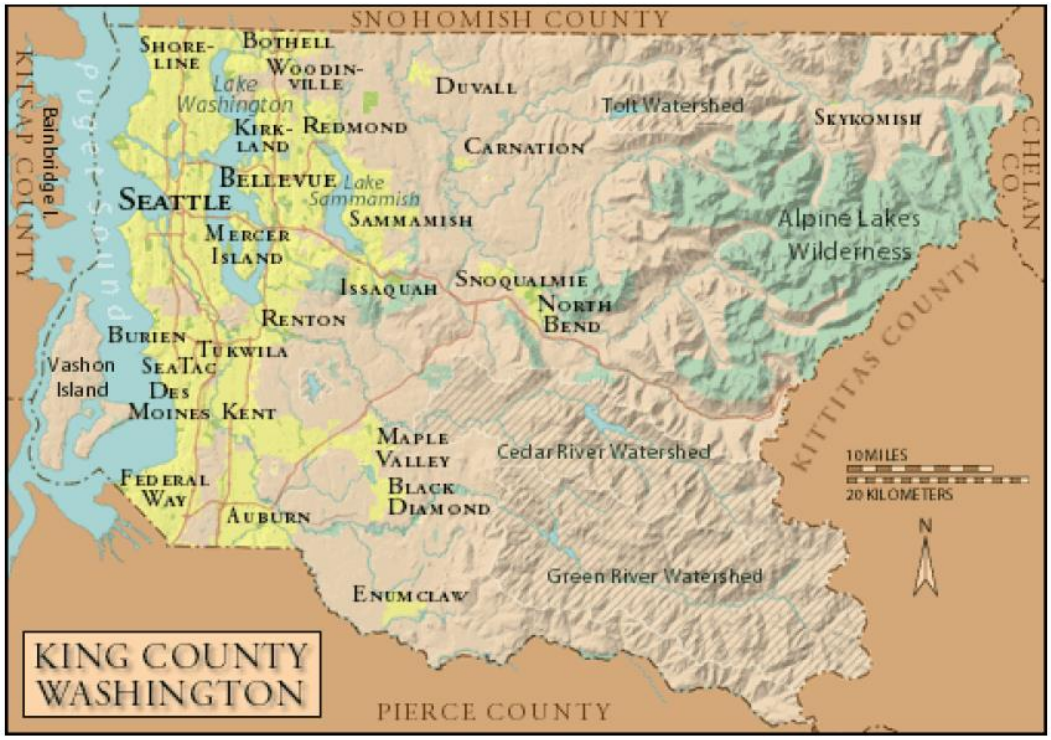


Figure 3. *King County, Washington*

Source: King County website

King County is located between Puget Sound to the west and the crest line of the Cascade Range to the east (Vance-Sherman, 2013). It borders Snohomish County to the north and Pierce County to the south. King County covers 2,130 square miles, and is geographically diverse. It extends from Puget Sound in the west to 8,000-foot Mt. Daniel at the Cascade crest to the east. King County's various landforms include saltwater coastline, river floodplains, plateaus, slopes, and mountains, punctuated with lakes and salmon streams[2].The County is composed of a diverse landscape of vibrant cities to rural areas. This dissertation focuses on

[2] Source: King County Website http://www.kingcounty.gov/exec/PSB/Demographics/KCGrowthReport/GettingToKnowKC.aspx

density and social equity in urban spaces and therefore excludes rural areas and focuses on urban areas. The density in the urban areas of the county varies considerably from suburb to central business district (CBD), and it is appropriate to investigate and analyze the phenomenon of density in urban space.

Table 5 shows the comparison of some census data between King County and the U.S. average. According to the American Community Survey, King County has a larger Asian population than the national average. Most King County residents age 25 and older (91.9 percent) are high school graduates, which compares favorably with 85.4 percent of U.S. residents. Those with a bachelor's degree or higher made up 45.7 percent of King County residents age 25 and older, compared to 28.2 percent of U.S. residents. As shown in Table 1, the median household income was $70,567 in 2011, more than the national average of $52,762.In 2011, 10.5 percent of the population was living below the poverty level, lower than the national average of 14.3 percent.

Table 5

Comparison between King County and the U.S. Average

		King County	USA
Population percent change (April 1, 2010-July 1, 2012)		3.9%	1.7%
Race	White alone (2012)	71.3%	77.9%
	Black/African American (2012)	6.5%	13.1%
	American Indian/Alaska native (2012)	1.0%	1.2%
	Asian (2012)	15.5%	5.1%
	Hispanic/Latino (2012)	9.2%	16.9%
	Two or more races (2012)	4.7%	2.4%
Education	High school graduate or higher (2007-2011)	91.9%	85.4%
	Bachelor's degree or higher (2007-2011)	45.7%	28.2%
Economic Status	Median value of owner-occupied housing units (2007-2011)	$402,300	$186,200
	Median household income (2007-2011)	$70,567	$52,762
	Persons below poverty level (2007-2011)	10.5%	14.3%

Source: U.S. Census Bureau Quick Facts

Figure 4. *Seattle*

Source: Campoli and MacLean, 2007

Scale of Analysis and Data

This study chooses neighborhoods as the unit of analysis since they can be considered as the "basic building block of urban form" (Song & Knaap, 2004, p. 215). Thus, the study investigates density and social equity by census tract scale. As in most small-area research, the dissertation defines neighborhoods by census tracts. The census tract is a geographic region defined for the purpose of taking a decennial census and the American Community Survey. According to the U.S. Census Bureau, it is "designed to be relatively homogeneous units with respect to population characteristics, economic status, and living conditions."[3] Census tracts are small geographic units with an average of about 4,000 residents (Dwyer, 2010). Therefore, census tracts are the best units available and the most commonly used, even though their

[3] Source: http://www.census.gov/acs/www/data_documentation/custom_tabulation_request_form/geo_def.php

boundaries do not necessarily correspond with what residents consider neighborhood boundaries. The selection of this analysis unit also enables us to obtain a large database, sufficient for employing a statistical model.

The dissertation focuses on density and social equity in urban space. Therefore, the study selected 374 out of 398 census tracts in the county after excluding 24 tracts with very low population density, 1,000 persons per square mile based on the study Ewing et al. (2002). The database for each census tract consists of a combined file from King County's GIS center[4], 2010 census data, and the American Community Survey on demography, economy, housing, and transportation.

How to Measure Density

Issues to consider when measuring density. There are different types of density, as well as many ways and scales of measuring it (Churchman, 1999; Burton, 2000; Dovey & Pafka, 2014). There are a lot of definitions of density, and it also raises issues about which dimension to use and when to use it. For urban planning research, the most appropriate approach for selecting which density measure to use often depends on the purpose for using the density measure, the characteristics of the development and the surrounding area. Some scholars have suggested that density is a composite of concepts such as intensity, compactness, and height (Boyko & Cooper, 2011). Thus, for better understanding of the relation between density and urban form, scholars and decision-makers in urban planning need to consider other aspects of the urban fabric and incorporate them into density definitions (Berghauser Pont &

[4] Source: http://www5.kingcounty.gov/gisdataportal/Default.aspx

Haupt, 2007). In addition, urban spaces are three dimensional in scope and scale, thus, there is a need to develop measures that are able to represent the three dimensionality of urban form, such as spatial measurement using Geographical Information System (GIS).

Urban density indicators. The most widely used methods for determining density are population density and residential density. Population density is a ratio in which a measure of the population serves as the numerator and a measure of the land area as the denominator. Residential density, which is used more often to determine density in urban planning, is usually represented as dwelling unit per acre. In the field of urban design, housing density seems to be more useful than population density because population is a variable affected by the size of households. In addition, there are two kinds of density: the gross density, in which the denominator is total land area, and net density, in which the denominator is a pared-down measure of the usable land area (Hess et al., 2007). Lopez and Hynes (2003) suggest that low-density areas are 200 to 3,500 persons per square mile, and high density areas are more than 3,500 persons per square mile. Wolman et al. (2005) suggests that an area with a density of at least 1,000 persons per square mile is an urbanized area. Housing density or residential density means the average number of residential units per square mile of developed land area. Galster et al. (2001) claims that lower densities are more sprawl-like, but there is little evidence on a specific number for sprawl. Lopez and Hynes (2003) provide low-density areas are 200 to 3,500 persons per square mile, and high density areas are more than 3,500 persons per square mile. Wolman et al. (2005) suggests that an area with a density of at least 1,000 persons per square mile is an urbanized area. Housing density or residential density means the average number of

residential units per square mile of developed land area. Galster et al. (2001) claims that lower densities are more sprawl-like, but there is little evidence on a specific number for sprawl.

Generally, in measuring density, the numerators represent the volume of activities, and the denominators denote the area of land that is available for the corresponding activities. Therefore, the numerators can be substituted with other activities to measure density. The number of employees in a certain area can be a variable to measure urban density (Cutsinger et al., 2005; Lin & Yang, 2006). Job density or employee density is calculated as the total number of filled jobs in an area divided by an area of urban development land. The number of jobs in an area comprises jobs done by residents and jobs done by workers who commute into the area (Hastings, 2003). Employees' commuting is related to transportation system. The street network affects inflow and outflow of population and urban resources, and street density is associated with urban density. Vehicle density can be used as a measurement for density in urban space (Bramley & Power, 2009).

Ewing et al. (2002) suggest the percentage of population living at densities greater than 12,500 persons per square mile should be used to measure density. The population density of 12,500 persons per square mile is the density that begins to be transit-supportive. Higher concentrations of people make mass transit feasible, and transit is the most efficient way to move large numbers of people (Campoli & MacLean, 2007). Therefore, people can use public transit in the area with 12,500 people per square mile, and perceive higher density in the area than in car-dependent areas.

Table 6

Urban Density Indicators

Dimension	Indicator		Measurement
Physical density	Population density	Gross density	Population per square mile of census tract area
		Net density	Population per square mile of urban built-up area[5]
	Housing density		Housing units per square mile of urban built-up area
	Street density		Streets length per urban built-up area
	Job density		Employees per square mile of urban built-up area
	Vehicle density		Vehicles in households per square mile of urban built-up area
Spatial density	P12500		Percentage of population living at densities greater than 12,500 persons per square mile, an urban density that begins to be transit-supportive
	Block size		Average perimeter of blocks

Block size can also be associated with spatial density. A census block is defined as an area formed by streets, roads, railroads, streams, and geopolitical boundary lines[6]. According to Ewing et al. (2003, pp.572-573), "a traditional urban neighborhood is composed of intersecting

[5] The urban built-up area is the developed land area. In this study, the urban built-up area is calculated by the land area in parcels, such as residential, commercial, industrial, and other land use parcels.

[6] Source: www.census.gov/geo/reference/pdfs/GARM/Ch11GARM.pdf

roads that create a boundary around a block or neighborhood..... Therefore, the length of each side of that block, and the block size, is relatively small. By contrast, a contemporary suburban neighborhood does not make connections between adjacent cul-de-sacs or loop road. Thus, the length of a side of a block is quite large." Thus, smaller block size promotes higher density development, and is one of the spatial characteristics to make people perceive dense urban form.

How to Measure Social Equity

Accessibility. First, this study measures access to urban services and facilities to evaluate spatial distribution using GIS data from the GIS center of King County. In terms of measuring social equity, accessibility is commonly employed as a fundamental measure (Burton, 2000; Nicholls, 2001; Cutts et al., 2009). The principle of justice can be understood as meaning that all people in a place have equal access to the good things and equal distance from the bad ones (Lindsey et al., 2001; Witten et al., 2003; Redman & Jones, 2005). Thus, this study measures spatial distribution through access to urban service facilities. Territorial justice can be achieved when access to services is equalized across geographical areas (Kay 2005). The study focuses on a local scale, exactly census-tract level, in light of the everyday experience of the urban facilities. Dempsey et al. (2011) suggest the following facilities as local services for daily needs: doctor/GP surgery, post offices, pharmacy, supermarket, bank, corner shop, primary school, restaurant/coffee shop/pub, library, sports/recreation facility, community center, facility for children, and public space. Mullligan and Carruthers (2011) suggest that urban amenities are critical facilities for the quality of life of residents, and they use several services, such as public goods and services, private consumption goods, transportation and

communication, and cultural institutions, to evaluate quality of urban life. To examine access to urban services, this study chooses grocery store, library, park, medical facility, fire station, and police station, based on the study of the previous studies.

This study relies on place-based accessibility measures to identify and measure accessibility in a census tract. The place-based measures examine the proximity to desired activity locations from an original location for an individual such as home or workplace (Miller 2007).There are a variety of place-based measures: for example, the travel distance to the nearest service location, the number of services within a particular geographical unit, and the gravity-based measures (Neutens et al., 2010). This study employs one of the most popular measures, the travel distance to the nearest service location, and calculates the length of the shortest network path along transportation infrastructure such as streets and roads, using Network Analyst in ArcGIS 10.2. To explain more specifically, this study computes the distance between the centroid of the block centroids (original location) and the service in the census tract (service location), and then calculates the average distance between the block centroids and the service to get the geographical accessibility of a service for a population living in a census tract. For evaluating accessibility to urban resources in residential areas, spatial units with socioeconomic information vary in size from smaller areas (block) to larger ones (census tract), and accessibility measured for smaller units is more precise aggregation methods. This method accounts for the spatial distribution of the population inside the census tract in order to minimize aggregation error (Apparicio et al., 2008).

This study also examines differences in access to the urban facilities using the Gini coefficient, which is recognized as a measure of inequality (Neutens et al., 2010). The Gini

coefficient is calculated as the ratio of the area between a Lorenz curve and the line of perfect equality to the triangular area below the line of perfect equality. A Lorenz curve is a graphical representation of the cumulative distribution of wealth across the population in the field of economics, but it can be also applied to any quantity that can be cumulated across a population (Delbosc & Currie 2011). The Lorenz curve plots the rank-ordered cumulative distribution of population against the cumulative distribution of accessibility (Ahmad Kiadaliri et al., 2011).

In terms of the Gini coefficient, when B is the area under the Lorenz curve, then the Gini coefficient (G) can be calculated as the ratio of the area that lies between the Lorenz curve and the line of equality (area A) and the total triangular area under the line of equality (are A + area B) (Wang et al., 2012).

$$G = \frac{A}{A + B}$$

As shown in Figure 5, the line of equality shows that accessibility is uniformly distributed among the population. The Gini coefficient ranges from 0 to 1. A higher Gini coefficient indicates unequal distribution, with 1 corresponding to perfect inequality, while a lower Gini coefficient indicate a more equal distribution, with 0 corresponding to perfect equality. Therefore, this study calculates a Lorenz curve and Gini coefficient for accessibility to each facility, and compares them to examine differences in the facilities.

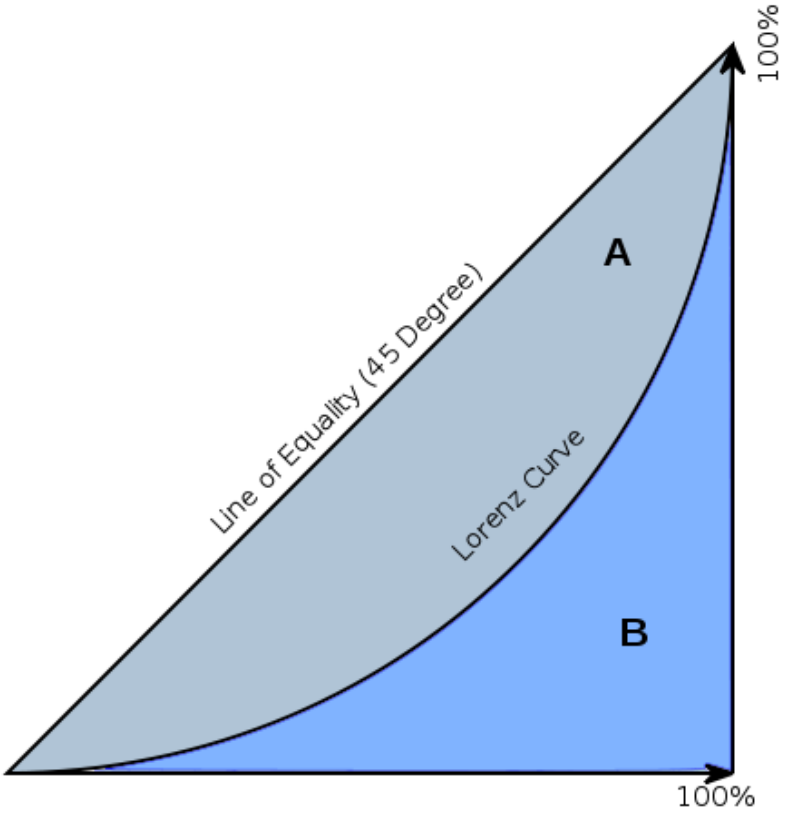


Figure 5. Gini coefficient (general)

Source: http://en.wikipedia.org/wiki/File:Economics_Gini_coefficient.svg

Diversity. To evaluate social equity, this study also measures the degree of segregation and diversity to examine the level of social mixing in a community. Massey and Denton (1988) identify five key dimensions of segregation: evenness, exposure, concentration, centralization, and clustering. The evenness dimension identifies the degree to which a group is spread in equal proportions among another group across area units, as the most commonly studied for segregation (Dwyer 2010). Thus, the evenness dimension can be aligned with the concept of

diversity. "Evenness" refers to the differential distribution of social groups among units in a city. A minority group is said to be segregated if it is unevenly distributed over areal units (Blau, 1977). Evenness is maximized and segregation minimized when all units have the same relative number of minority and majority members as the city as a whole. Conversely, evenness is minimized, and segregation maximized, when no minority and majority members share a common area of residence. Plenty of studies regarding segregation are neighborhood-level studies rather than research focusing on the broader spatial region (Dwyer, 2010). Therefore, this study investigates the degree of evenness for economic status in each census tract.

To evaluate the evenness of a census tract, this dissertation uses the calculation of an entropy index in terms of race and income. The entropy index measures the distribution of groups across a census tract, and the entropy score is defined by the following formula, from Iceland (2004):

$$Entropy = \{-\sum\nolimits_k [(p_i)(\ln p_i)]\} / (\ln k)$$

To examine the distribution pattern of different races and incomes uses within a census tract, the index spells out that p_i=proportions of each of the race/income types. When there is only one group in the population, the index will be 0. The maximum is attained when all the ethnic groups or all the income level groups are equally present and is calculated as 1.

In addition, to examine the degree of segregation in a census tract, the dissertation employs a dissimilarity index, which is one of the most commonly used measures of residential evenness (Massey & Denton 1988). The index is used to assess segregation between two groups

and has a value of between 0 and 1. In this dissertation, this measure computes the sum total in a census tract of the differences in the relative populations in subareas. This chapter looks at non-white and white segregation in each of the census tracts of King County, using census blocks as the subareas. One formula for the dissimilarity index is:

$$D_j = \frac{1}{2}\sum_{i=1}^{n}\left|\frac{x_{ij}}{X_j} - \frac{y_{ij}}{Y_j}\right|$$

In the equation, *j* denotes the census tract and *i* denotes the census block; x and X represent the number of minorities at the block and census tract levels of observation, respectively; y and Y represent the number of white people at the two levels. In other words,

D = the index of dissimilarity for two groups being compared within a census tract *j*

X_{ij} = the population of group x (minority) in block *i*

X_j= the total population of group x (minority) in the overall census tract *j*

y_{ij}= the population of group y (white) in block *i*

Y_j = the total population of group y (white) in the overall census tract *j*

where x_{ij}/X_j and y_{ij}/Y_j are the respective percentages of non-whites and whites residing in block *i*. This index varies from 0 (no segregation) to 1 (complete segregation). D indicates the percentage of non-whites (or whites) that would have to move to other blocks in order to achieve parity between non-whites and whites in their percentage distributions across all blocks in the community.

Affordable housing for low-income households. This study examines the ratio of affordable housing for low-income households out of total housing units. Low-income housing is a prominent urban service and facility for the disadvantaged in an economic status. Housing is one of the most important services that a city provides to people within the city and is an indispensable part of their lives. For low-income housing, this study specifically deals with affordable housing for low-income households, including rental units and ownership. The rental units and ownership are considered affordable if they cost less than 30 per cent of a household's income. This study focuses not on services offered by housing, but on the stock of the housing. Thus, this study calculates the affordable housing units for low-income households in King County.

This study examines occupied units that are affordable for low-income households whose yearly income is less than $35,000. Aurand (2010) provides a definition of "very low-income household" based on the study of the U.S. Department of Housing and Urban Development (2007). This dissertation follows the definition, "a very low-income household is less than 50 per cent of their area's median." According to the American Community Survey (2007-2011) from the US Census Bureau, the median income of King County is $70,567. Census household income data for tracts is available only as categorical measure of the number of households at defined income levels: for example, less than $20,000, $20,000 to $34,999, $35,000 to $49,999, $50,000 to $74,999, $75,000 or more. This study uses less than $35,000 for low-income household because it is the closest to the value of the half of the median income. Thus, it includes two categories, less than $20,000 and $20,000 to $35,000, in the dataset for low-income households.

In terms of affordable housing, according to the US Department of Housing and Urban Development (HUD), an affordable housing unit is one whose cost is no more than 30 per cent of income (Aurand, 2010). Therefore, a housing unit is affordable if the housing cost is at the affordable level. This study also classifies the units of affordable housing into rental and owned homes.

Crime. This study categorizes crime into violent and property crime. Violent crime includes assault, robbery, homicide, and others, while property crime includes vehicle theft, burglary, and others. For the study, property and violent crimes were selected from a database of crimes that were reported to the Seattle Police Department in 2011.

How to Explore Association between Density and Social Equity

Mapping through GIS. At the heart of all applications of the GIS are the concepts that researchers collectively describe as "spatial thinking." A researcher can be said to be thinking spatially when he/she draws inferences from data arrayed spatially, that is, presented in the form of a map or data contained in a GIS database (Goodchild, 2010). The geographic world is visualized though maps, which are correct representations of the spatial distribution of phenomena. Maps simplify and scale the world, allowing the researcher to search for patterns and correlations. By making a map, it is often possible to gain insight into the kinds of processes at work on the landscape, because the map or the researcher's own knowledge might link an anomaly to other possible factors in the anomaly's "spatial context" (Goodchild, 2010, p.382).

Statistical analysis. The dissertation employs statistical analysis such as factor analysis, correlation analysis, ANOVA, and regression analysis. Statistical analysis focuses on relationships when pursuing the answer to the research question or the posed hypothesis, and testing that hypothesis for validity and reliability. The most notable attribute of quantitative methods is that they allow the researcher to generalize results more readily than qualitative methods do, if data are derived from a random sample of sufficient size (Fowler, 1984). Statistical analysis, as one example of quantitative research, can also be more easily replicated on different populations and subpopulations, eventually allowing predictions to be made. Quantitative researchers have more control over confounding variables, allowing them to develop cause and effect explanations more credibly (Johnson et al., 2004).

CHAPTER 4

GEOSPATIAL UNDERSTANIDNG OF URBAN DENSITY

This chapter investigates the meaning of density by tracing some of the ideas related with urban forms. This chapter aims to develop an integrated density including physical features relevant to urban form index and then classify the census tracts in King County accordingly.

Variables for Urban Density

From the previous studies, this study has eight indices for density in order to measure the level of density (Table 7). In the study, urban density is considered as having two dimensions: physical density and spatial density. The database for each census tract consists of a combined file from King County's GIS center[7], 2010 census data, and the American Community Survey on demography, economy, housing, and transportation.

Table 8 shows the result of descriptive statistics and reliability test of instrument items, and Table 9 shows the correlation matrix of factor scale items. Correlational studies can establish statistically significant associations between variables. In Table 5, seven items except block size (BLCKSZ) are positively associated with other density items, and they are statistically significant ($p<0.001$). The block size (BLCKSZ) has a negative association with the others. Therefore, BLCKSZ is transformed into inverse form to make an appropriate density index.

[7] Source: http://www5.kingcounty.gov/gisdataportal/Default.aspx

Table 7

Variables for Urban Density

Dimension	Variables		Measurement	Direction on urban density	Influence on density
Physical density	Population density	Gross density	Population per square mile of census tract area	Positive (+)	Concentration of people
		Net density	Population per square mile of urban built-up area[8]	Positive (+)	Concentration of people
	Housing density		Housing units per square mile of urban built-up area	Positive (+)	concentration of housing
	Street density		Streets length per urban built-up area	Positive (+)	concentration of street
	Job density		Employees per square mile of urban built-up area	Positive (+)	concentration of jobs
	Vehicle density		Vehicles in households per square mile of urban built-up area	Positive (+)	concentration of vehicle
Spatial density	P12500		Percentage of population living at densities greater than 12,500 persons per square mile, an urban density that begins to be transit-supportive	Positive (+)	Physical environment and people mobility with public transit
	Block size		Average perimeter of blocks	Negative (-)	Large lot size, space between buildings

[8] The urban built-up area is the developed land area. In this study, the urban built-up area is calculated by the land area in parcels, such as residential, commercial, industrial, and other land use parcels.

Table 8

Descriptive Statistics and Reliability Test of Instrument Items

Variable	Obs	Mean	Std. Dev.	Min	Max	Item-rest correlation	Cronbach's Alpha(item)	Cronbach's Alpha
POPGROSS	374	9974.34	9988.13	608.15	75883.53	0.9544	0.8437	0.9005
POPNET	374	12551.9	15817.02	859.61	127783.3	0.9721	0.9015	
HOUS	374	3766.63	6283.97	109.95	56461.67	0.9641	0.8625	
JOB	374	4114.95	6001.03	150.69	58633.28	0.9583	0.8657	
VEHICLE	374	3414.62	5685.1	80.43	56369.27	0.9607	0.8684	
STREET	374	30.01	22.52	4.62	172.1385	0.7970	0.9377	
BLCKSZ	374	3324.47	1239.79	1195.50	7643.972			
P12500	374	26.82	26.33	0	100			

Table 9

Correlation Analysis

	POPGROSS	POPNET	HOUS	JOB	VEHICL	STREET	BLCKSZ	P12500
POPGRO	1							
POPNET	0.9730**	1						
HOUS	0.9080**	0.9399**	1					
JOB	0.9057**	0.9324**	0.9701**	1				
VEHICLE	0.9017**	0.9300**	0.9921**	0.9828**	1			
STREET	0.7538**	0.8186**	0.7811**	0.7451**	0.7497**	1		
BLCKSZ	-0.5481**	-0.5321**	-0.5035**	-0.5318**	-0.4976**	-0.6464**	1	
P12500	0.7151**	0.6772**	0.6840**	0.6549**	0.6565**	0.6600**	-0.6387**	1

** significant at a 0.01 level (two-tailed)

Exploratory Factor Analysis

The eight density variables were factor analyzed to identify the relationships among the variables. Table 8 and 10 show the results of reliability test and factor analysis (EFA). The factor analysis (EFA) was used to check the dimensions for urban density factors. In the model, eight items were conducted for specifying urban density (Table 8). As a result, two factors was retained (Obs=374, $Chi^2(28) = 6182.49$, $Prob>chi^2 = 0.0000$). Table 10 shows the Eigen value and two factors (Eigen value >1) that were retained. The eigenvalue of factor1 (physical density factor) is 5.44, which means that this one factor accounts for more of the variance in the original dataset than five of the individual variables combined. The eigenvalue of factor 2 (spatial density factor) is 1.76.

Table 10

Rotated Factor Loadings for Urban Density

	Variables	URBAN DENSITY	Uniqueness	Eigenvalue	Variance Percentage (%)
Factor 1	POPGROSS	0.9546	0.0887	5.4416	90.69
	POPNET	0.9804	0.0389		
	HOUS	0.9810	0.0376		
	JOB	0.9720	0.0553		
	VEHICLE	0.9755	0.0483		
	STREET	0.8429	0.2895		
Factor 2	N_BLCKSZ	0.9393	0.1177	1.7645	88.23
	P12500	0.9393	0.1177		

Method: principal-component factors / Rotation: orthogonal varimax

Urban density index. The next issue is how to combine the two factors into a single urban density index. Should the two factors be weighted equally, or should one given more weight than the others? Density has generally received more attention as an aspect of physical density (such as population density and housing density) than has spatial density, even though recent studies, for example Dempsey et al. (2010) and Dave (2011), focus on perception of density. Thus, each item is standardized based on a 0 to 1 scale, and the two factors were simply summed. The integrated urban density index indicates the sum of eight variables collected at the census tract level. Thus, physical density had more weight than spatial density because physical density had total 6 items and spatial density had 2 items.

Table 11

Urban Density Index

Variable	Obs	Mean	Std. Dev.	Min	Max
zPOPGROSS	374	0.1244	0.1327	0	1
zPOPNET	374	0.0921	0.1246	0	1
zHOUS	374	0.0649	0.1115	0	1
zJOB	374	0.0678	0.1026	0	1
zVEHICLE	374	0.0592	0.1010	0	1
zP12500	374	0.2682	0.2634	0	1
znew_BLCKSZ	374	0.3085	0.2025	0	1
zSTREET	374	0.1516	0.1345	0	1
DENSITYINDEX	374	1.1367	1.0465	0.0453	7.1730

The integrated urban density index was normalized to a positive Z score, with the highest dense area receiving a score of the highest score (8) and the lowest dense area receiving a score of 0. Normalization of scores is an acceptable technique in density studies (Ewing et al., 2002, Frenkel and Ashkenazi, 2008), and is done to transform the scores into an equable and convenient scale that enables a relative comparison of observation. The positive Z score was computed by standardization to mean of 0. The study normalized the final density index *Xi* to a *Z* score *Zi* as follows:

$$Z_i = \frac{X_i - X}{\sigma} \times 100$$

where *X* is the average weighted sprawl index of the sample and σ is the standard deviation of the sample. The study chose to work with a positive nominal scale of *Z* scores. Hence all *Z* scores were shifted accordingly by adding to them the absolute value of the minimal (and negative) score of the scale. Based on standardized scores, percentile groups of the urban density index were calculated. Comparing the percentile ratios indicates whether densities of census tracts are remaining at the same level, becoming more dense, or less dense.

Based on the integrated urban density index value (Zi), each of the census tracts in the sample was ranked on a relative "density scale" (density score 1-10). The study then divided the sample into five density groups (Figure 6). Highly dense areas are nearly all Seattle areas and suburban cities, and low-density areas are usually the outskirts of the county. The census tracts with small size are likely to have high density. Low-density tracts usually have higher land consumption than do high-density tracts.

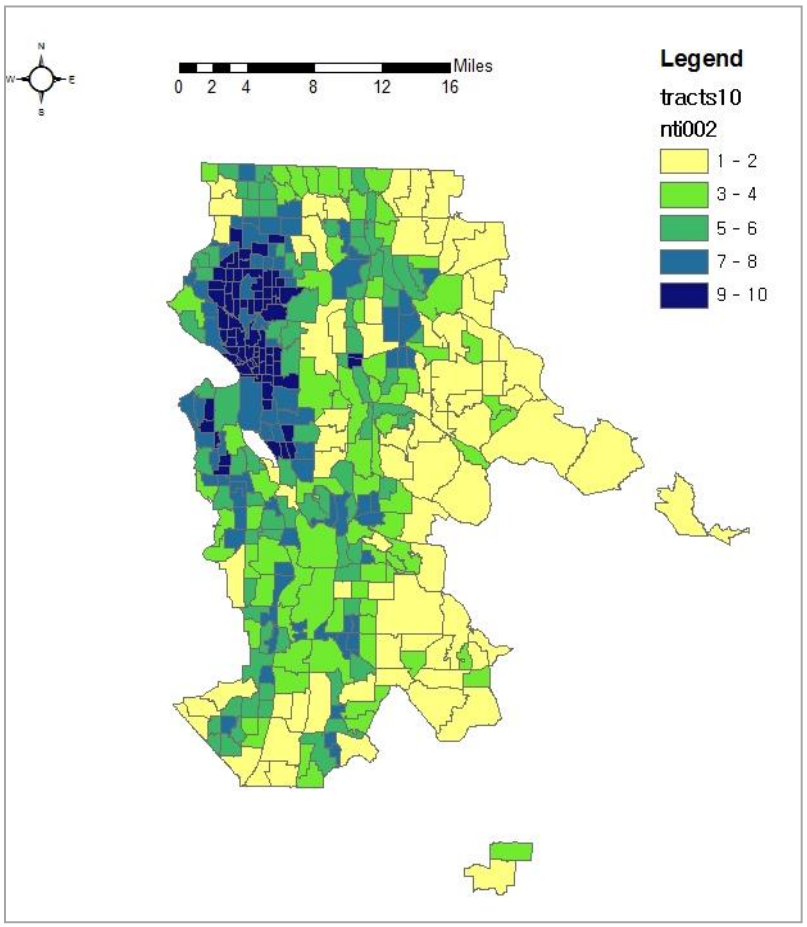


Figure 6. *Urban Density Index (King County, Washington)*

Discussion

How is the integrated density including urban form different from residential density, mainly used in the case of urban planning? The integrated density index, suggested in this chapter, is composed of a variety of urban activities, such as employee, transportation and block size, while the population and housing density focuses on the activity of residence in cities.

Therefore, the study calls the index made up from gross population density, net population density, and housing density as "residential density" from now on, to examine if there is any difference between the residential density index and the integrated index in terms of spatial pattern.

To compare the integrated index with residential density, census tracts were first categorized by comparing the composite score from the three items (zPOPGROSS, zPOPNET, and zHOUS) with the summed score of the integrated density index from eight items (zPOPGROSS, zPOPNET, zHOUS, zJOB, zVEHICLE, zP12500, znew_BLCKSZ, and zSTREET). Table 12 shows descriptive statistics of residential density index and integrated density index. The integrated density index has more variance than the residential index. As shown in Table 13, two indices are significantly correlated.

Table 12

Descriptive Statistics of the Residential Density Index and the Integrated Density Index

Variable	Obs	Mean	Std. Dev.	Min	Max
Residential density index	374	0.281	0.361	0.0076	2.8757
Integrated urban density index	374	1.136	1.046	0.0453	7.1730

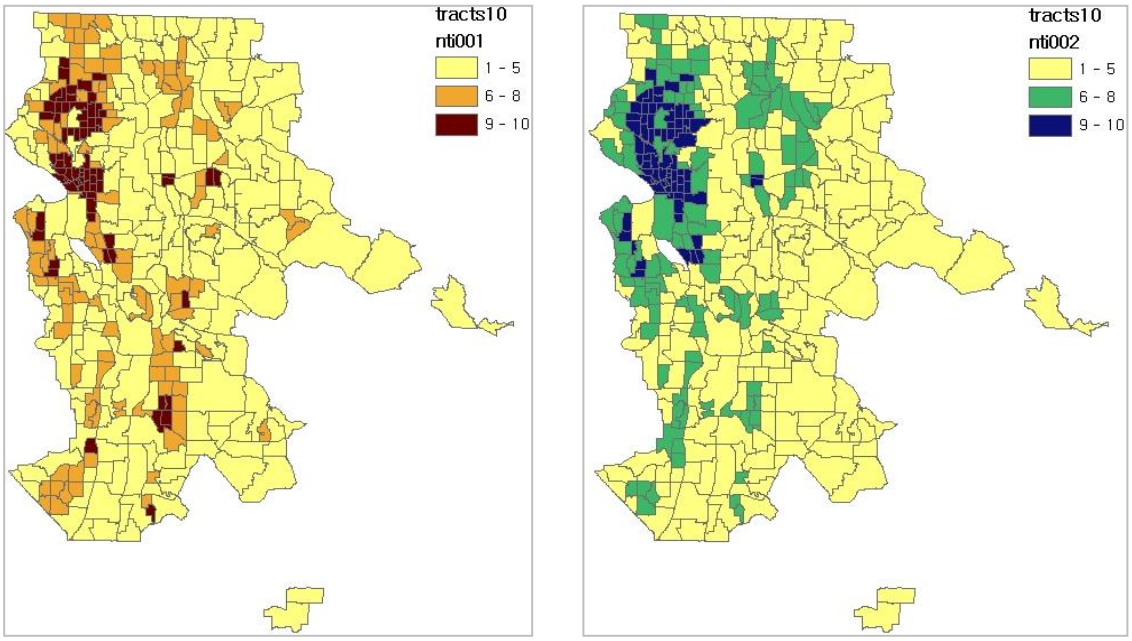
Table 13

Correlations between the Residential Density Index and the Integrated Density Index

		Residential density index	Integrated density index
Residential density index	Pearson Coefficient Sig. (2-tailed) N	1	
Integrated density index	Pearson Coefficient Sig. (2-tailed) N	.9476** .000 374	1

**. Correlation is significant at a 0.01 level (2-tailed).

Based on standardized scores, percentile groups of residential density index and the integrated urban density index were calculated. Comparing the percentile ratios indicates whether densities of census tracts are remaining at the same level, becoming more dense, or becoming less dense. The study calculated the percentile ratios with the residential density index and the integrated density index, and compared them. In this study, density index values between 1 and 5 indicate low density, values between 6 and 8 indicate moderate density, and values between 9 and 10 indicate a high level of density. Figure 7 shows the spatial pattern from the density index as compared with the pattern from residential density.



Left: Residential Density Index Right: Integrated Urban Density Index

Figure 7. *Residential Density Index and Integrated Urban Density Index (King County, Washington)*

Table 14 shows that there are some variations between residential density index and integrated density index. The number of census tracts in remaining groups at the same level (low-low, med-med, and high-high) is more than 92%, but 27 census tracts (7.2%) show increasing or decreasing patterns.

Table 14

Change between Residential Density Index and Integrated Density Index

	Residential density index		Integrated density index
Low (n=160, 42.8%)	Low	→	Low
Changed: Increased (n=20, 5.3%)	Low	→	Medium
	Low	→	High
	Medium	→	High
Medium (n=124, 33.2%)	Medium	→	Medium
Changed: Decreased (n=7, 1.9%)	High	→	Medium
	High	→	Low
	Medium	→	Low
High (n=63, 16.8%)	High	→	High

To clarify the difference between the residential density index and the integrated density index, it is important to identify the characteristics of 27 census tracts (7.2%) that showed increasing or decreasing patterns. For example, Census Tract 005302 is in the low-density group when it comes to only residential density. However, the tract has a high-density score for integrated urban density. That is, the tract can be categorized as a highly dense area in terms of urban morphology. The tract is located in the central area of Seattle, and has many

high-rise buildings such as the University of Washington, Husky Ball Park, and Museum (Figure 8). Therefore, the tract has dense urban form and a high value for the integrated density, while residential density is low because there are small number of residents and houses.

On the contrary, Census Tract 032211 is included in the medium-density group for residential density, but has a low value for integrated density (Figure 9). The tract is located in a suburban area and was developed for residential areas with a lot of housing. For this reason, there is a difference when residential density and integrated density are applied to the area.

Figure 8. *Residential Density Index (Low) →Integrated Density Index (High): Census Tract 005302, King County*

Figure 9. *Residential Density Index (Medium) →Integrated Density Index (Low): Census Tract 032211, King County*

Figure 10 and 11 show a low-density neighborhood (A) and high-density one (B) with the same scale, 1:50,000. The neighborhoods A and B represent residential areas, and the parcels in grey are housing; single-family and multi-family housing. As shown in Figure 10 and 11, high-density neighborhood (B) has smaller parcel size, more street intersections and street connectivity when it is compared to low-density neighborhood (A). From the maps representing neighborhood design, the physical features for low- or high-density can be suggested.

Figure 10. *Low-Density Neighborhood (Census Tract 022102, Scale 1: 50,000)*

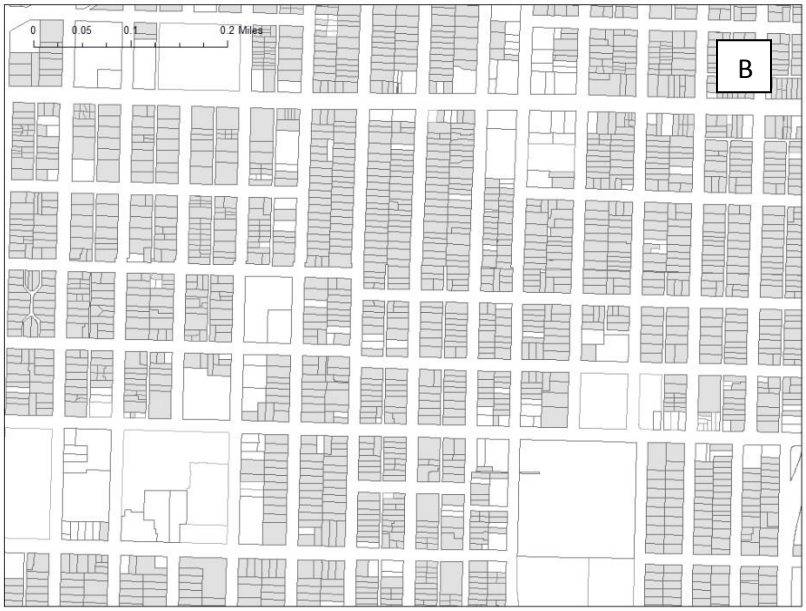


Figure 11. *High-Density Neighborhood (Census Tract 008700, Scale 1: 50,000)*

Though density is quite an objective indicator, it is a very complex concept because density is likely to be susceptible to individual's perception influenced by physical features. Urban density has a complicated relationship with urban morphology (Cheng, 2010). Despite the same density, different types of community development can exhibit quite different urban forms. Figure 12 shows three settlements with the same residential density of 76 dwellings per hectare, but they represent different urban forms. Therefore, density needs to be considered in relation to urban form, and it is not enough to evaluate density by only the concentration of people and urban resources. Urban form and architecture style can influence urban density with different layouts in many aspects.

Density is one of the prominent factors for urban design, and it influences not only urban form but also urban life. In addition, spatial density can be directly or indirectly affected by physical design because affects their quality of life through interaction with location and the shape of built environments.

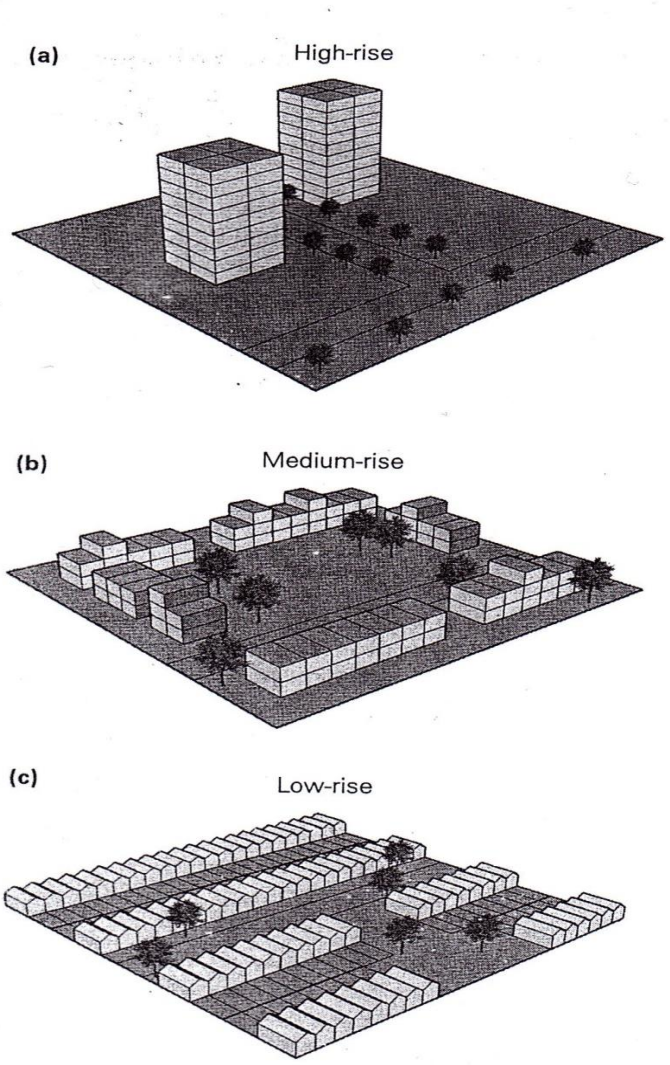


Figure 12. *Same Density in Different Layouts*

Source: Cheng(2010) p.10

This chapter reviewed the use of the term density and the complexity of the term. At the basic level, the measurement of density is simple and quite objective. However, the concept of

density can include the interrelationship with urban morphology, making its measurement more complex.

Successful density has been defined as “high enough to support the services and facilities locally provided,” and “large enough to attract employers to the area to capitalize on the workforce in the area” (Kaido, 2005, p.313). Successful density is not one solution that will meet the needs of every situation and context. There are various solutions for communities, housing, and transportation based on the needs of communities, regions, states, or/and countries. Thus, solutions should depend on an understanding of the differences in needs and expectations.

CHAPTER 5

GEOSPATIAL UNDERSTANDING OF SOCAIL EQUITY

This chapter identifies geospatial distribution of social equity in King County in terms of accessibility, diversity, and affordability.

Data and Analysis

The data for this chapter are to acquire accessibility, diversity, affordable housing for low-income households in census tracts within King County (Table 15, 16, and 17). Data on the locations of urban facilities, as suggested in Chapter 3, such as library, grocery shop, medical facility, park, fire station, and police station, were obtained from the GIS center in King County. The facilities include business/retail (grocery store), public space (park), culture (library), health (medical doctor/ hospital), and safety (fire station and police station), can be obtained from the GIS center of King County. GIS shape-files for the boundary and census tracts of King County were also accessed through the GIS center web site of the County. Data on income, races, and affordable housing were obtained through the U.S. Census Bureau, representing data from the 2011 American Community Survey.

Table 15

Data for Measuring Accessibility

Variable	Description	Dataset	Source
Access to grocery stores	Distance to the nearest grocery store (feet)	Parcel data (shape file)	King County GIS center
Access to medical facilities	Distance to the nearest hospital (feet)	Parcel data (shape file)	King County GIS center
Access to libraries	Distance to the nearest library (feet)	Parcel data (shape file)	King County GIS center
Access to parks	Distance to the nearest park (feet)	Parcel data (shape file)	King County GIS center
Access to fire stations	Distance to the nearest fire station (feet)	Parcel data (shape file)	King County GIS center
Access to police stations	Distance to the nearest police station	Parcel data (shape file)	King County GIS center

Table 16

Data for Measuring Diversity

Variable	Description	Dataset	Source
Poverty status	People in poverty status (%)	American Community Survey (2007-2011)	U.S. Census Bureau
Entropy Index: Income	Income diversity: even distribution across income groups[9] (0 to 1)	American Community Survey (2007-2011)	U.S. Census Bureau
Entropy Index: Race	Ethnicity diversity: even distribution across ethnic groups[10] (0 to 1)	American Community Survey (2007-2011)	U.S. Census Bureau
Dissimilarity Index: Race	Segregation of Nonwhite/White (0 to 1)	American Community Survey (2007-2011)	U.S. Census Bureau

[9] For this study, and the income groups are composed of 10 categories based on the U.S. Census data: less than $10,000, $10,000 to $14,999, $150,000 to $24,999, $25,000 to $34,999, $35,000 to $49,999, $50,000 to $74,999, $75,000 to $99,999, $ 100,000 to 149,999, $150,000 to $199,999, and 200,000 or more, based on the U.S. Census data.

[10] For this study, the ethnic groups are categorized into six ethnicities: White, Hispanic, Black, Asian, American Indian, and Others.

Table 17

Data for Measuring Affordable Housing for Low-income

Variable	Description	Dataset	Source
Affordable rental units for low-income family: monthly housing costs less than 30% of household income	Affordable rental units for low income/ Total rental units (%)	American Community Survey (2007-2011)	U.S. Census Bureau
Affordable owned homes for low-income family: monthly housing costs less than 30% of household income	Affordable owned housing for low income/ Total owned units (%)	American Community Survey (2007-2011)	U.S. Census Bureau

The analysis of these results progressed through two methods. First, all data were entered into a STATA database, and descriptive statistics and correlations were computed. Second, visualization through some graphs and mapping was employed to analyze spatial equity in this chapter.

Results

Accessibility. This study employs network distance to acquire accessibility to urban services. Walkability is also a measure of accessibility, especially for evaluating pedestrian access, but walkability is related to not only spatial access to urban services, but also other urban characteristics such as mixed-land use. This study employs a distance based analysis to measure accessibility to urban facilities.

With respect to the accessibility of the 374 census tracts, the distance to grocery stores ranged from 685 feet (0.12 mile) to 18,073 feet (3.42 mile), with an average of 4,499 feet (0.85

mile), as shown in Table 16. The average distance to a library of all census tracts is 8,605 feet, with a maximum distance of 28,528 feet and a minimum distance of 1802 feet. The average distance to a park is the shortest (3086 feet) among the facilities (min 784, Max 9,275, Std. Dev. 1470). The average distances to a medical facility, police station, and fire station are 8,869, 10,253, and 6,145 feet, respectively.

Table 18

Descriptive Statistics for Variables: Access to Facilities

Variable	Obs	Mean	Std. Dev.	Min	Max
Distance to grocery	374	4499.05	2807.54	685.92	18073.58
Distance to library	374	8605.87	4823.92	1802.25	28528.19
Distance to park/recreation	374	3086.00	1470.75	784.61	9275.49
Distance to medical facility	374	8869.99	5204.99	1115.44	32685.55
Distance to police station	374	10253.75	4977.60	2006.64	29355.05
Distance to fire station	374	6145.73	2273.66	1923.13	15999.79

Correlation coefficients between all the distances to the facilities were computed. Table 19 presents a summation of the correlation analysis, showing all positive correlations as well as those that were significant at the level $p<0.01$. All the following correlation results are statistically significant at the 0.01 level based on a two-tailed test. All distances to the facilities

are positively related with other facilities. For example, a community with longer distance from a grocery has longer distance from library, medical facility, park, fire station, and police station.

Among them, many scholars have suggested that proximity to parks is linked to quality of life and benefits (Chiesura, 2004; LSE, 2006). Particular, proximity to park can have benefits in terms of social and economic dimensions. Parks are publicly owned open space, and a well-distributed park system can help deliver public goods and promote social equity (Talen, 2010). In terms of economic dimension, park locations can influence on property values, and urban scholars have been interested in the relationship between proximity to park and economic benefits (Brown, 2008; Dehring & Dunse, 2006).

Table 19

Correlations: Accessibility

	GROCERY	LIBRARY	MEDICAL	PARKREC	POLICE	FIRE
GROCERY	1					
LIBRARY	0.7290**	1				
MEDICAL	0.6692**	0.6077**	1			
PARKREC	0.6430**	0.6554**	0.5353**	1		
POLICE	0.5174**	0.5804**	0.5608**	0.4120**	1	
FIRE	0.6621**	0.6356**	0.5204**	0.6054**	0.4241**	1

** significant at a 0.01 level (2-tailed)

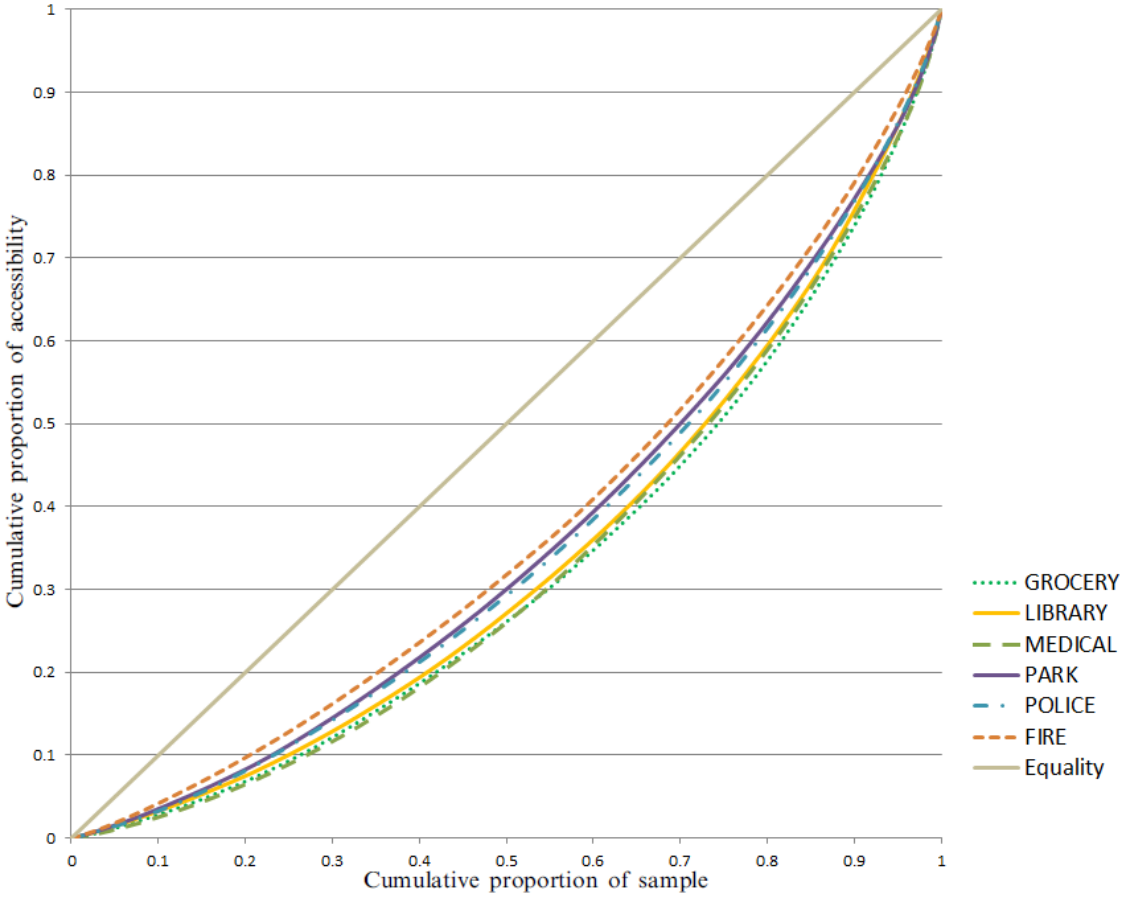


Figure 13. *Access to Urban Facilities: Lorenz Curves and Gini Coefficients*

(Gini Coefficients: $GC_{grocery}$= 0.29, $GC_{library}$=0.27, $GC_{medical}$= 0.27, GC_{park}= 0.21, GC_{police}=0.22, GC_{fire}=0.16)

The respective Lorenz curves are plotted and the Gini coefficients are shown in Figure 13. The higher the Gini coefficient, the more unequally accessibility is distributed among the population: 0 corresponds to perfect equality, in other words everyone has exactly the same accessibility, while 1 corresponds to perfect inequality. In this analysis, the highest Gini

coefficient appeared in grocery store ($GC_{grocery}$=0.29), and the lowest Gini coefficient is from fire station (GC_{fire}=0.16). Consistent with the traditional interpretation of inequality in distribution, a high Gini coefficient implies a greater disparity for a majority of the population. Therefore grocery stores have more disparity in the county in terms of accessibility.

Diversity. The entropy index, representing diversity or even distribution, varies between 0 and 1. When the race/income entropy index is higher, all the ethnic/income groups are more equally distributed. The average of race entropy is 0.43 (min: 0.03, Max: 0.76), and the average of income entropy is 0.89 (min: 0.30, Max: 0.93). The dissimilarity index varies from 0 to 1, where 0 means no segregation, while 1 represents complete segregation. The average of dissimilarity index is 0.43 (min: 0.17, Max: 0.99).

Table 20

Descriptive Statistics for Variables: Diversity and Segregation

Variable	Obs	Mean	Std. Dev.	Min	Max
RACENTROP	374	0.436	0.163	0.033	0.767
INCENTROP	374	0.896	0.041	0.309	0.930
DISSIM	374	0.434	0.115	0.178	0.991

Table 21

Correlations: Diversity and Segregation

	RACENTROP	INCENTROP	DISSIM
RACENTROP	1		
INCENTROP	0.0953	1	
DISSIM	0.1636**	-0.0118	1

** significant at the 0.01 level (2-tailed)

Table 21 shows the correlative relationship between the indices for diversity/segregation. The result of correlation for diversity/segregation is statistically significant at either the 0.01 or the 0.05 level based on a two-tailed test. A higher dissimilarity index (higher segregation of white/non-white) tends to have a higher race entropy index (more even distribution) at the 1% significance level.

In terms of race and income entropy index, the scores vary from 0 to 1 (0 means unequal distribution across the race/income groups, while 1 means perfectly equal distribution across the race/income groups[11]). Figure 14 shows the race entropy map. The tracts with dark red have more unequal distribution (entropy score <0.25), and the tracts in dark blue have more equal distribution across the ethnic groups (entropy score>0.61). Figure 15 represents income entropy.

[11] For this study, the race groups consist of six ethnicities: White, Hispanic, Black, Asian, American Indian, and Others, and the income groups are composed of 10 categories: less than $10,000, $10,000 to $14,999, $150,000 to $24,999, $25,000 to $34,999, $35,000 to $49,999, $50,000 to $74,999, $75,000 to $99,999, $ 100,000 to 149,999, $150,000 to $199,999, and 200,000 or more, based on the U.S. Census data.

Most tracts (362 out of 374 tracts) have an entropy score of more than 0.83, thus the areas have quite equal distribution across all the income groups.

Figure 16 shows the spatial pattern of the dissimilarity index, and the index represents the level of segregation between White and Non-White. The dark red tracts in the map are more segregated in White (or Non-White) (dissimilarity index>0.45), and the dark green areas are less segregated (dissimilarity index<0.22).

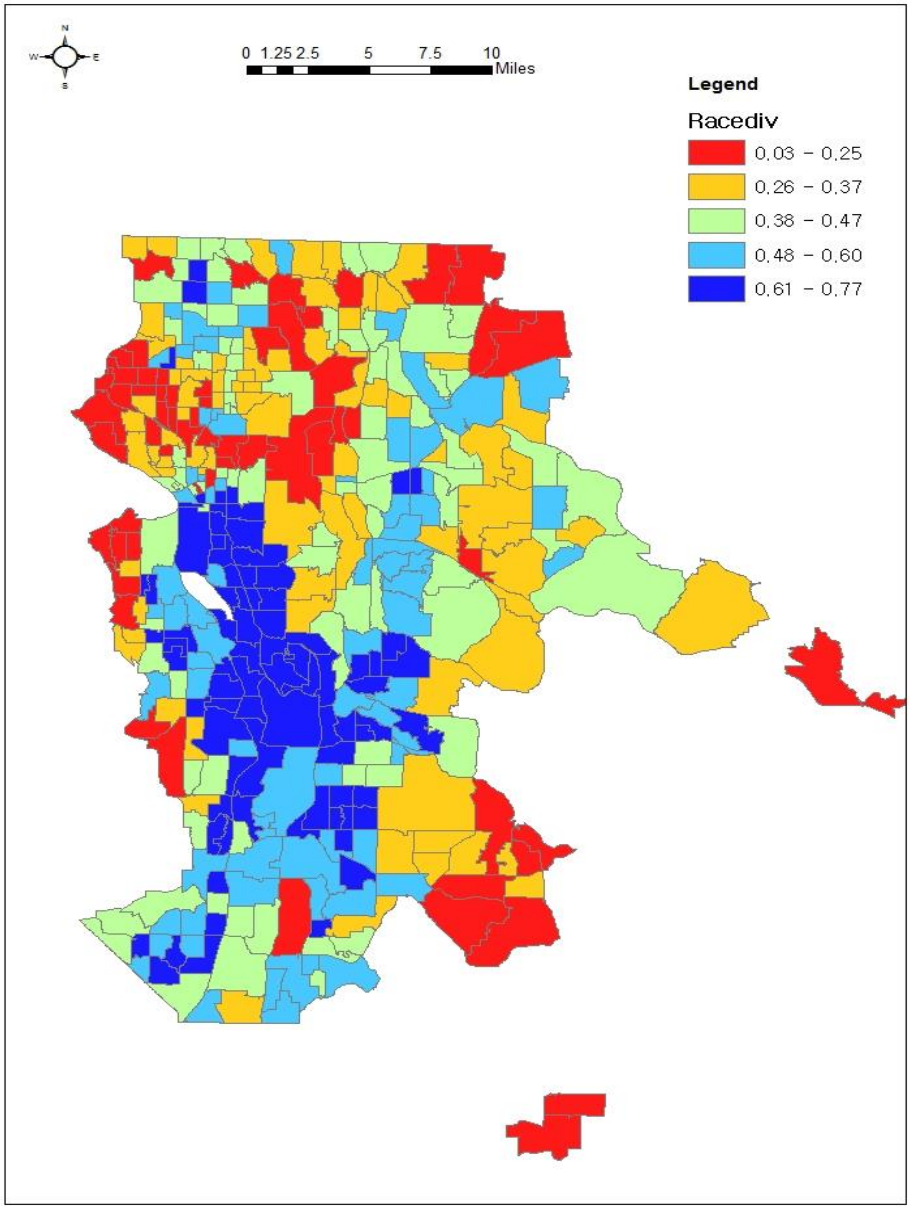


Figure 14. *Race Diversity*[12]

[12] The race diversity represents the distribution among White, Hispanic, Black, Asian, American Indian, and others.

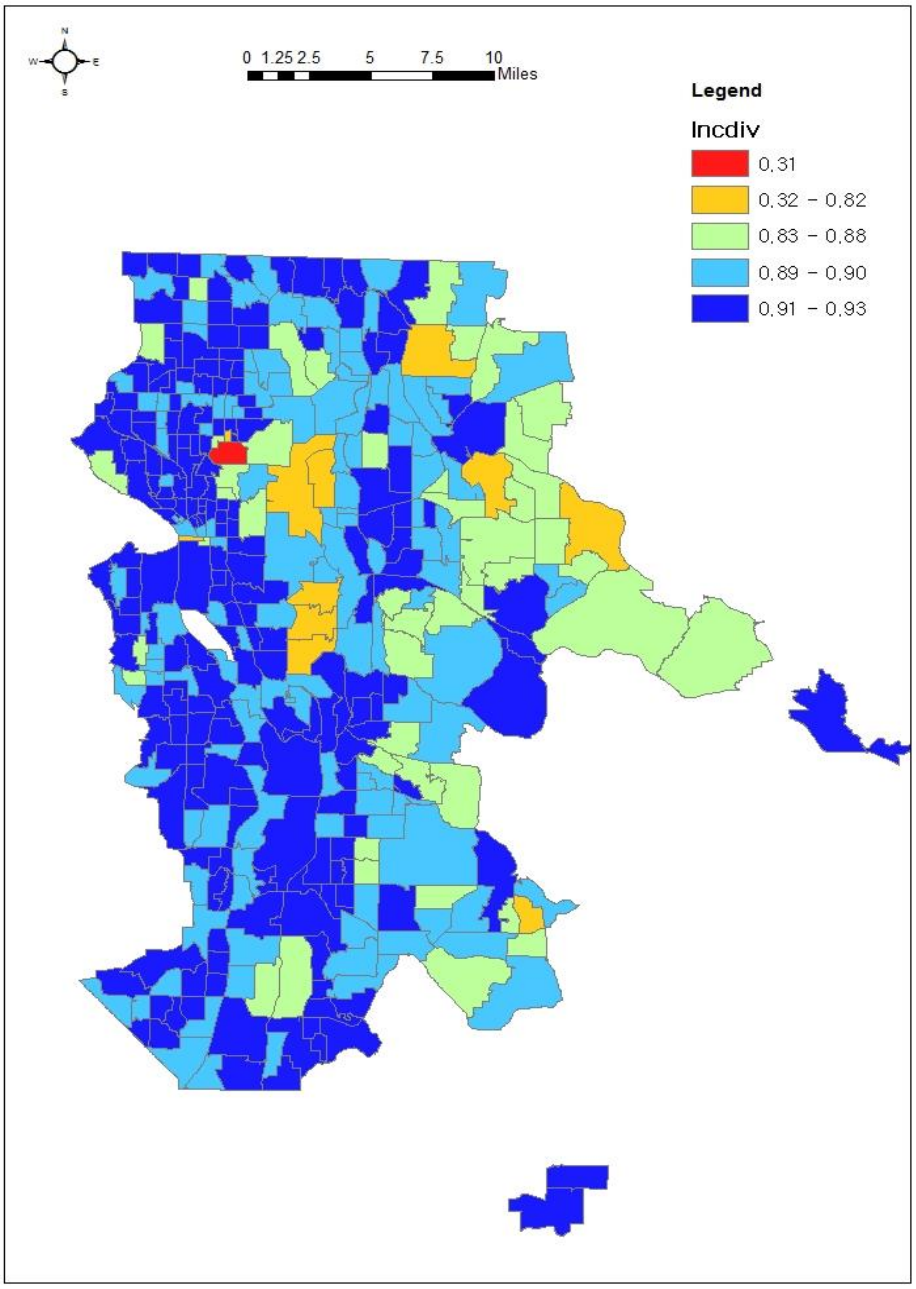


Figure 15. *Income Diversity*

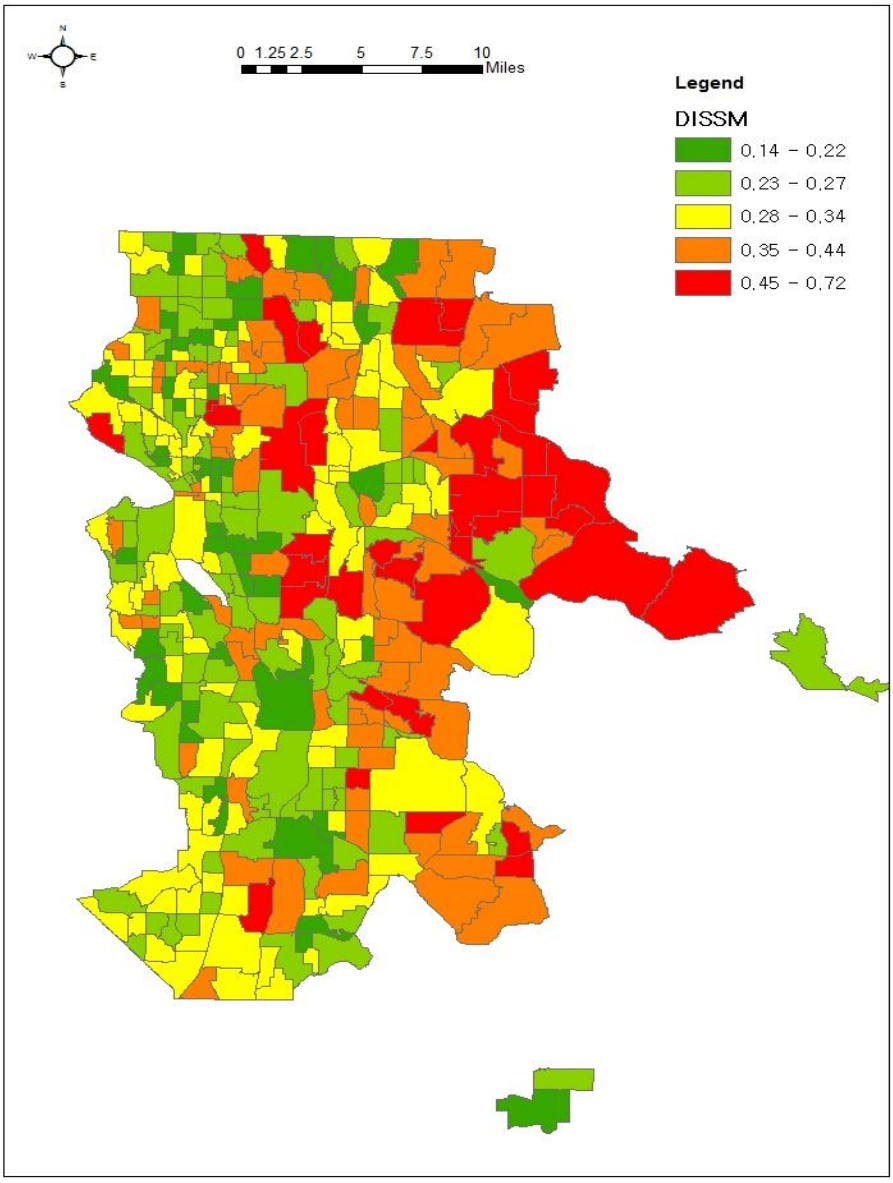


Figure 16. *Dissimilarity (White/ Non-white)*[13]

[13] The dissimilarity represents the degree of segregation between White and Non-white groups (Hispanic, Black, Asian, American Indian, and Others).

Affordable housing for low-income families. Table 22 shows descriptive statistics for affordable housing variables. The average of affordable rental units for low-income families is 11.3%, and the average of affordable ownership for low-income families is 25.4%.

Table 22

Descriptive Statistics for Variables: Affordable Housing

Variable	Obs	Mean	Std. Dev.	Min	Max
AFF_OW	374	0.254	0.193	0	1
AFF_RE	374	0.113	0.145	0	1

Table 23

Correlations: Affordable Rentals and Owned Housing

	AFF_OW	AFF_RE
AFF_OW	1	
AFF_RE	0.0186	1
	Sig. 0.7206	

Figure 17 shows the percentages of affordable rental units and owned housing for low-income families in all the tracts. Figures 18 and 19 display the proportion of affordable and owned homes and rental units, respectively. Overall, the percentage of affordable owned homes

is high and the percentage of affordable rental units is low. For instance, among the tracts with 50% more there are 21 tracts for owned homes and only 4 tracts for rental units. The tracts with 5% less include 58 tracts for owned homes and 160 tracts for rental units.

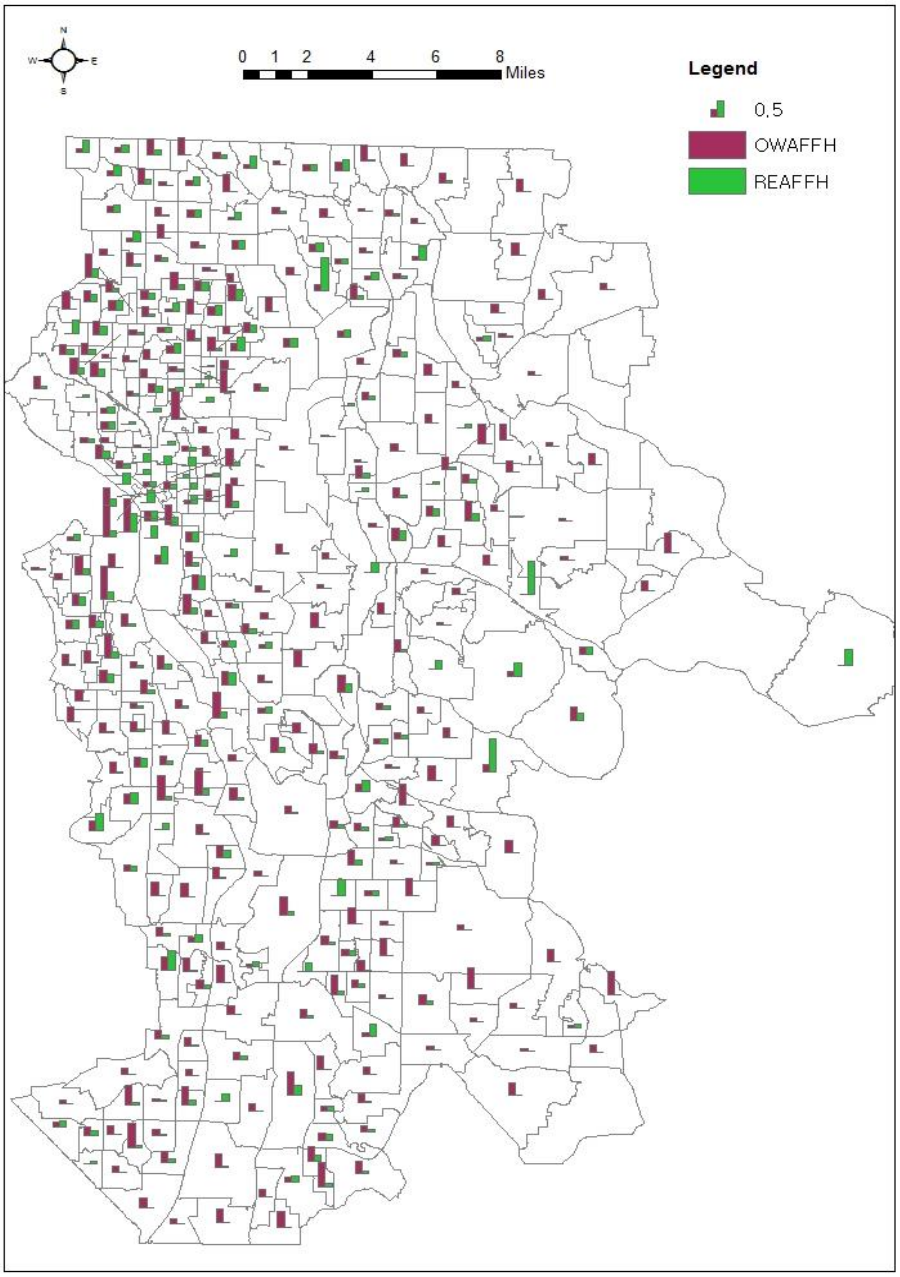


Figure 17. *Affordable Rental Units and Affordable Ownership for Low-income*

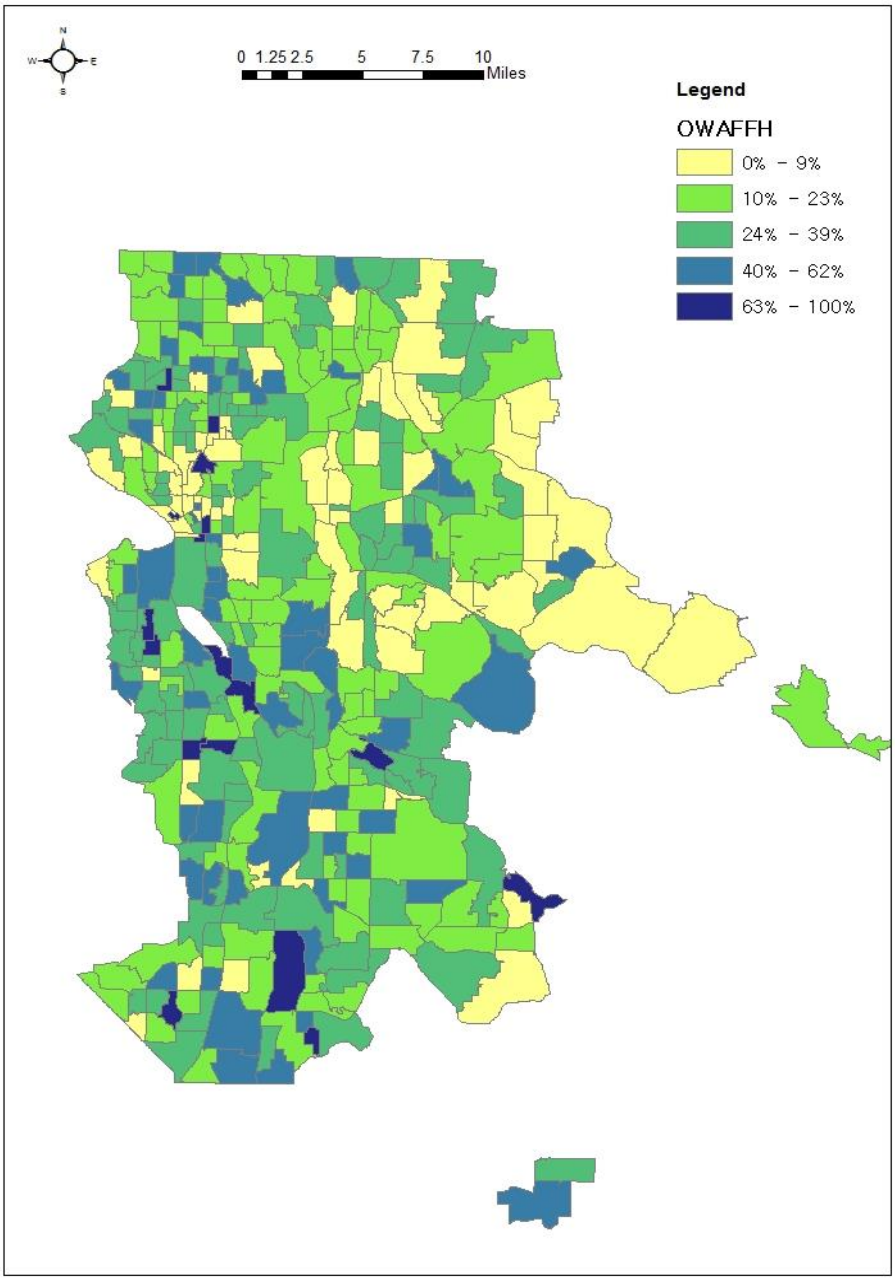


Figure 18. *Affordable Housing for Low-income: Ownership*

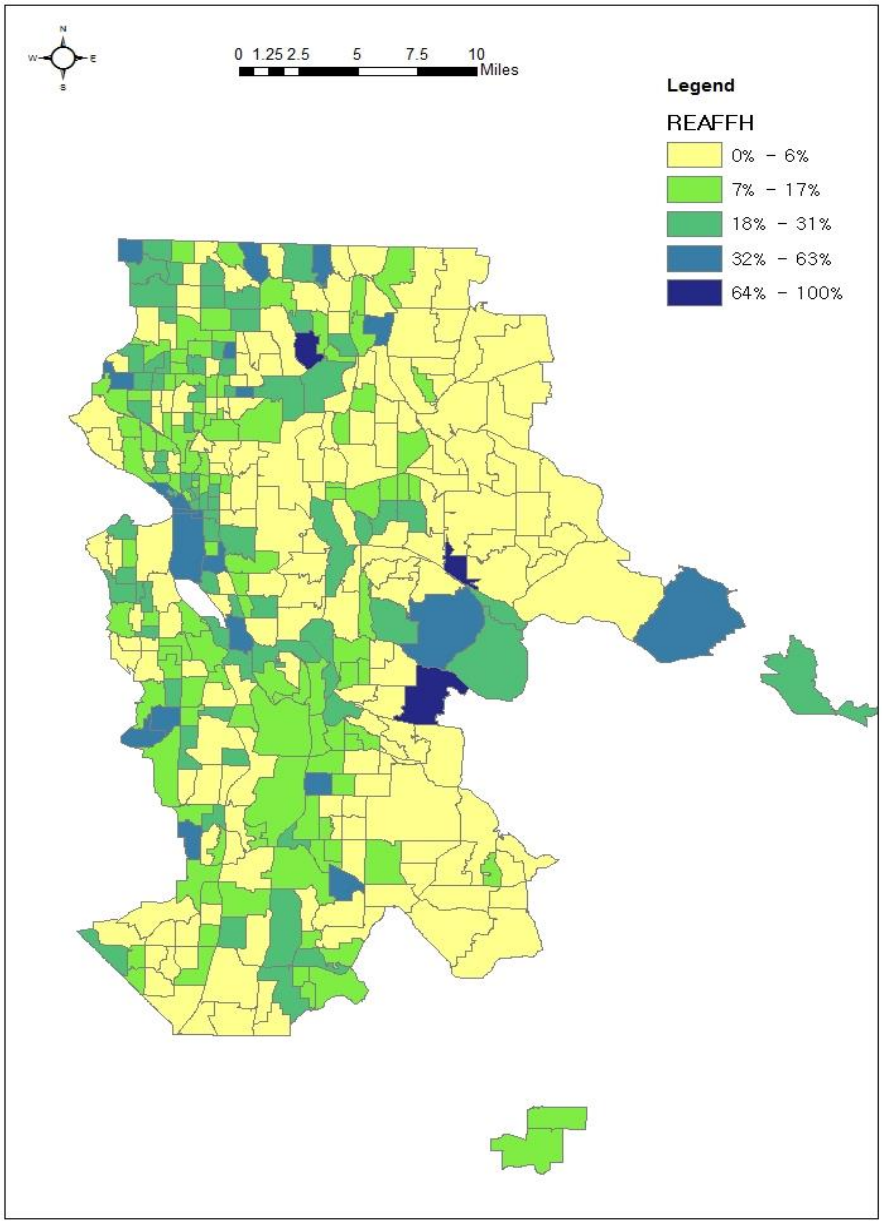


Figure 19. *Affordable Housing for Low-income: Rental*

Discussion

This study calculated the Gini coefficients of several facilities in King County, and the results show that the Gini coefficient of grocery store is the highest, while the Gini coefficient of fire station is the lowest. These mean that grocery store access is less equitable and fire station access is more equitable than the accesses to other facilities. When comparing the distances to the facilities, the distance to police station is far from the centroids of the census blocks (mean: 1.94 mile). On the contrary, park and grocery is closer to the centroids of the census blocks (respectively, mean= 0.58 mile, mean= 0.85 mile). Thus park and grocery are located within the closest distance (less than 1 mile) from residents' places within the community.

In terms of affordable housing, the proportion of affordable housing for low-income households out of all owned housing is higher than the proportion of affordable rental units for low-income households out of all rental units. In other words, the proportion of affordable rental housing of whole rental units is lower than in the case of owned homes. During a few decades, poverty rates have increased in the County, especially in the suburbs (Figure 20), and the numbers of people below the poverty level have also increased (Figure 21). Generally, affordable rentals are the most important segment of the housing market for low-income families (Aurand, 2010). Thus, providing more affordable rentals is a need for low-income housing policy in the county.

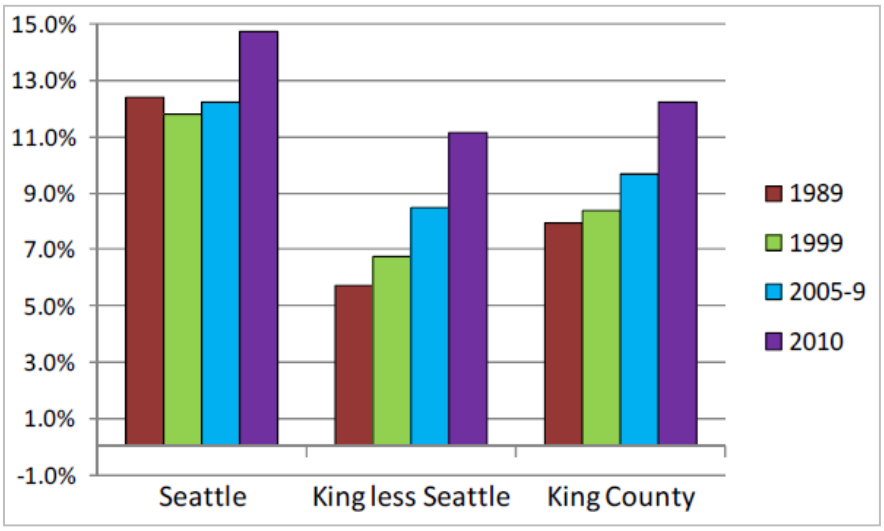


Figure 20. *Poverty Rates*

Source: King County Office of Performance, Strategy and Budget (2013)

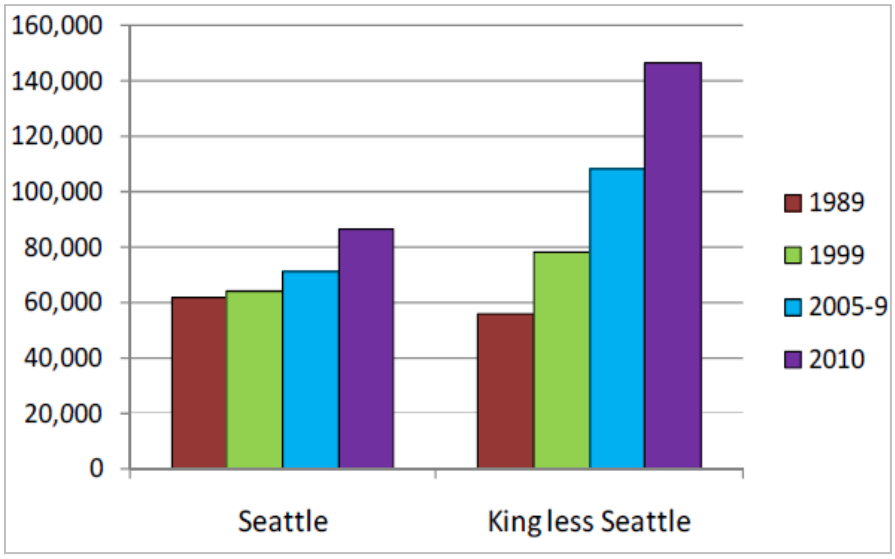


Figure 21. *Numbers of Persons below Poverty*

Source: King County Office of Performance, Strategy and Budget (2013)

This chapter advocated a conceptualization of social equity, in spatial terms. Synthesizing thought and theory from a range of disciplines including urban planning, geography, sociology, and political science, this chapter suggested the concept and measure of social equity for urban planning: accessibility, diversity, and affordable housing, and analyzed the areas in King County.

Social equity is a complex concept to define and measure, and there are some limitations to the analysis. The investigation of accessibility presented above has omitted any consideration of other possibilities besides network distance. There is a wide variety of factors involved in the determination of urban service facilities, including attractiveness of facility (for example, size, quality of service, efficiency of transportation, etc.) Therefore, urban facility inequities need to be evaluated in considering benefits from facility attractiveness, as well as distance in a future study.

Despite the limitation, this study contributes to social equity research and practice by providing a means of measuring considerations into urban planning. This study also help to advance urban planning thought and practice by spelling out the role of urban form for social equity.

CHAPTER 6

URBAN DENSITY, ACCESSIBILITY, DIVERSITY AND AFFORDABILITY

This chapter is an investigation of the association between urban density and social equity. To do this, two analyses are employed: correlation and ANOVA. Through correlation analysis, the associations between density and accessibility, between density and diversity/segregation, and between density and affordable housing for low-income accessibility are examined. To clarify these associations and acquire more detailed information regarding them, the samples are categorized into three groups: high-, medium-, and low-density groups, and some differences between the three groups regarding social equity indicators - accessibility, diversity, and affordable housing - are identified. Specific questions addressed in this section include: Is social equity in communities associated with urban density? In what ways and to what extent does urban density contribute to the social indicators? To what extent do dimensions of the social indicators occur in communities of differing densities? How do these findings inform public policy aimed at enhancing social equity in communities? Finally, the aim of this chapter is to investigate the relationship between urban density and social equity in communities.

Analysis

The analysis of these results progressed through two steps. First, all data were entered into a STATA database, and descriptive statistics and correlations were computed and analyzed to obtain an overall picture of the variables for density and social equity (access, race entropy,

income entropy, dissimilarity, affordable housing) and their relationships to each other. Next, the census tracts of the samples are divided into three groups according to density index: low-, moderate-, and high-density groups. Then, an ANOVA test is employed on the groups for each social equity indicator with the F-test to help describe the groups.

Table 24

Data and Variables Used in This Chapter

Dimension	Variable	Description	Source
Accessibility	Access to grocery store	Distance to the nearest grocery store (feet)	King County GIS center
	Access to medical facility	Distance to the nearest hospital (feet)	King County GIS center
	Access to library	Distance to the nearest library (feet)	King County GIS center
	Access to park	Distance to the nearest park (feet)	King County GIS center
	Access to fire station	Distance to the nearest fire station (feet)	King County GIS center
	Access to police station	Distance to the nearest police station (feet)	King County GIS center
Diversity	Entropy Index: Race	Degree of even distribution of ethnicity (0 to 1)	U.S. Census Bureau, American Community Survey (2007–2011)
	Entropy Index: Income	Degree of even distribution of income (0 to 1)	U.S. Census Bureau, American Community Survey (2007–2011)
	Dissimilarity Index: Race	Degree of racial segregation (white/nonwhite, 0 to 1)	U.S. Census Bureau, American Community Survey (2007–2011)
Affordable housing for low-income individuals	Affordable housing (rentals and owned) for low-income individuals	Percentage of affordable rentals (0 to 1) + percentage of affordable owned homes (0 to 1)	U.S. Census Bureau, American Community Survey (2007–2011)

Results

Table 25 represents the descriptive statistics for the variables on density and social equity. Table 26 shows the correlative relationship between the density variable and the social equity variables. A correlation coefficient is a standardized analytic tool for measuring the degree to which two variables vary together (Keith, 2006), and the coefficient means the degree of the linear relationship between two variables. A correlation coefficient varies from -1 to 1.

Table 25

Descriptive Statistics for Variable

Variable	Obs	Mean	Std. Dev.	Min	Max
DENSITYINDEX	374	1.14	1.05	0.05	7.17
ACCESS_GROCERY	374	4499.06	2807.54	685.92	18073.58
ACCESS_LIBRARY	374	8605.87	4823.93	1802.25	28528.19
ACCESS_MEDICAL	374	8869.99	5204.99	1115.44	32685.55
ACCESS_PARKREC	374	3086.01	1470.75	784.62	9275.50
ACCESS_POLICE	374	10253.75	4977.60	2006.65	29355.05
ACCESS_FIRE	374	6145.74	2273.67	1923.13	15999.79
RACENTROP	374	0.44	0.16	0.03	0.77
INCENTROP	374	0.90	0.041	0.31	0.93
DISSIMILARITY	374	0.43	0.11	0.17	0.99
AFFORDABLEHOUS	374	0.36	0.24	0	1.55

According to Table 26, correlation analysis supports the notion that density is likely to have direct and strong relationship with access to the urban services and facilities such as grocery stores, libraries, hospitals, parks, police stations, and fire stations at the 1% significance level. That is, higher density is likely to be related to shorter distances to grocery stores, libraries, hospitals, parks, police stations, and fire stations, which means that higher density is likely to correlate with better accessibility to the facilities. Particularly, grocery stores, libraries, and parks have stronger relationship with density, and we can know that the facilities in daily needs- grocery stores, libraries, and parks- are more accessible, as urban density is higher.

Density is not statistically correlated with the dissimilarity index and race entropy. However, density is likely to have positive relationship with income entropy and affordable housing at the 1% significance level. Thus, higher density is statistically more likely to be associated with income entropy and affordable housing in communities.

Table 26

Correlations (density, access, entropy, dissimilarity, and affordable housing)

	DENSITY	GROCERY	LIBRARY	MEDICAL	PARKREC	POLICE	FIRE	RACENT~P	INCENTROP	DISSIM	AFF
DENSITY	1										
GROCERY	-0.5943**	1									
LIBRARY	-0.5586**	0.7290**	1								
MEDICAL	-0.5537**	0.6692**	0.6077**	1							
PARKREC	-0.5583**	0.6430**	0.6554**	0.5353**	1						
POLICE	-0.4114**	0.5174**	0.5804**	0.5608**	0.4120**	1					
FIRE	-0.5551**	0.6621**	0.6356**	0.5204**	0.6054**	0.4241**	1				
RACENTROP	0.0488	-0.2085**	-0.0842	-0.2264**	0.018	-0.3062**	-0.0158	1			
INCENTROP	0.1465**	-0.2836**	-0.2015**	-0.2302**	-0.1465**	-0.1212	-0.1638**	0.0953	1		
DISSIM	-0.056	0.0534	-0.0355	-0.008	0.0407	-0.0289	0.0316	0.1636**	-0.0118	1	
AFF	0.1488**	-0.1869**	-0.1533**	-0.158**	-0.1246*	-0.1751**	-0.136**	0.0638	0.1408**	0.1024*	1

* Significant at a 0.05 level (2-tailed) ** Significant at a 0.01 level (2-tailed)

The correlation matrix shows the relationships between density and social equity. To clearly identify the association between density and social equity, the sample areas were classified into three categories: high-, medium-, and low-density groups based on the z-value of after taking the natural log of density. As shown in Table 27, the z-scores of natural log values of density range from -3.520 to 2.631. The zDenLogcat is in low density group range from -3.520 to 0. Similarly, medium density and high density range from 0 to 1, and from 1 to 2.631, respectively.

Table 27

Density Index (z-score)

Variable	Obs	Mean	Std. Dev.	Min	Max
densityindex	374	1.137	1.047	0.045	7.173
DenLog	374	-0.196	0.823	-3.094	1.970
zDenLog	374	0.000	1.000	-3.520	2.631

Then, the social equity indicators - accessibility, race entropy, income entropy and the dissimilarity index- were compared in the three groups using ANOVA. As shown in Table 28, the tracts with low-density constitute 51.34 % of the samples. The percentage of medium-density is 33.16% and high density is 15.51%

Table 28

Three Categories of Density Level

	zDenLogcat	Freq.	Percent
Low-density	z<=0	192	51.34%
Medium-density	0<z<=1	124	33.16%
High-density	z >1	58	15.51%
Total		374	100.0%

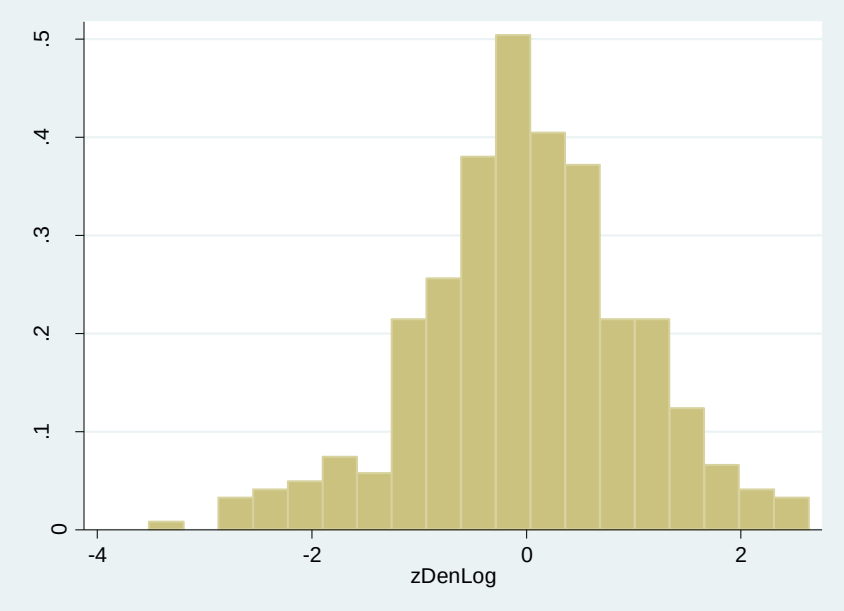


Figure 22. *Histogram of the density index (z-score, log value)*

Table 29 shows the results of the ANOVA test for access, race entropy, income entropy, dissimilarity, and affordable housing. Three models had a significant difference based on different density levels, but not the dissimilarity and affordable housing models. In terms of the distance to facilities, the mean of the low-density group is 8,659 feet, medium density 5,762 feet, and high density 3,571 feet at the 1% significance level ($p<0.01$). The income entropy in the high-density group is high, and the low-density group has low income entropy.

Table 29

ANOVA

		Density			Total (N=374)	F-Statistics	P-value
		Low (N=192)	Medium (N=124)	High (N=58)			
ACCESS	Mean	8659.457	5762.753	3571.876	6910.069	F(2, 371) =143.82	p=0.0000
	Std. Dev.	2756.479	1521.434	1076.368	2928.617		
EN_RACE	Mean	0.417	0.474	0.415	0.436	F(2, 371) =5.31	p=0.0053
	Std. Dev.	0.154	0.167	0.172	0.163		
EN_INC_cubic	Mean	0.705	0.740	0.744	0.723	F(2, 371) =12.86	p=0.0000
	Std. Dev.	0.070	0.074	0.055	0.071		
DISS	Mean	0.427	0.450	0.422	0.434	F(2, 371) =1.81	p=0.1656
	Std. Dev.	0.117	0.113	0.110	0.115		
AFF	Mean	0.347	0.380	0.411	0.368	F(2, 371) =1.76	p=0.1728
	Std. Dev.	0.242	0.216	0.297	0.243		

Discussion

The results show that high density promotes accessibility in neighborhoods. The average distance to facilities in high-density neighborhoods is 3,571 feet (0.67 miles), and the average distance to facilities in low-density neighborhoods is 8,659 feet (1.63 miles). In other words, the average distance to grocery stores, libraries, parks, hospitals, police stations, and fire stations is 0.67 miles. On the other hand, the average distance to urban facilities within low-density neighborhoods is 1.63 miles, which is more than double distance in high density. The results can be connected to transportation strategies. People in low-density neighborhoods may depend on transport for local activities. The transportation strategies can be linked to local sustainability and social activity. Transportation modes beyond car dependency can promote other social impacts, such as social interaction and public health. In addition, high-density development with walkability supports sustainable energy use, for example low energy use for everyday travel. The advocates of high-density development believe that the high density can enhance not only social benefits, but also environmental and energy advantages (Holden & Norland, 2005).

The results from ANOVA also show that high-density neighborhoods have higher value, and low-density neighborhoods have lower value in terms of income entropy. High-density is likely to have more income-mix than low-density. High-density development includes multiple family housing, such as apartments and townhomes as well as single family homes. Multiple family homes can include a range of housing types for various people. These results support that high-density development can housing mix with a variety of housing types and socially mixed communities which is composed of various residents in terms of income.

From the results, hypotheses H1, H2, H3, and H5 are shown to be acceptable, and H4 are not statistically significant, and prove unacceptable (Table 30).

Table 30

Hypotheses and Summary of Significant Relationships between Density and Social Equity

Hypothesis	Result
H1. Density is positively correlated with accessibility to urban facilities.	accepted
H2. Density has a strong relationship with access to daily activity services such as grocery store and park.	accepted
H3. Density is positively correlated with social diversity	income-mix: accepted, race-mix: not significant
H4. Density is negatively correlated with social segregation.	not significant
H5. Density is positively correlated with affordable housing.	accepted

The results show that high-density is positively associated with income diversity and affordable housing for low-income family. Many people are unaware of the various types affordable housing; it encompasses a diversity of housing styles, including secondary suites, small-lot single-family homes, townhouses, and low-rise and high-rise multi-family units (Table 31). The variety of housing types can help meet the diverse needs for affordable housing and strategies for community development.

Table 31

Types of Affordable Housing

Type	Description	Image
Small-lot urban neighborhood housing	Stand-alone houses on 3,000 to 6,000 square foot (e.g.,50 x 100 ft) lots.	
Secondary suites and accessory units	Additional units incorporated into single-family homes, including basements, attics, lane houses, and converted garages	
Duplexes and townhouses (row houses)	Houses with one or two shared walls, and ground-floor entrances (each unit has its own front door)	
Lowrise (2-4 story) apartments and condominiums	These can be affordable, particularly if built using simple, standard, woodframe construction, and no elevators	
Highrise (5+ stories) apartments and condominiums	These buildings tend to be more costly to construct but may be cost effective where land prices are high	
Residential-over-commercial.	It is often possible to build housing over ground-floor retail	
Conversions of non-residential buildings.	Some older industrial or commercial buildings in an accessible location are suitable for conversion to residential	

Source: Litman (2011)

CHAPTER 7

URBAN DENSITY AND CRIME

The purpose of this chapter is to identify any significant relationships between density and crime. This chapter examines violent crimes and property crimes among types of crime. It is hypothesized that there will be a significant difference between violent crimes and property crimes in terms of their relationship to urban density. This study hypothesizes that violent and property crimes will be inversely related to density owing to a surveillance effect.

Analysis

The relevant data were collected for each of the tracts in Seattle in order to examine the relationship between density and crime. This chapter first examines the correlation between density and crime, and then employs a multiple linear regression analysis to establish the most important predictors from a range of variables. The raw data for this analysis consisted of violent and property crimes reported to Seattle police department in 2011. Other variables in this chapter can be found in Table 32.

Table 32

Data and Variables Used in This Chapter

Variable		Description	Source
Crime[14]	Violent crime	Violent crime per 1,000 residents	Seattle Police Department
	Property crime	Property crime per 1,000 residents	Seattle Police Department
Density		Urban density index (0 to 8)	2010 Census, 2012 American Community Survey, King County GIS Center
Police		Distance to police station (feet)	King County GIS Center
Nonwhite		Nonwhite residents (%)	2012 American Community Survey
Poverty		People in poverty (%)	US Census Bureau

Results

Figure 23 represents the spatial distributions of urban density (A), violent crime (B), and property crime (C) in Seattle, and Table 33 shows descriptive statistics for the crime data set. The variable "VIOLEN" is transformed into a normally distributed variable, "sqrtVIOLEN," which is used as the dependent variable in the multiple regression analysis.

[14] https://data.seattle.gov/Public-Safety/Seattle-Police-Department-Police-Report-Incident/7ais-f98

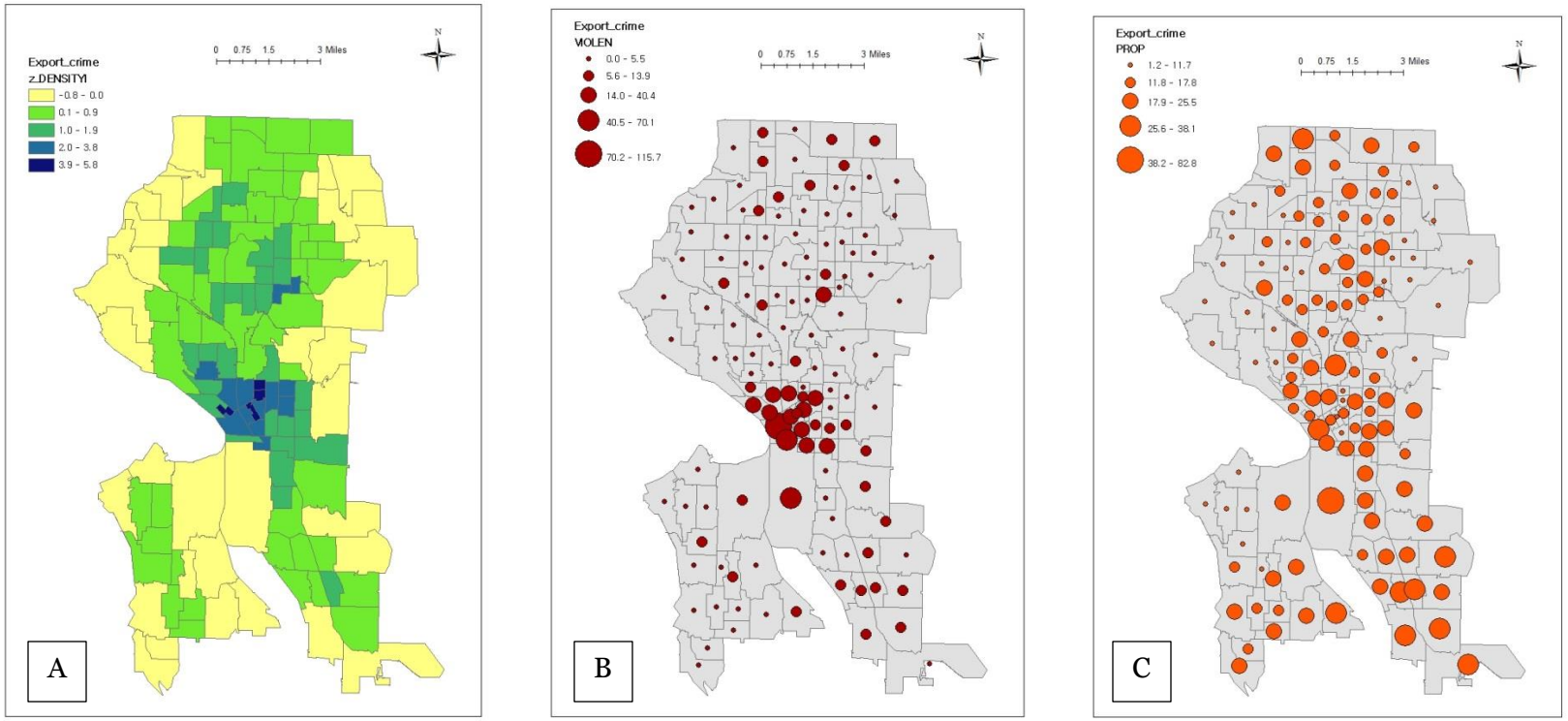


Figure 23 *Urban density (A), Violent crime (B), and Property crime (C) in Seattle*

Table 33

Descriptive Statistics: Crime

Variable	Obs	Mean	Std. Dev.	Min	Max
PROP	128	16.285	6.626	5.297	38.100
VIOLEN	128	6.651	8.734	0	57.345
sqrtVIOLEN	128	2.230	1.299	0	7.572
DENSITY	128	2.015	1.306	0.341	7.173
POLICE	128	9436.035	4962.673	2006.646	21919.11
NONWH	128	0.302	0.205	0.083	0.902
POVERTY	128	0.130	0.104	0.019	0.565

Correlation coefficients are calculated between the density and each of the crime measures (Table 34).

Table 34

Correlations (Crime, Density, and Socioeconomic Variables)

	Violen	SqrtViolen	Property	Density	Police	Nonwhite	Poverty
Violen	1						
SqrtVioen	0.9533**	1					
Property	0.2526**	0.3739**	1				
Density	0.4691**	0.5058**	-0.1141	1			
Police	-0.4872**	-0.5743**	-0.4545**	-0.5377**	1		
Nonwhite	0.3265**	0.4466**	0.5725**	0.0034	-0.3900**	1	
Poverty	0.5059**	0.5613**	0.2022	0.4126**	-0.4488**	0.4812**	1

** Significant at a 0.01 level (two-tailed)

Table 35 presents the results of the regression analysis of the effects of density and socioeconomic variables on violent crime. The violent crime model is statistically significant ($F(4, 123) = 32.25$, $p < 0.000$). Turning to the effects of individual variables, violent crime is positively correlated with density ($\beta = 0.299$, $p = 0.000$). Nonwhite people ($\beta = 0.256$, $p = 0.002$) and poor people ($\beta = 0.2174$, $p = 0.009$) are also significantly positively related to violent crime, but distance to police is negatively related ($\beta = -0.215$, $p = 0.012$).

Table 35

Violent Crime Model

	Coef	Beta (β)	Std. Err.	t	P>|t|
Density	0.297	0.299	0.827	3.60	0.000
Police	-0.0000564	-0.215	0.0002	-2.56	0.012
Nonwh	1.623	0.256	0.505	3.21	0.002
Poverty	2.713	0.2174	1.017	2.67	0.009

Number of obs= 128
F (4, 123)= 32.25
Prob>F = 0.0000
R-squared= 0.5119
Adj R-squared= 0.4960

In the property crime model, as shown in Table 36, density is negatively related to property crime ($\beta = -0.367$, $p = 0.000$). Distance to police stations is also negatively correlated with property crime ($\beta = -0.529$, $p = 0.000$). The percentage of nonwhite people is significantly positively associated with property crime ($\beta = 0.405$, $p = 0.000$), while poverty has a negative, but not statistically significant, relationship ($\beta = -0.078$, $p = 0.344$).

Table 36

Property Crime Model

	Coef	Beta (β)	Std. Err.	t	P>|t|
Density	-1.866	-0.367	0.427	-4.36	0.000
Police	-0.0007	-0.529	0.0001	-6.19	0.000
Nonwh	13.056	0.405	2.611	5.00	0.000
Poverty	-5.001	-0.078	5.260	-0.95	0.344

Number of obs= 128
F(4, 123)= 30.59
Prob>F= 0.0000
R-squared= 0.4987
Adj R-squared= 0.4824

Table 37

Hypotheses and Summary of the Relationship between Density and Crime

Hypothesis	Result
H6. Density is negatively associated with violent crime	Reject
H7. Density is negatively associated with property crime	Accept

Discussion

This chapter shows that high density is associated with high violent crime rates and low property crime rates. Further, this chapter also determines that the percentage of nonwhite

people is positively related to violent and property crime, while poverty is positively associated only with violent crime.

From the findings, we can conclude that property crime may have a surveillance effect, since according to the Seattle Police Department's database, higher density is associated with lower property crime rates. Much of *The Death and Life of Great American Cities* (Jacobs, 1961) focuses on people's contributions to maintaining order on the street, explaining how pedestrians and local buildings provide a sense of "eyes on the street." The natural surveillance effect of eyes on the street tends to vary depending on the type of crime. In terms of violent crime, this study, however, shows a positive association with urban density because higher density tends to lead to more opportunities for wrongdoing and violence.

The results of the study are different from those of Harries (2006), which implied that higher density was associated with a higher possibility of both violent and property crimes. However, Harries focused only on population density, whereas this study includes urban form factors, such as block size and street connectivity, as well as population density. The cases of property crimes, such as burglary and thefts, emphasize "breaking and entering" and "destruction of property" (Harries 2006, p.28). Therefore, property crimes are likely to be connected to an urban environment, and dense urban forms may deter property crime, owing to the effect of surveillance. This expectation can be related to "broken window"[15] logic, in that an urban environment may prevent crime in neighborhoods.

[15] The broken window theory predicts that "citizens' perceptions of disorder in their communities cause fear and social withdrawal, which thereby opens the streets for serious predatory crime." (Gau & Pratt 2008, p.163).

CHAPTER 8

CONCLUSION

This chapter provides a general summary of the dissertation, its findings, and conclusions. First, it gives a brief overview of the research topics, conceptual framework, and methodologies. Then, it summarizes the main research findings. After summarizing key findings and policy implications, this chapter presents the contributions of the research, and points out limitations and future research directions.

Overview

The aims of the study were to investigate the relationship between density and social equity. Density is a critical factor in urban design, but the terminology associated with density is not consistently applied. Therefore, the study reviewed previous studies of density and supplied a concept of density for urban development. Social equity is an important social goal with regard to urban development, especially smart growth and sustainable development; however, a definition of the concept of social equity from an urban planning perspective was still lacking. In response to these deficiencies, the study used quantitative and qualitative methods and synthesized multiple social and spatial perspectives to provide guidance for density and social equity planning, community design, and public policy. In addition, the study used data for the area of King County, Washington to explore the empirical relationship between density and social equity. The analysis was tailored to the neighborhoods in the county, yet the results and findings are flexible enough to be geographically customized to neighborhoods in other cities.

Research Findings and Policy Implications

The findings of this study can help shed light on the relationship between urban density and social equity at the neighborhood level. First, the results show that density promotes accessibility at the neighborhood level. In examining access to several facilities, this dissertation found that distances to parks and grocery stores were shorter than those to other facilities, such as the library, hospital, police station, and fire station. The average distance to parks and grocery stores in King County is shorter than the distances to other facilities within acceptable community walking distance; such facilities are closely associated with the daily lives of residents. Parks and grocery stores are indispensable facilities because they meet people's daily needs. Urban planners should therefore design communities in ways that best meet the needs of residents. Furthermore, density is strongly correlated with accessibility to local facilities (0.5943), with such a relationship influenced by market conditions, such as the location of grocery stores (0.5943). However, density has a weak relationship with accessibility to police stations (0.4114).

The dissertation also calculated the Gini coefficients of access to facilities in King County to examine whether these facilities are equally distributed. The results show that the Gini coefficient of grocery stores is the highest, whereas that of fire stations is the lowest. These findings show that grocery store access is less equally distributed, whereas fire station access is more equally distributed than other facilities. Therefore, the variation of distances to grocery stores is greater than that to other facilities, and the equal distribution of commercial and business facilities needs to be considered to enhance social equity at the neighborhood level.

In terms of the relationship between density and accessibility, the results show that high density promotes accessibility in communities. The average distance to facilities in high-density

communities is 0.67 miles, and that in low-density communities is 1.63 miles. Therefore, high-density development can be associated with community walkability. A high-density development can involve the use of various transportation modes, such as walking, bicycling, and public transit. Transportation modes that move beyond car dependency can result in other positive outcomes, such as increased social interaction and improved public health. Furthermore, a high-density development that features walkability supports sustainable energy use (for example, low energy use for everyday travel). The advocates of high-density development believe that high density has not only social benefits but also environmental and energy advantages (Holden & Norland, 2005).

In terms of diversity, density is positively associated with both income diversity and affordable housing for low-income families. In the analysis of the relationship between density and racial diversity/racial segregation, no statistically significant association is determined. The results indicate that a high density promotes a mixed-income neighborhood and increased diversity in terms of income. These findings support the idea that high-density development can result in both a housing mix and social mix in communities. The results also confirm the findings of previous studies that high-density development helps improve housing choice and enable affordability (Downs, 2001; Alexander & Tomalty, 2002). Therefore, diversity in residential areas is important for equity reasons, and in relation to urban design, social mixing can be directly associated with housing policy through affordable housing programs.

The results of the study on affordable housing indicate that the proportion of affordable housing for low-income households (owned housing) is higher than that of affordable rental units for low-income households (rental units). In other words, less affordable rental housing exists among rental units than affordable housing among owned homes. Generally, affordable rentals

are the most important segment of the housing market for low-income families, and providing affordable rentals is an important consideration for low-income housing policies in the county. In recent years, the population of King County has continuously increased as a result of people's immigration from Asia, Latin America, Eastern Europe, and Africa (King County, 2013). Therefore, the County needs to provide a variety of housing types and facilities to meet the needs of various residents. Community design is meaningless without consideration of community residents; community development for social equity needs to consider the context of the community and focus on residents: "help poor people, not poor places" (Glaeser, 2011; p. 260, in Kirby 2013).

ANOVA test shows that high-density neighborhoods do not necessarily mean they are equitable in all social aspects. Overall, dense urban forms are associated with somewhat good outcomes in relation to social equity. In particular, access to services is generally good in dense urban forms, and more neighborhoods with mixed-income residents can be found in dense urban forms.

In terms of the relationship between density and crime, this study shows that high density is associated with high violent crime rates and low property crime rates. The percentage of nonwhite people is positively related to violent and property crime, while poverty is positively associated only with violent crime. From the findings, property crime may have a surveillance effect, since according to the Seattle Police Department's database. Much of *The Death and Life of Great American Cities* (Jacobs, 1961) focuses on people's contributions to maintaining order on the street, explaining how pedestrians and local buildings provide a sense of "eyes on the street." The natural surveillance effect of eyes on the street tends to vary depending on the type of crime.

In sum, this study supports the finding that higher density is associated with better access to facilities and less segregation, along with Burton's (2000, 2003) studies. Some aspects of the results of this study are different from Burton's studies. While Burton contends that higher density is likely to lead to a lack of affordable housing and increased crime rates, this study shows that higher density is associated with more affordable housing and lower property crime rates.

The findings of this study can aid in the development and evaluation of urban policy and density planning aimed at promoting social benefits in urban space. Therefore, this study is useful to a range of stakeholders, including urban planners, policy makers, residents, and social science researchers across different disciplines.

Contributions of the Study

This dissertation examined the relationships between urban density and social equity in multiple dimensions. It proposed some indicators to understand urban density and social equity at the neighborhood level, and it investigated the empirical association between urban density and social equity with the use of specific indicators. The study of social equity at the community level can help develop effective and desirable urban forms in a practical way for urban planners, as well as contribute to consolidating and expanding social equity theory for urban design.

The theoretical and empirical contributions of this dissertation advance urban density discourse in two ways: by exploring the meaning of social equity with regard to urban planning and by providing empirical evidence on the association between density and social equity in the fields of social science, geography, and planning. In terms of its theoretical contribution, this study moves beyond current simplistic measures to establish a full conceptualization of urban

density as complex, built environment systems that support multiple and distinct social functions heavily influenced by their spatial context. In terms of its methodological contributions, after exploring different definitions of density, this study proposes the simplification of the concept of density or re-considering it in a way that makes it easy to understand within the design of urban environments. The findings also enhance understanding of the current physical, social, built, and spatial characteristics of King County. In addition, the results provide an empirical test and evaluation of social equity policy as applied to urban space.

Limitations and Future Research Directions

This research focused on the evaluation of urban density and social equity, as well as the effects of density on social equity. Urban density and social equity are complex concepts to define and measure, so the analysis expectedly involved several limitations.

This study measured two dimensions of urban density: the physical and spatial dimensions. However, the research did not cover many critical issues of spatial density. Spatial density, which is emphasized by the interaction in space between an individual and the built environment, is related to urban morphology. The literature on spatial density has identified several design attributes, such as building size, space between buildings, building height, and building height-to-space ratio, which affect morphology (Cooper-Marcus & Sarkissian, 1988; Boones et al., 1991; Cheng, 2010). Future research in this area should therefore consider additional spatial density variables to shed light on the concept of urban density.

With regard to the measure of social equity, the investigation of accessibility made in this study has omitted any consideration of other criteria besides network distance. A wide variety of factors, such as the attractiveness of a facility (e.g., size, quality of service, and

efficiency of transportation), are involved in the evaluation of urban service facilities. In addition to distance, other urban facility characteristics, such as facility attractiveness, therefore need to be considered in future studies.

This dissertation examined King County, Washington as the study area. From the point of view of sustainability and smart growth, King County has many well-planned cities (including Seattle) and communities in terms of density and social equity. Therefore, this dissertation focused on the specific situation in King County only; the results of the analysis are not generalizable to other areas, particularly poorly planned cities or communities. Furthermore, density is not a universal solution to the relationship between density and social equity in contemporary cities. For example, East Asian cities, such as Seoul and Hong Kong, have very high population densities; however, this feature does not seem to conclusively promote social equity and improve the quality of life in such cities because of their lack of open space, pollution issues, and high noise levels. Therefore, the close association between density and social equity can be applied better to the Western context than to the Asian one (Grant, 2006). Future study areas can explore the relationship between the degree of urban density and social equity in highly dense Asian cities to determine the relationship between these two variables.

Furthermore, this research used cross-sectional analysis. Future studies can conduct longitudinal analyses at the county level. The relationship between the historical and meaningful changes in density and social equity of King County can generate information that is otherwise difficult to identify through cross-sectional analysis.

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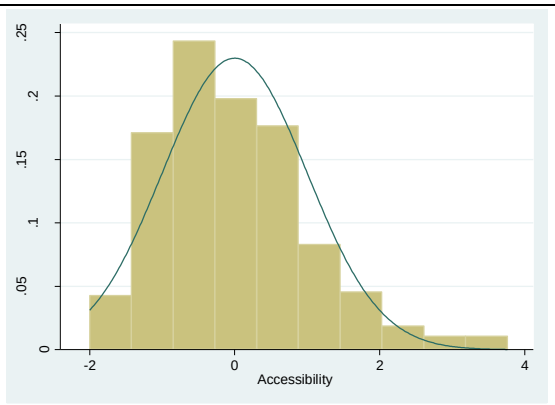
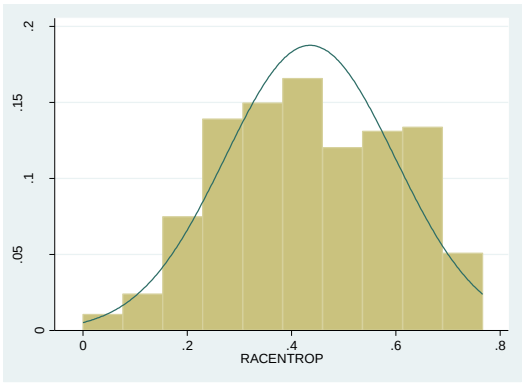
APPENDIX A

HISTOGRAMS OF SOCIAL EQUITY INDICATORS

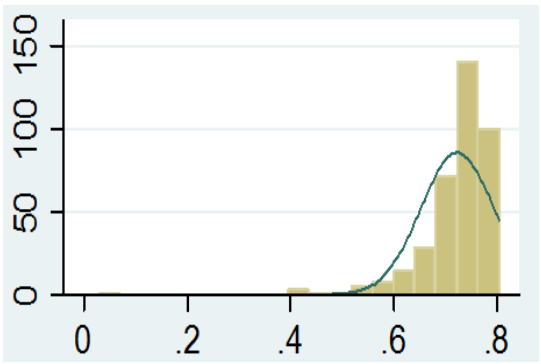
(King County, Washington)



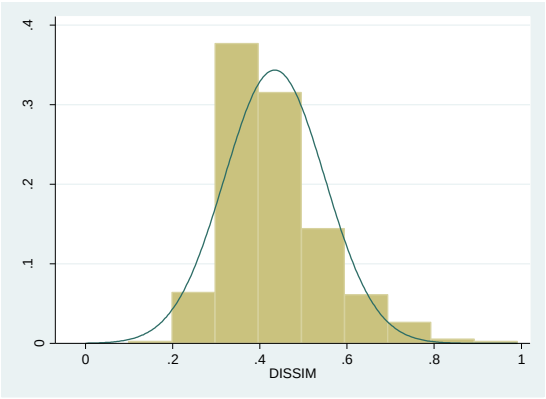
Accessibility



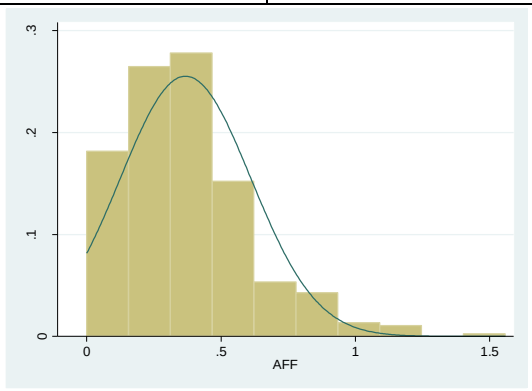
Race entropy



Income entropy



Dissimilarity

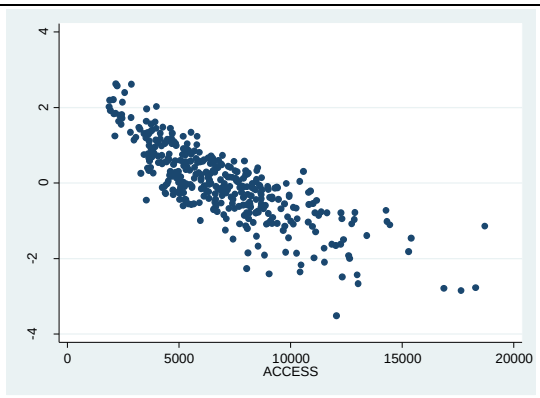


Affordable housing

APPENDIX B

SCATTER PLOTS OF SOCIAL EQUITY INDICATORS

(King County, Washington)



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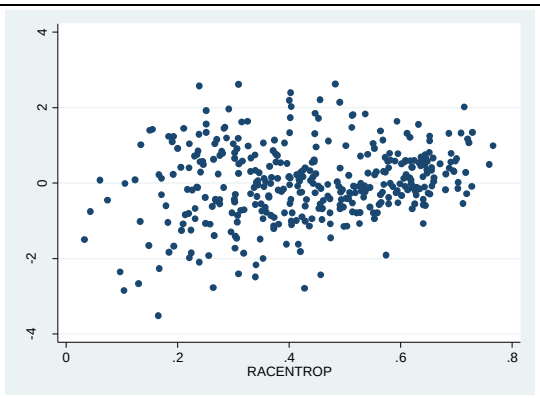

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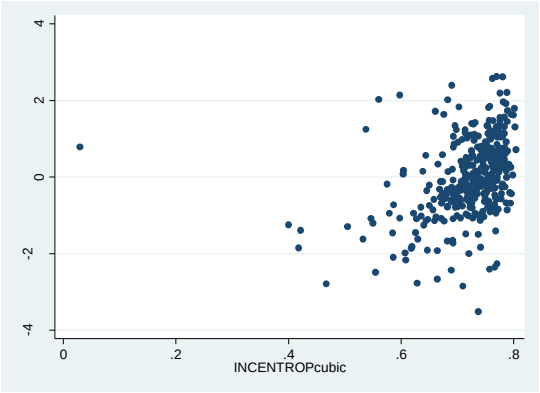
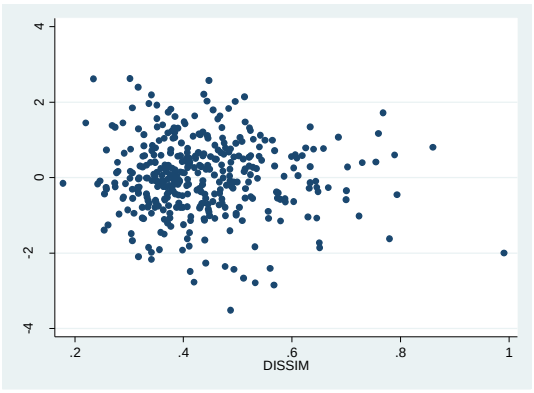


Income entropy



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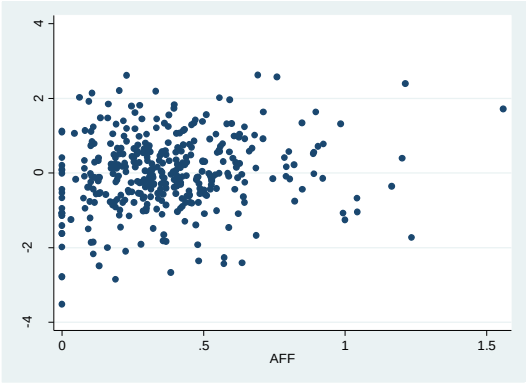

Affordable housing