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Comparison of GIS Methods for Estimating the Social Vulnerability in Response to Natural Hazards in the West Part of the City of Tualatin

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Comparison of GIS Methods for Estimating the Social Vulnerability in Response to Natural Hazards in the West Part of the City of Tualatin

by

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Abstract

The influence of natural hazards on social vulnerability is an important topic in the risk analysis of natural disasters in the human-environment system. Due to the difficulty of directly measuring social vulnerability, composite indexes are used as a surrogate. Social vulnerability indexes attempt to characterize access to societal and local social services during or after disastrous events, using various indicators such as age, gender, ethnicity, socioeconomic status, housing organization, access to shelters, and medical facilities. Geographic information systems (GIS) are used for vulnerability analysis due to their visualization methods and demographic data analysis. However, limitations in GIS applications for social vulnerability analysis are associated with a selection of a GIS method and based on different spatial resolutions. For example, performing vulnerability analysis at a coarse spatial resolution can lead to an overestimation or underestimation of vulnerable populations. Though most studies use census data for vulnerability analysis, the spatial size of census data does not always correlate well with the spatial variations of hazards or demography. Therefore, research should be performed at a finer spatial resolution to receive a more comprehensive analysis of social vulnerability. In this research, I disaggregated the census block group data at the parcel level to estimate the social vulnerability indexes. I also compared and contrasted two GIS methods, the areal apportionment and dasymetric methods, to estimate social vulnerability in the West part of the City of Tualatin. The areal apportionment method, which is based on the estimation of vulnerable populations as the proportion of those affected by the natural hazard to those in the whole census enumeration unit, is widely applied in social vulnerability research. The dasymetric method is based on the disaggregation of vulnerable populations from the whole census enumeration unit to each residential parcel within the parts of the whole census enumeration unit affected by hazards. This method considers additional social information, which can improve the social vulnerability assessment results. This study investigates if the dasymetric method provides an accurate estimate of vulnerable populations. The research reveals that the dasymetric method is more suitable for the estimation of vulnerable populations and social vulnerability analysis than the areal apportionment method when characterizing the flooding risk vulnerability in the city of Tualatin, Oregon. The results of this research can be applied to vulnerability assessment of other areas.

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Introduction

The dramatic climate change in the past decades has expanded the adverse effects of human-nature interaction. Climate change can potentially increase the frequency of natural disasters and cause elevated human and property losses. After a series of disasters occurred in the United States in the recent decades, the U.S. government reoriented from a post-event response strategy to pragmatic planning aimed at mitigating the negative impacts of future disasters (Cutter et al., 2000). In 2002, the Federal Emergency Management Agency (FEMA) released the Interim Final Rule 44 CFR Part 201, which describes a new approach to natural disaster mitigation planning. The new rule requires all states and local governments to develop natural hazards mitigation plans to be eligible for certain grant programs. A similar natural hazard mitigation plan became effective in September 2020 as a part of Oregon's strategic planning (Department of Land Conservation and Development, 2015).

Oregon faces various natural hazards, such as droughts, floods, landslides, tsunamis, earthquakes, winds, and wildfires. However, the most frequent natural hazards in the Portland metropolitan area are floods and landslides (Booth et al., 2009; Kelly, 1998; Mahalingam, et al., 2016). Due to the frequency of these hazards, the most important task is to forecast their impact on societies. In addition, assessing social vulnerability, which is the ability of a population to resist natural or man-made disasters, can help minimize losses from hazards.

The functionality of geographic information systems (GIS) can be used to improve social vulnerability assessment because of its effective demographic data representation and powerful spatial analysis methods. Choosing the correct GIS method ensures the most accurate social vulnerability analysis of populations in a certain area. In this research, I compare the results of applying the areal apportionment and dasymetric GIS methods for mapping social vulnerability in response to flood risk in Tualatin, Oregon. Both methods use some quantitative indexes for the estimation of vulnerable populations, such as the social vulnerability index (SVI) developed by Susan Cutter et al. (2000). Notably, the mapping of social vulnerability indexes is highly dependent on the spatial scale (the size of an area). Therefore, changing the spatial resolution from the block group level to the parcel level can provide more accurate results in social vulnerability analysis (Nelson et al. 2015).

Although SVI analysis is used to illustrate the methods, the focus of this research is on GIS methods for mapping SVI and vulnerable populations. It can be used as an example of a GIS method application for further SVI analysis. The goal of this research is to compare the areal apportionment and dasymetric GIS methods for mapping SVI and to evaluate which method produces more accurate estimations of SVI. The research question: Is the estimation of vulnerable populations and SVI sensitive to a GIS method?

Literature Review

Though the literature presents many similar definitions of vulnerability, the most cited is by Susan L. Cutter (1996) who describes vulnerability as a “potential for loss.” The focus of vulnerability research is the study of social vulnerability. Social vulnerability is “derived from the activities and circumstances of everyday life or its transformations” and includes a lack of access to informational resources, limited access to political power, speaking different than English languages, weak buildings or weak individuals, and restricted access to social services (Cutter, 1996). Natural hazards causing losses directly affect social vulnerability. While the degree to which populations are vulnerable partially depends on their physical proximity to natural hazards, social characteristics of the population, such as age, race, gender, etc. also impact social vulnerability (Cutter et al., 2003).

One of the first social vulnerability assessments was presented in Cutter’s case study of Georgetown County, South Carolina (Cutter et al., 2000). This study used a conceptual hazard-of-place model of vulnerability and incorporated social and biophysical indicators to assess vulnerability at the local level (Cutter, 1996). Georgetown County is often affected by various natural hazards, and its population exhibits several social characteristics. For their research, the author conducted an analysis of the hazards that affected the study area and estimated their occurrence. In determining the areas with a high risk of natural hazards, the authors created a hazard zone delineation. Moreover, to estimate the social vulnerability, the author used social data from the U.S. Census Bureau. The census data is publicly available and can be used to determine the social and economic characteristics of populations.

The most important social and economic characteristics of vulnerable populations used for SVI construction are a lack of access to resources, information, and knowledge; age; gender; wealth or poverty; environmental equity; population distribution; and density. These characteristics are connected with certain evacuation limitations and the restricted ability of vulnerable populations to recover and mitigate losses (Cutter et al., 2003).

To identify local vulnerable communities, researchers usually review the following information: poverty, languages spoken at home, age (under the age of 18 and over the age of 65), disability, population density, mobility (vehicle ownership and access to public transportation), immigration status, and nighttime versus daytime population (Kailes & Enders, 2007). These characteristics of vulnerable populations affect their everyday lives.

Furthermore, since individual households in the United States are expected to possess their own resources to resist natural disasters, poverty plays a significant role in post-disaster recovery. Poor populations often do not have the resources to pay for services and supplies in the recovery period following a disaster, and poor households' tendency to recover slowly can lead to greater losses. Furthermore, poor populations usually live in inadequately built or deficient housing. These types of housing are often mobile or modular homes, or renters' multifamily houses with poor management. This situation is aggravated by the fact that poor households are often located in vulnerable places such as floodplains (Morrow, 1999).

Another important characteristic of vulnerable populations is their mobility. Poor households often possess one or no vehicle, have less access to public transportation, and respond more slowly to evacuation warnings because there is often a cost attached to driving miles away from home and staying in a hotel. Consequently, an immobile population can be isolated and be in the risk zone for human losses. This risk increases for the young and elderly population, people with disabilities, women, and single-parent families (Morrow, 1999). Table 1 presents the most common social factors, or social vulnerability indicators used in SVI construction. These factors are usually extracted from the demographic data for a census unit.

Table 1: Measures of Socially Vulnerable Populations (Cutter et al., 2000)

Population Criteria	**Social Vulnerability Indicators**
Population and structure	Total population Total housing units
Differential access to resources/greater susceptibility to hazards due to physical weakness	Number of females Number of nonwhite residents Number of people under age 18 Number of people over age 65
Wealth or poverty	Mean house value
Level of physical or structural vulnerability	Number of mobile homes

In the literature, the process of identifying relevant social indicators is based on methods such as the principal component analysis (Cutter et al., 2003; Sherly et al., 2015) and the simple averaging method (Chakraborty et al., 2005; Cutter et al., 2000).

In their study of Georgetown County, Cutter et al. standardized each social indicator by calculating the ratio of the variable in each census block to the total number of the variable in the county (Cutter et al., 2000). Table 2 presents an example of this method for standardizing social indicators.

Table 2: Example of Standardization of a Social Vulnerability Indicator for Mobile Homes

Census Block	# of Mobile Homes in Block	# of Mobile Homes in County	Ratio of Block to County (X)	Mobile Home Vulnerability Index (X/ maximum X)
A	125	3,500	0.036	1.00
B	76	3,500	0.022	0.61
C	4	3,500	0.001	0.03
D	21	3,500	0.006	0.17

After standardizing individual social indicators, the authors calculated the social vulnerability indexes of census blocks by summing the values of these indicators. This process provides a realistic understanding of the spatial distribution of vulnerable populations within the census blocks. Additionally, the census block level SVIs provide estimated social vulnerability indexes, which Cutter et al. (2000) overlapped with the zone boundaries of natural hazards to represent the social vulnerability of their study areas.

Similar studies by the National Assessment have applied social vulnerability to environmental hazards (Cutter et al., 2003). Other examples of the application of Cutter's model of social vulnerability include similar research conducted for Charleston, SC; Los Angeles, CA; and New Orleans, LA (Schmidtlein et al., 2008).

Most of these studies handled their analysis of social vulnerability at the census block groups level. The advantage of this analysis is in the availability of demographic data at the census block group level from the U.S. Census Bureau. However, the insufficient social and socioeconomic data offer a challenge (Sherly et al., 2015). Another limitation of using standard census areal units is that hazards usually affect the population on a finer scale. Therefore, calculating social vulnerability indexes at the census block group level may lead to an underestimation or overestimation of the vulnerable population.

Some researchers have run their social vulnerability research at the parcel level. This fine-resolution approach is described in Nelson et al.'s (2015) social vulnerability study of Davidson County, TN. One benefits of calculating social vulnerability indexes at the parcel level is that it provides a more accurate analysis of the intersecting areas of biophysical and social vulnerabilities (Chakraborty et al., 2011).

A detailed description and examples of the areal apportionment method is found in Maantay et al.'s (2008) research. This method estimates the vulnerable population in a census bock group by calculating the proportion of those affected in a natural hazard area to the total area of the census block group. For example, if the intersection of natural hazard boundaries and a census block group area is approximately 37%, the number of vulnerable populations of the census block group is estimated to be 37% of the total population of this census block group. Consequently, this number is used to calculate the social vulnerability indicators and to construct the SVI of an area.

The dasymetric method estimates the vulnerable population within populated units such as parcels (Chakraborty et al., 2011). Dasymetric mapping also excludes unpopulated places from the population distribution and redistributes the total population to populated places (Petrov, 2012). Land use and the size of residential areas (a residential building area within a parcel) are usually used as supplementary information in the dasymetric method.

Nelson et al. (2015) describe the dasymetric method as a high-resolution method for estimating vulnerable populations. Their method includes the following five steps:

- disaggregation of the total population from census block groups to parcels using dasymetric mapping techniques;
- identification of proper social vulnerability indicators in the study area and creation of census block group level vulnerability indexes;
- disaggregation of the identified social vulnerability indicators from census block group level to parcel level;
- identification of relevant parcel level vulnerability variables and creation of parcel level social vulnerability indexes;
- comparison of the intersections of hazard areas and social vulnerability indexes at the block group and parcel levels.

In their research, Nelson et al. found a significant difference in social vulnerability between census block group level and parcel level, and greater accuracy of the dasymetric method over the areal apportionment method (Nelson et al., 2015).

In a flood hazard study in New York, Maantay and Maroko (2009) compared the areal apportionment method (i.e., areal weighting) and the dasymetric method (i.e., cadastral-based expert dasymetric system) in the calculation of vulnerable populations inside flood zones. The initial hypothesis for this study was that the smallest population units are logically better for the calculation of vulnerable populations because, due to their size, they follow the borders of the 100-year floodplain more accurately than any census units. An occupied parcel is the smallest population unit that can be used in social vulnerability analysis. However, for privacy reasons, parcel level census data are not publicly available from the U.S. Census Bureau; instead, the smallest available units in the U.S. Census Bureau are census blocks; they are available for most U.S. states. For states without census block data, the census block group data can be used as a surrogate. Due to the lack of parcel level data, the greatest challenge for scientists is disaggregating available census data down to the parcel level. Furthermore, for the dasymetric method, it is more suitable to use census block group data because it helps to avoid data inhibition of subpopulations while disaggregating data to the parcel level (Maantay et al., 2007). By applying of the areal weighting (AW) and the cadastral-based expert dasymetric system (CEDS) Maantay et al. (2007) identified that CEDS provides more "realistic results" when calculating vulnerable populations. Figure 1 presents a graphical comparison of AW and CEDS methods.

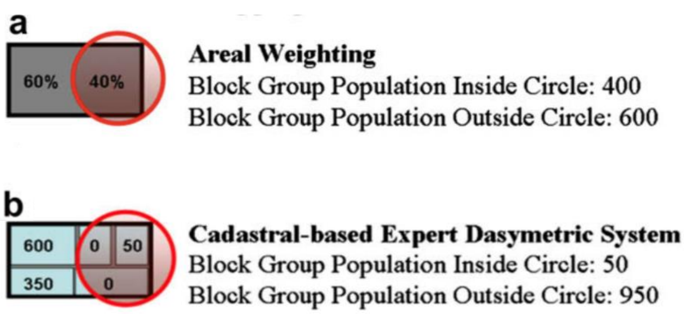

Figure 1: Methodological Differences and Potential Improvement of Population Estimation of the CEDS Method (b) and Simple Areal Weighting (a) (Maantay & Maroko, 2009)

While the methodology of my study was adapted from Cutter et al.'s (2000) case study, it also borrows the five-step method used in Nelson et al.'s (2015) research.

Additionally, the population disaggregation method in my research repeats the disaggregation techniques used in Maantay et al.'s (2007) research. By combining the two methods, I was able to calculate SVI in western Tualatin using the areal apportionment and dasymetric methods.

Study Area

To compare the results of the areal apportionment and dasymetric methods, I decided to select six census block groups in Tualatin, Washington County, OR, for the study area. This area meets the following criteria: the area is affected by the risk of floods, the population has different social and socio-economic characteristics, and some of the census block groups within the study area have homogenous social vulnerability indicators, allowing data on different spatial levels to be verified. Figure 2 presents the study area located in the western part of the city of Tualatin.

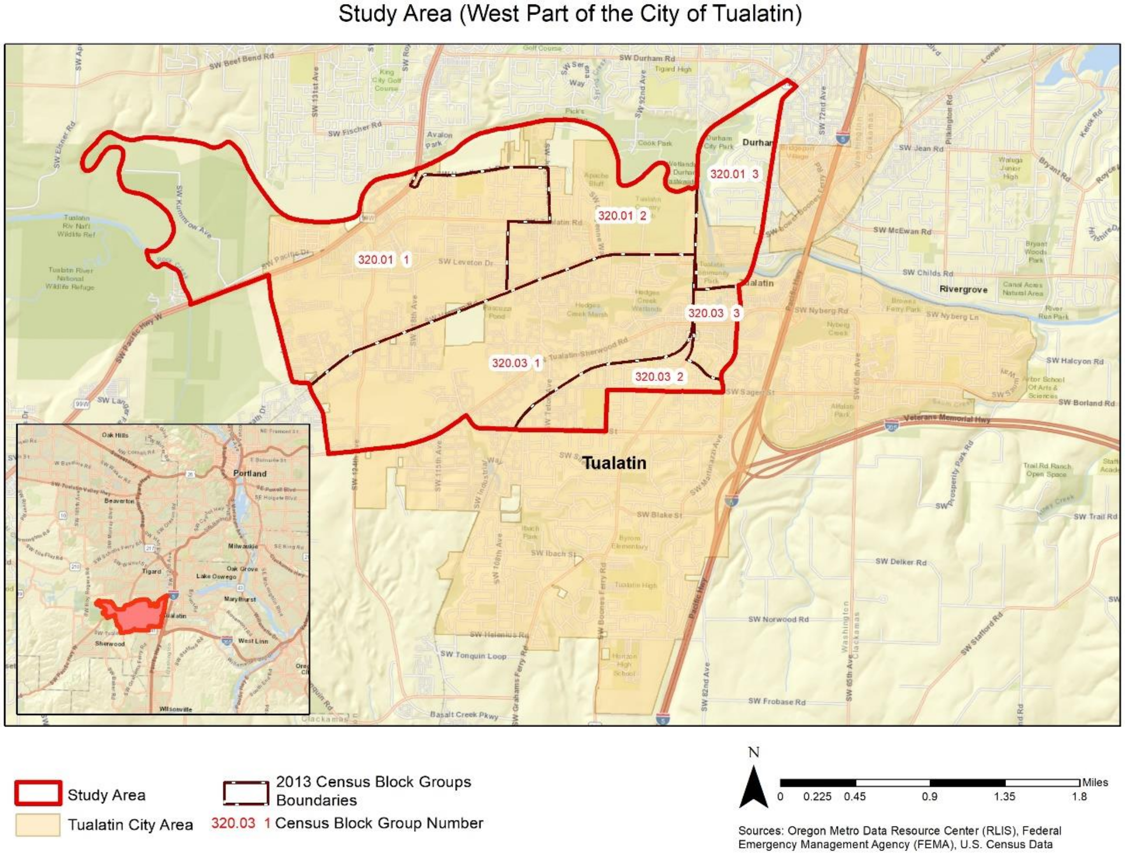

Figure 2: Study Area in Tualatin, OR

Tualatin is a part of Washington County in Oregon. It is located along the Tualatin River and characterized by a 0.2 % annual chance of flood hazard (FEMA). The geological structure of this area is mostly built by loose river alluvium, which increases the earthquake liquefaction susceptibility (Ma et al., 2012).

At least two registered floods occurred in Tualatin in 1974 and 1996, causing people to evacuate. According to Nafsinger, "In 1996 the water level reached 126.3 feet, which is more than two feet above the 100-year floodplain." (Nafsinger, 1996). I found a 1996 flood peak mark in the Tualatin Community Park, which is depicted in Figure 3. The city of Tualatin monitors the level of the Tualatin River during floods to inform residents about evacuation if the river level becomes too dangerous and poses a threat to flood-adjacent neighborhoods. However, despite these public warnings, residents need to be prepared for extreme flooding events and arrange their own measures to protect their families and properties (Flooding in Our Area | the City of Tualatin Oregon Official Website, n.d.).

Figure 3: 1996 Flood Peak Mark

Some of the demographic characteristics of the population in the research area are found in the American Community Survey, 5-Year Estimate data for 2013 (ACS). Table

3 presents the demographic characteristics according to the ACS tables B02001 (“race”), B01001 (“age and sex”), and B17010 (“poverty”). The research area includes two census tracts: 320.01 and 320.03, comprising six block groups. The total population in the research area was 8,979 in 2013, of which 4,671 (52%) were females, 931 (10%) were non-white residents (other than white race), 2,069 (23%) were younger than 18 years old, 850 (9%) were older than 65 years, and 2,197 (24%) were living below the poverty level.

Table 3: Demographic Profile of the Population Within the Research Area

Tract #	Block Group #	Total Population	Females	Non-White Residents	Population Younger than 18	Population Older than 65	Population Living Below the Poverty Level
320.01	1	3160	1775	279	881	358	755
320.01	2	1284	721	32	284	180	336
320.01	3	870	441	93	152	169	266
320.03	1	1437	776	124	304	89	313
320.03	2	1505	667	236	281	37	378
320.03	3	723	291	167	167	17	149

Figure 4 presents the map of the number of people living within six census block groups in the study area in 2013. According to the ACS data, the most populated census block groups are in the northwest and southwest parts of the research area: block groups 320.01 1, 320.03 1, and 320.03 2 (U.S. Census).

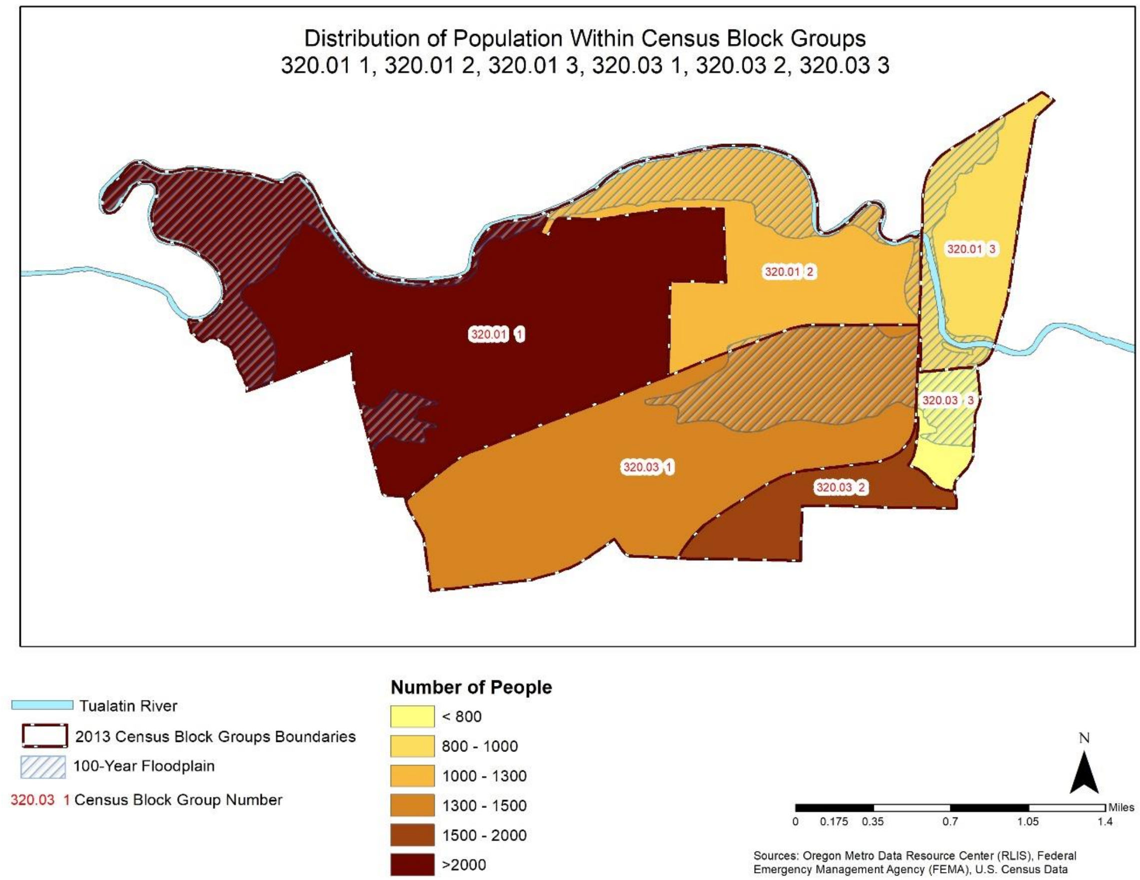

Figure 4: Distribution of Population Within the Research Area in 2013

Figure 5 shows that in the research area, there are 2,590 parcels within six block groups, composed of 1,667 "single family residence" (SFR) parcels, 22 "multi family residence" (MFR) parcels, 3 "mobile home park" (MHP) parcels, 627 "commercial" (COM) and "agricultural" (AGR) land use types parcels, and 271 other of land use parcels (e.g., publicly owned land, forests, rail roads, and vacant lands). Figure 5 represents the distribution of residential parcels within the research area.

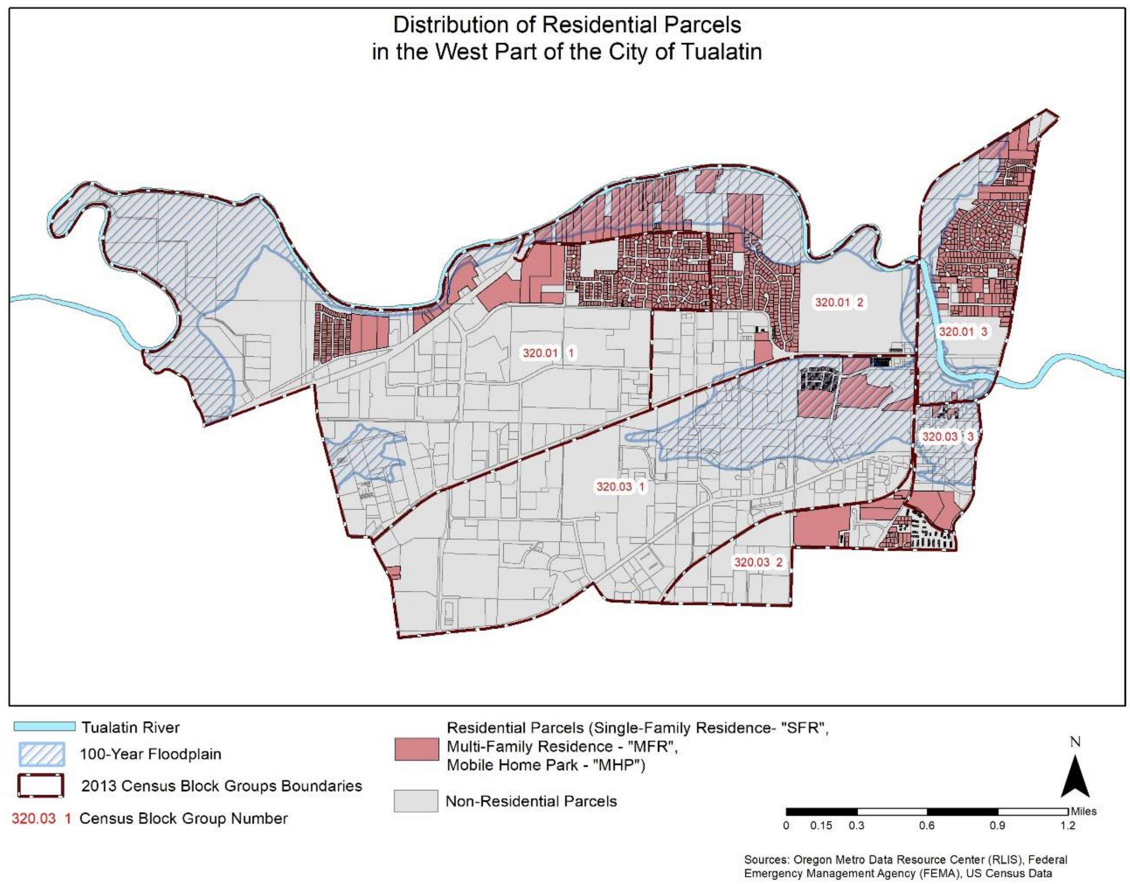

Figure 5: Distribution of Residential Parcels in the West Part of the City of Tualatin

Methodology

In this research, I used ESRI ArcGIS 10.8 for mapping SVI distributions on two levels in the study area. The following GIS layers were downloaded from the Regional Land Information System (RLIS) of Oregon State: “borders of the 2010 census tracts,” “2010 census block groups,” “tax lots,” “buildings footprints,” and “rivers.” Additionally, the layer with the borders of the 100-year floodplain was downloaded from the Oregon Department of Geology and Mineral Industries (DOGAMI). Using these layers, I generated a base map for the further creation of social vulnerability maps.

In this research I used two GIS methods – the areal apportionment and dasymetric methods, to estimate the vulnerable population at the traditional block group level and at the parcel level to further map the study area’s SVI. The purpose of this analysis was to identify the location of a higher proportion of vulnerable populations at increased risk of living in proximity to a flood hazard and the GIS method that provides a more accurate spatial distribution of SVI.

The Areal Apportionment Method

The analysis for the areal apportionment method included the following steps:

- intersection of the FEMA 100-year floodplain with the census block groups within the study area;
- identification of proper social vulnerability indicators;
- calculation of the block group SVIs.

The delineation of block group parts that are affected by the flooding hazard is the starting point of this research. By using GIS' "intersect" tool, it was possible to overlay a 100-year flooding data to a census block group layer to select only the affected block groups in the study area. Moreover, GIS tools allow researchers to calculate what percentage of the block group's total area is in the flooding zone. This information was used in the areal apportionment method to calculate the number of people possibly affected by a flood.

The 2013 American Community Survey data was used to construct and further map the block group SVI (BGSVI) using the areal apportionment method. ACS provides data about the U.S. population at different spatial levels. These data include some publicly available social-demographic information, such as total population, sex, race, and age. Census blocks are the smallest spatial units that are is the closest census unit to the size of a parcel. However, for research purposes, using the ACS data at the block group level was more appropriate than at the block level because, for the construction of the BGSVI, information about the poverty level of the population should ideally be included in the calculation.

The ACS data for the selected block groups in the study area was assigned in GIS to the block group objects in the "2010 census block groups" layer. Using the 2010 block group borders in GIS and the data from the ACS report was possible because the block group boundaries did not change between 2010 and 2013 (Liu & Martinez, 2019). In addition, the land use cadaster data was used to acquire necessary information about the number of mobile homes within census block groups. According to Cutter et al.'s (2000) study, the number of mobile homes is an important factor in the construction of SVI.

Based on the information extracted from the ACS data and land use data, the following social vulnerability indicators are applied to construct the BGSVI:

- number of populations in the block group;
- number of females;
- number of nonwhite residents;
- number of people under age 18;
- number of people over age 65;
- number of people living below the poverty level;
- number of mobile homes in the block group.

I standardized the individual social vulnerability indicators and assigned them individual values. Standardization refers to determining the proportion of a certain value of a certain census block group to a maximum value between all the census block groups within the research area. The highest value of a social vulnerability indicator is 1, and other values fall between 0 and 1.

The BGSVIs are calculated by finding their average value. The highest BGSVI value equals 1, and the lowest value equals 0. The other SVI values at the block group level consequently received values between 0 and 1. The census block groups were then overlapped with the 100-year floodplain area, and the block group SVIs were assigned to the parts of census blocks that were affected by the hazard.

The Dasymetric Method

The initial data for calculating the PSVI were taken from the 2013 American Community Survey 5-Year Estimates' detailed tables. The information retrieved from the ACS matches the social vulnerability indicators for the BGSVI. In addition to the 2013 ACS data, two GIS layers were added to a GIS data frame to calculate the PSVI. The following layers from Oregon Spatial Data Library were added: "2007 buildings" and "2010 tax lots."

The dasymetric method included the following steps:

- disaggregating the total population from census blocks groups to parcels;
- identifying the proper social vulnerability indicators in the study area;
- disaggregating the identified social vulnerability indicators from the block group level to the parcel level;
- creating the parcel level social vulnerability indexes;
- comparing the intersection of flooding areas and social vulnerability indexes at the block group and parcel levels.

For the purpose of this research, only three types of land use were considered – SFR, MFR, and MHP – because they are directly linked to the "habitual" attribute, and these parcels are used to calculate and map SVI. Even though some studies in the literature consider including other types of land use in the calculation of SVI, only SFR, MFR, and MHP parcels were selected because it is the primary responsibility of the population that resides on parcels with these types of land use to be prepared for natural hazards.

An essential element of the dasymetric disaggregation method is the “residential area” (Liu & Martinez, 2019). The GIS layer “buildings” provides the necessary data to calculate the residential area. Generally, the building area is equal to the residential area only for parcels with the SFR land use type because only one family usually resides within this type of parcel. Meanwhile, the residential areas for the MHP parcels are calculated as the sum of all building areas within one parcel. Calculating the residential areas of multifamily houses requires knowledge of the number of floors, which was gained through Google Maps’ Streetview® option. To calculate the residential area for this type of parcels, Maantay et al. (2007) suggested excluding the non-residential areas from the total building area. However, within the study area for this research there are no mixed-use buildings. The MFR areas were thus calculated as a building area multiplied by the number of floors in that building; then, all the residential areas within one parcel were summed.

In the first step of the dasymetric method, population disaggregation was used to disaggregate ACS census block group data to the parcel level. The equation for disaggregating the block group population and subpopulation is solved by finding the proportion of a residential area in a block group (RA_{BG}) and a residential area of a parcel (RA_P) multiplied by the population of a block group:

$$\mathrm{POP}_P = POP_{BG}\frac{RA_P}{RA_{BG}}$$

where:

POP_P = disaggregated parcel level population/subpopulation;

POP_{BG} = block group population/subpopulation;

RA_P = residential area at the parcel level;

RA_{BG} = residential area at the block group level.

The second step is the identification of proper social vulnerability indicators in the study area. For this task, block group level data were extracted from the ACS. Similar to the vulnerability indicators used to calculate the BGSVI, the following indicators were obtained:

- number of populations in the block group;
- number of females;
- number of nonwhite residents;
- number of people under age 18;
- number of people over age 65;
- number of people living below the poverty level.

The vulnerability indicator “the number of mobile homes in the block group,” which was used to calculate the BGSVI, was excluded in the construction of social vulnerability indicators at the parcel level. This omission was made because mobile homes share the same residential characteristics as single-family homes, or multi-family residential units when a few mobile homes are located on one parcel. In the event of flooding, mobile homes usually cannot be removed from the parcel to avoid damage or to improve the resilience of the population.

A vital advantage of the dasymetric method is that it can use some axillary information as additional vulnerability indicators to calculate the SVI of every parcel. For example, some researchers consider using distance to the nearest medical facilities, such as emergency rooms or hospitals, as a vulnerability indicator for calculating total SVI (Cutter et al., 2000). For the purposes of this research, I used the variable "distance to the nearest hospital." The city of Tualatin has only one hospital, Legacy Meridian Medical Center, located at 19300 SW 65th Ave, Tualatin, OR 97062. The distances were calculated in Google Maps using the "shortest driving distance" option.

The third step in the dasymetric method involves the disaggregation of the identified social vulnerability indicators from the block group level to the parcel level. Using the land use attributes of parcels helps to separate residential parcels from non-residential parcels; hence, only the parcels with residential land use attributes, such as single-family, multifamily, and mobile homes, can be included in the disaggregation process (Liu & Martinez, 2019). Using "residential area" in the disaggregation process makes the results more realistic. For example, a larger percentage of the population can probably reside within a larger residential area, such as apartment complexes. At the end of the disaggregation process, each parcel received the numerical values of the vulnerability indicators. These values were calculated as a proportion of the specific value of a certain census block group to the total value of census block groups in the study area.

Similar to calculating the social vulnerability indicators for the block group level, the normalization process was also performed at the parcel level in order to standardize the numeral values of vulnerability indicators. The normalized values were calculated as a proportion of a certain value of a certain parcel to a maximum value between all parcels within a certain block group. The highest value received an index equal to 1, and other values ranged between 0 and 1.

In the fourth step of the dasymetric method, the parcel level vulnerability indexes were created. The PSVI was calculated by summing the normalized values and calculating their average values. The highest PSVI received the value “1,” the lowest was assigned “0,” and the remaining received values between “0” and “1.”

For the final step of the research, I calculated the BGSVIs and PSVIs to be used in GIS mapping. Three maps were created: BGSVI, PSVI, and the differenced map of BGSVI and PSVI. On these maps, all social vulnerability indexes were represented by classifying into four groups: non-vulnerable (index score less than 0.05), slightly vulnerable (index score 0.05 - 0.4), moderately vulnerable (index score 0.4 - 0.7), and highly vulnerable (index score more than 0.7).

The qualitative evaluation of the research results was based on the expert opinion of an employee of the GIS department of the city of Tualatin. I asked this expert to provide their evaluation based on the following steps:

1) List the factors that can affect the social vulnerability indexes evaluation of the study area.
2) Compare the presented maps of SVI at the census block group level and at the parcel level with the existing data collected by the city of Tualatin to determine which mapping method provides the best quality result.
3) Use the presented maps to highlight areas on the maps that do not match the spatial patterns of SVI according to the city of Tualatin.

Finally, to answer the research question, I compared the data provided by the local expert, and concluded which method was more effective in characterizing the geographic distribution of vulnerable populations in the city of Tualatin. Table 4 describes the data and sources needed for this research.

Table 4: Research Data and Sources

Data type	Data Content	Source	Resolution	Data Quality
Boundaries	Boundaries of Oregon State, the Portland Metro area; study area census block groups borders	Oregon Metro Data Resource Center (RLIS) (http://rlisdiscovery.oregonmetro.gov)	City	Complete data
Census Data	2013 Census Data including necessary social information about selected census block groups for calculation a Social Vulnerability Index	2013 American Community Survey 5-Year Estimates Detailed Tables (https://www.census.gov/programs-surveys/acs/), Oregon Metro Data Resource Center (RLIS) (http://rlisdiscovery.oregonmetro.gov)	Census block group	Complete data
Local Population	Selected census block groups data	Oregon Metro Data Resource Center (RLIS) (http://rlisdiscovery.oregonmetro.gov), Oregon Spatial Data Library (http://spatialdata.oregonexplorer.info) Google Maps (http://maps.google.co)	Parcels	Complete Data
Hazards Boundaries	Areas affected by the natural hazards: floods	Oregon Department of Geology and Mineral Industries (DOGAMI) (http://www.oregongeology.org/hazvu/), Federal Emergency Management Agency (FEMA) (https://msc.fema.gov)	State	Complete data

Results

Following the steps described in the methodology chapter for performing the areal apportionment and dasymetric methods for mapping SVI, I first delineated the borders of the 100-year floodplain and intersected them with block groups and parcel borders within the research area. Next, I calculated the vulnerable population that resides within the research area, and calculated SVIs at the block group and parcel levels. Lastly, I created maps, which allowed me to compare the spatial distribution of SVIs at the block group and parcel levels.

The Areal Apportionment Method

As the first step in my research, I created a map of the intersection of the FEMA 100-year floodplain with the census block groups layer and the parcels layer in the study area. Figure 6 presents this map, which became the initial one to filter block groups and parcels that are affected by the 100-year flooding zone. The map reveals that five out of six census block groups and 278 out of 1,692 residential parcels are affected by the 100-year floodplain.

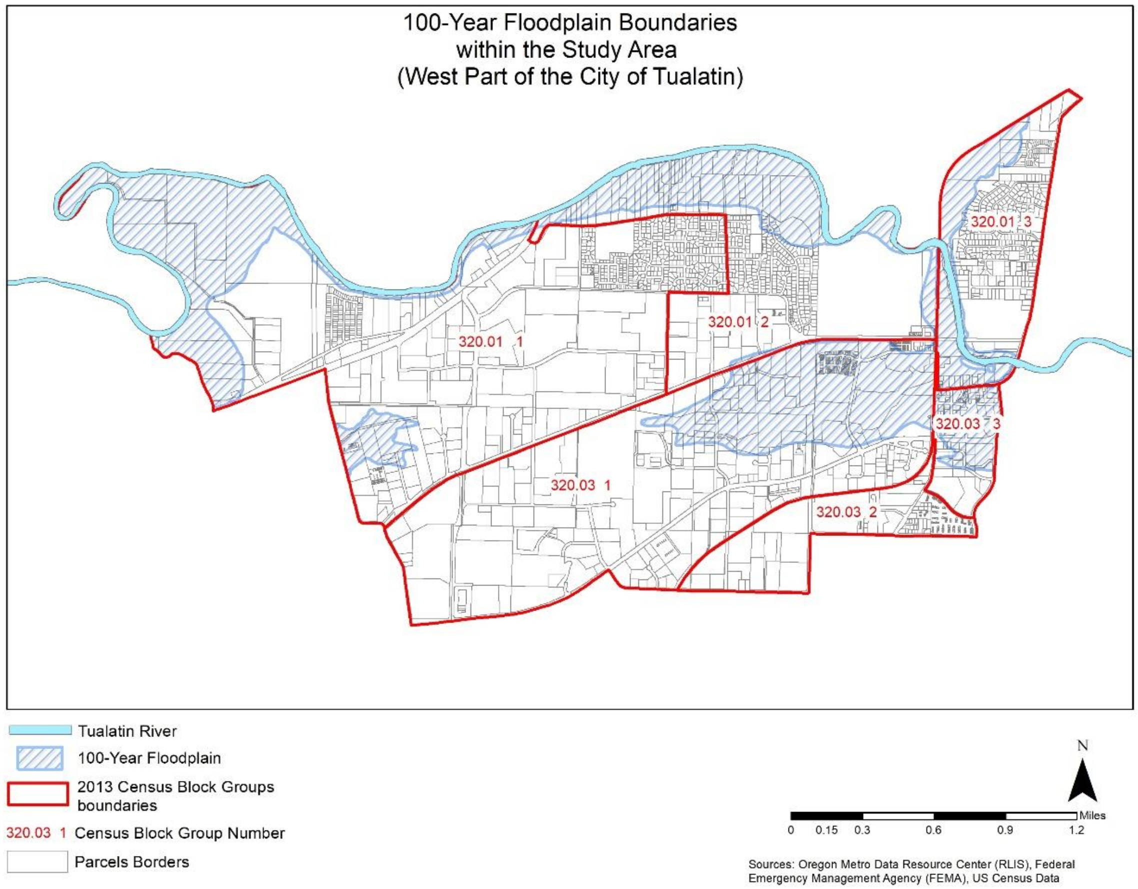

Figure 6: Intersection of the FEMA 100-year Floodplain with Census Block Groups and Parcels in the Study Area

By using the areal apportionment method, block groups were intersected with the 100-year floodplain area, and areas of census block groups that are affected by the flooding zone were extracted, as presented in Table 5.

Table 5: Census Block Groups Parts, Affected by the Tualatin River 100-year Floodplain

Block Groups	Total BG Area, sq. ft.	BG Area Within 100-year Floodplain, sq. ft.	Affected Block Group Area, %
320.01 1	54506064.53	13491528.34	25%
320.01 2	22428021.27	8331523.90	37%
320.01 3	12464999.55	4249468.50	34%
320.03 1	41605163.91	10786988.31	26%
320.03 2	7389879.76	0.00	0%
320.03 3	3764317.06	2385338.58	63%

The number of people affected by the 100-year floodplain was calculated according to the affected areas of block groups. For example, in Table 6, block group 320.01 1 contains 25% of the total area affected by the floodplain. Therefore, the number of the affected population equals 25% of the total population of the census block group. Other variables were adjusted by the same percentage of block group subpopulations that were affected by the 100-year floodplain. Table 6 presents the results of calculating the social vulnerability indicators and the BGSVIs. Additionally, as a result of mapping the SVIs at the block group level, a map of BGSVI distribution was created, as detailed in Figure 7.

Table 6: Calculation of the Block Group SVIs

Block Group	320.01 1	320.01 2	320.01 3	320.03 1	320.03 2	320.03 3
Total Population, 2013	3160	1284	870	1437	1505	723
Affected Population	782	477	297	373	0	458
VI – Population	1.000	0.610	0.379	0.476	0.000	0.586
Total Number of Females	1775	721	441	776	667	291
Number of Affected Females	439	268	150	201	0	184
VI – Females	1.000	0.610	0.342	0.458	0.000	0.420
Total Number of Non-White Residents	279	32	93	124	236	167
Number of Affected Non-White Residents	69	12	32	32	0	106
VI – Non-White Residents	0.653	0.112	0.300	0.304	0.000	1.000
Total Number of Population <18	881	284	152	304	281	167
Number of Affected Population <18	218	105	52	79	0	106
VI – Population <18	1.000	0.484	0.238	0.361	0.000	0.485
Total Number of Population >65	358	180	169	89	37	17
Number of Affected Population >65	89	67	58	23	0	11
VI – Population >65	1.000	0.755	0.650	0.260	0.000	0.122
Total Number of Population Living below Poverty Level	755	336	266	313	378	149
Number of Affected Population Living below Poverty Level	187	125	91	81	0	94
VI – Poverty	1.000	0.668	0.485	0.434	0.000	0.505
Number of Mobile Homes	96	0	0	0	0	0
VI – Mobile Homes	1.000	0.000	0.000	0.000	0.000	0.000
Total BGSVI	0.950	0.463	0.342	0.328	0.000	0.445

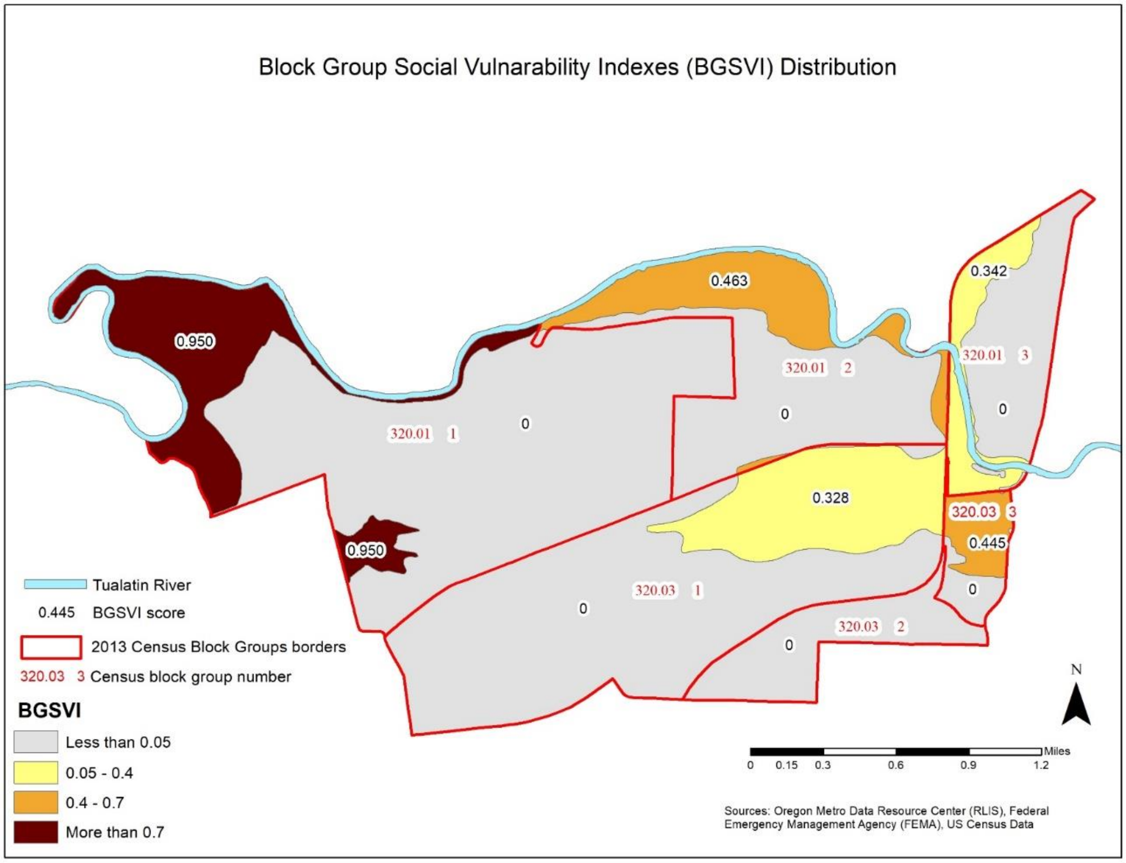

Figure 7: Map of the Distribution of the BGSVI in the Study Area

The map presented in Figure 7 indicates that the most vulnerable population (SVI = 0.950) resides in block group 320.01 1, and the moderately vulnerable population resides in census block groups 320.01 2 (SVI = 0.463) and 320.03 3 (SVI = 0.445). The slightly vulnerable population resides in census block groups 320.03 1 (SVI = 0.342) and 320.03 3 (SVI = 0.328), while there is no vulnerable population in census block group 320.03 2 (SVI = 0.000). On this map, the distribution of SVI follows the 100-year floodplain.

The Dasymetric Method

During the process of population disaggregation, the total block group population was distributed to all 1,692 residential parcels within the study area. The disaggregated population data were then used to calculate the social vulnerability indicators and social vulnerability indexes. The results of these calculations at the parcel level consist of all the disaggregated data for 278 residential parcels that are intersected by the 100-year floodplain (Appendix A, Table A.1). The maximum value of PSVI in Table A.1 is 0.930 for the most populated parcel, the minimum value is 0 for a non-populated parcel, and the average value is 0.093.

Figure 8 presents a map of the PSVI distribution over the study area. On this map, the most vulnerable population (SVI = 0.930) is represented in one parcel in block group 320.03 1. One parcel with a moderately vulnerable population is located in census block group 320.01 1 (SVI = 0.547), and another parcel is in census block group 320.03 1 (SVI = 0.635). The parcels with slightly vulnerable populations are distributed over all five block groups affected by the 100-year floodplain. One parcel with an SVI equal to 0.000 is located in census block group 320.01 2. There is no vulnerable population in census block group 320.03 2, and all residential parcels in this block group have an SVI equal to 0.000.

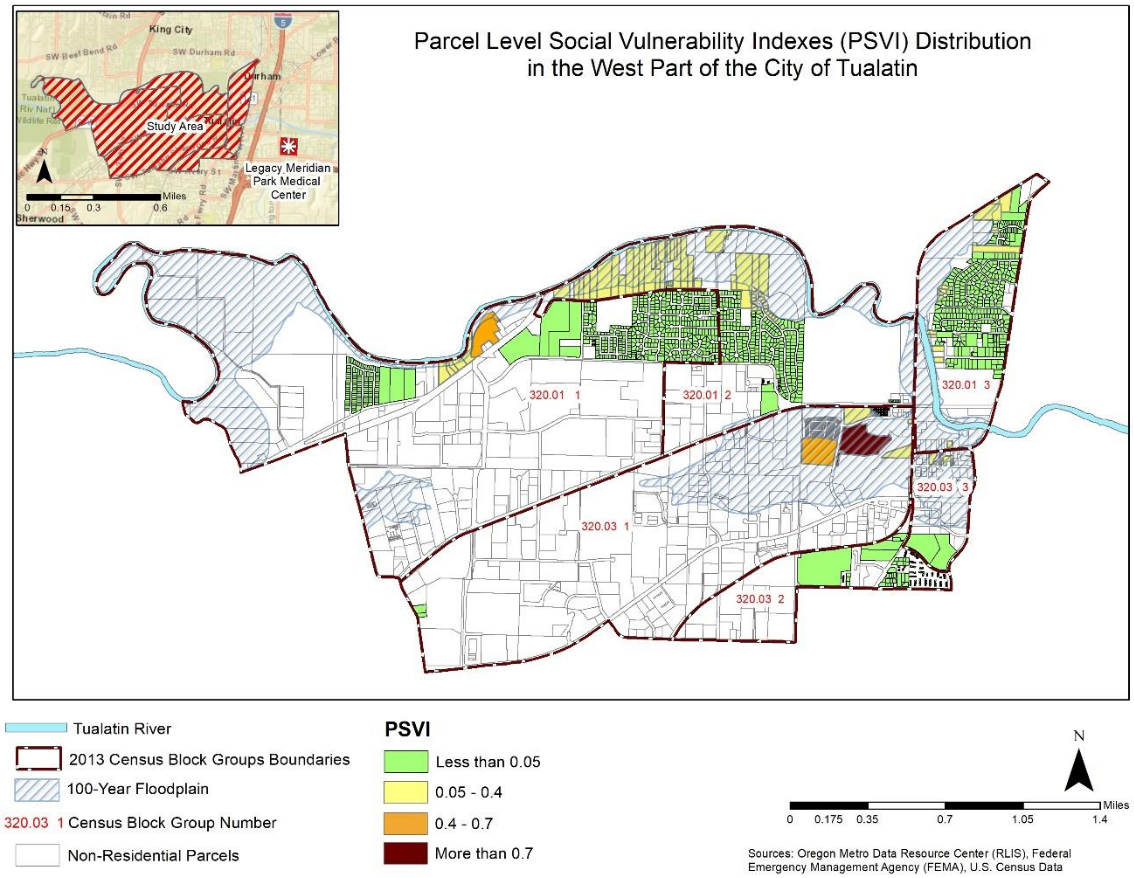

Figure 8: Map of PSVI Distribution in the Study Area

By overlapping the two initial maps created by applying the areal apportionment method and the dasymetric method, a differenced map showing the distributions of BGSVI and PSVI was created. Figure 9 illustrates the difference in BGSVI and PSVI distribution within the study area. For better understanding the distribution of the SVI on two levels, Figures 10–14 with maps of BGSVI and PSVI distribution on each census block group, affected by the 100-year floodplain were created.

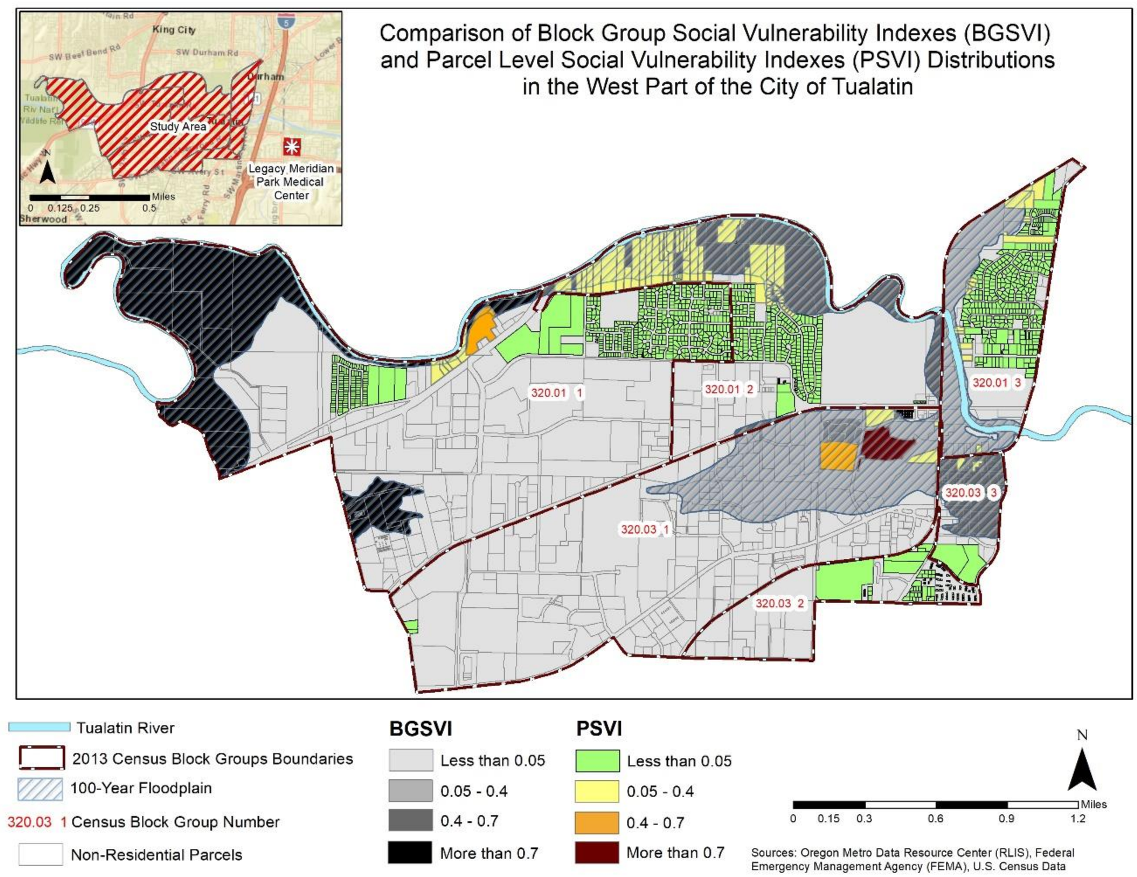

Figure 9: Distribution Differences of Social Vulnerability Indexes Between Block Groups and Residential Parcels

Figure 10 illustrates the difference in distribution of BGSVI and PSVI within census block group 320.01 1. Two areas at the block group level have an assigned SVI of 0.950 (highly vulnerable). This SVI is the maximum BGSVI for the whole study area. However, at the parcel level, none of the parcels within these two areas with the highest BGSVI have a PSVI greater than 0.7. The reason for this discrepancy is that the block group level areas disposed over non-residential parcels: industrial parcels and parcels with nature preservation purposes.

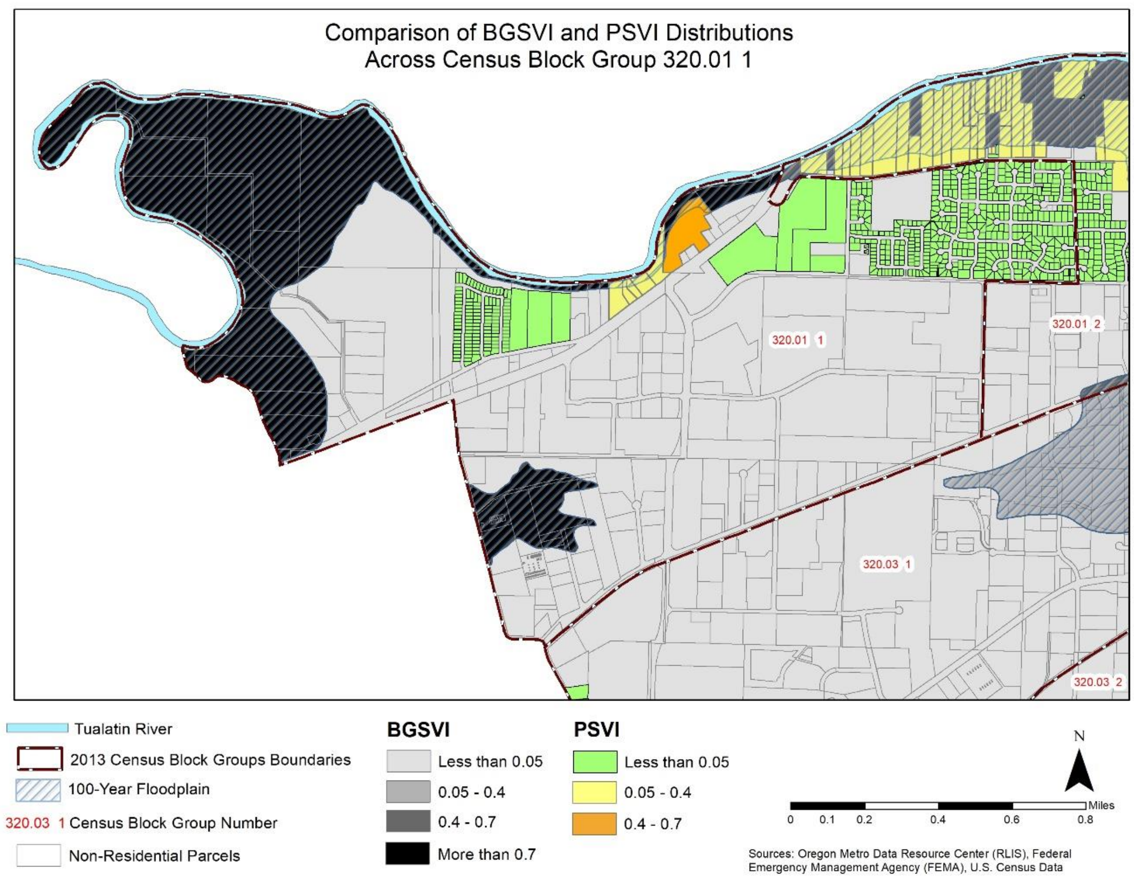

Figure 10: Comparison of BGSVI and PSVI Across Census Block Group 320.01 1

Figure 11 presents the differences in the distribution of BGSVI and PSVI within census block group 320.01 2. There are two zones with a moderate level of BGSVI (SVI = 0.463); one is located along the Tualatin River in the north part of the block group, and one is in the south part, along SW Herman Road. Compared to the SVI at the parcel level, there are no parcels with a moderate PSVI level; however, 53 parcels along the Tualatin River have slightly vulnerable indexes. Due to the parcels in the north part having the "SFR" land use purpose. Furthermore, there are parcels 0.000 PSVI along SW Herman Road, because there are no residential parcels in that area.

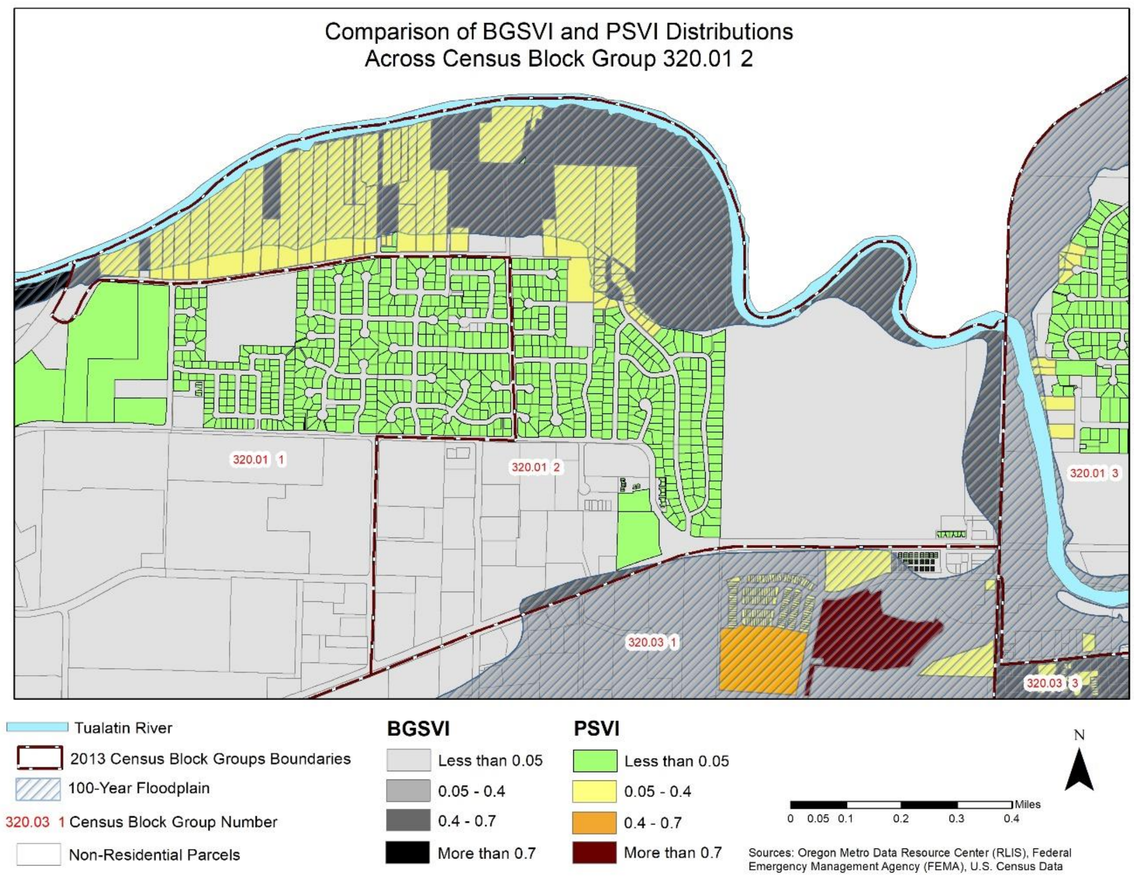

Figure 11: Comparison of BGSVI and PSVI Across the Census Block Group 320.01 2

Figure 12 illustrates the differences in the distribution of BGSVI and PSVI within census block group 320.01 3. At the block group level, approximatelly 34% of the population lives within the 100-year floodplain. However, at the parcel level, there are only 13 parcels with vulnerable populations with slight vulnerability indexes between 0.074 and 0.094. These parcels are occupied by single-family residences.

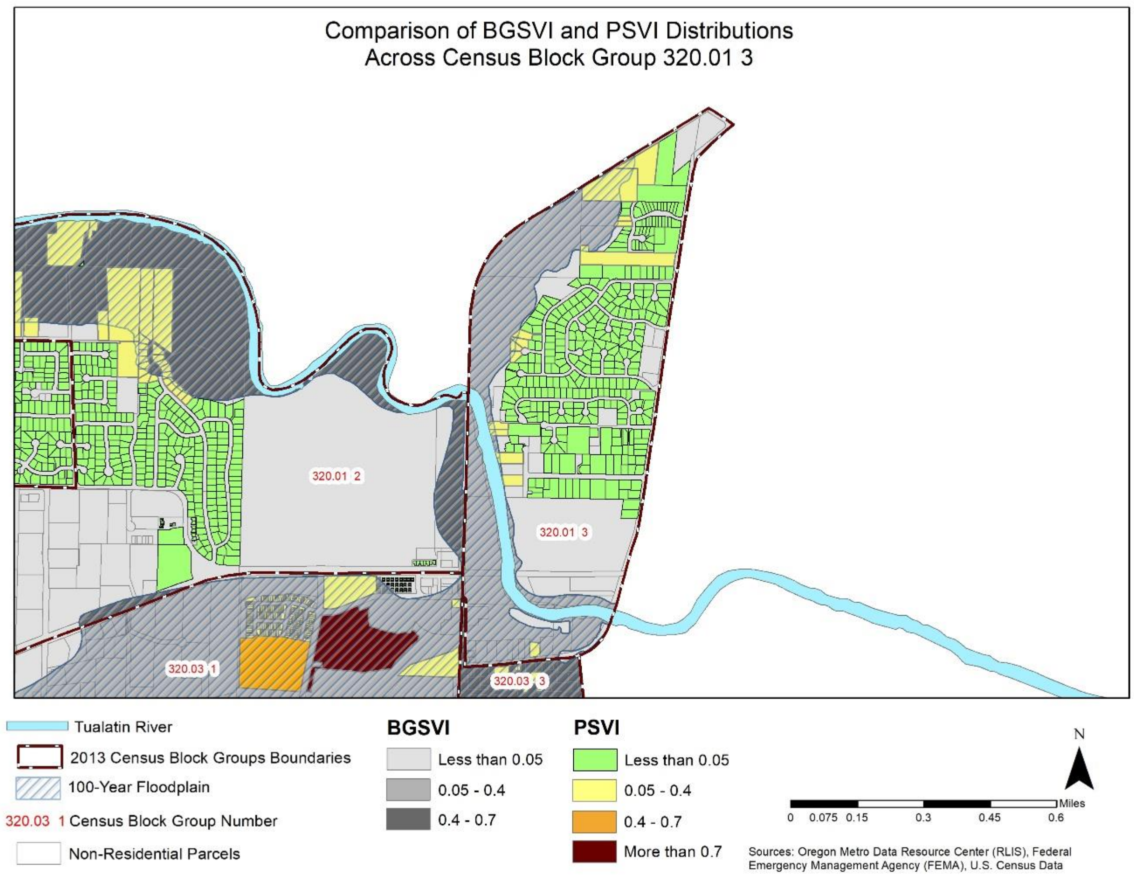

Figure 12: Comparison of BGSVI and PSVI Across Census Block Group 320.01 3

Figure 13 presents the differences in the distribution of BGSVI and PSVI within census block group 320.03 1. At the block group level, an area of approximately 34% of the total area of the census block group is slightly vulnerable (BGSVI = 0.328) because the least number of people affected by the flooding zone among all five affected block groups live in this area. However, at the parcel level within this block group, there are 176 parcels with slight vulnerability indexes. These parcels are mostly single-family residences (175 parcels) and one apartment complex (MFR).

One parcel has a moderate level of vulnerability (PSVI = 0.547), and one parcel has a high level of vulnerability (PSVI = 0.930); apartment complexes are located on both of these parcels. Most of the vulnerable areas at the block group level have parcels with 0.000 PSVI because those parcels are located within the industrial area in western Tualatin.

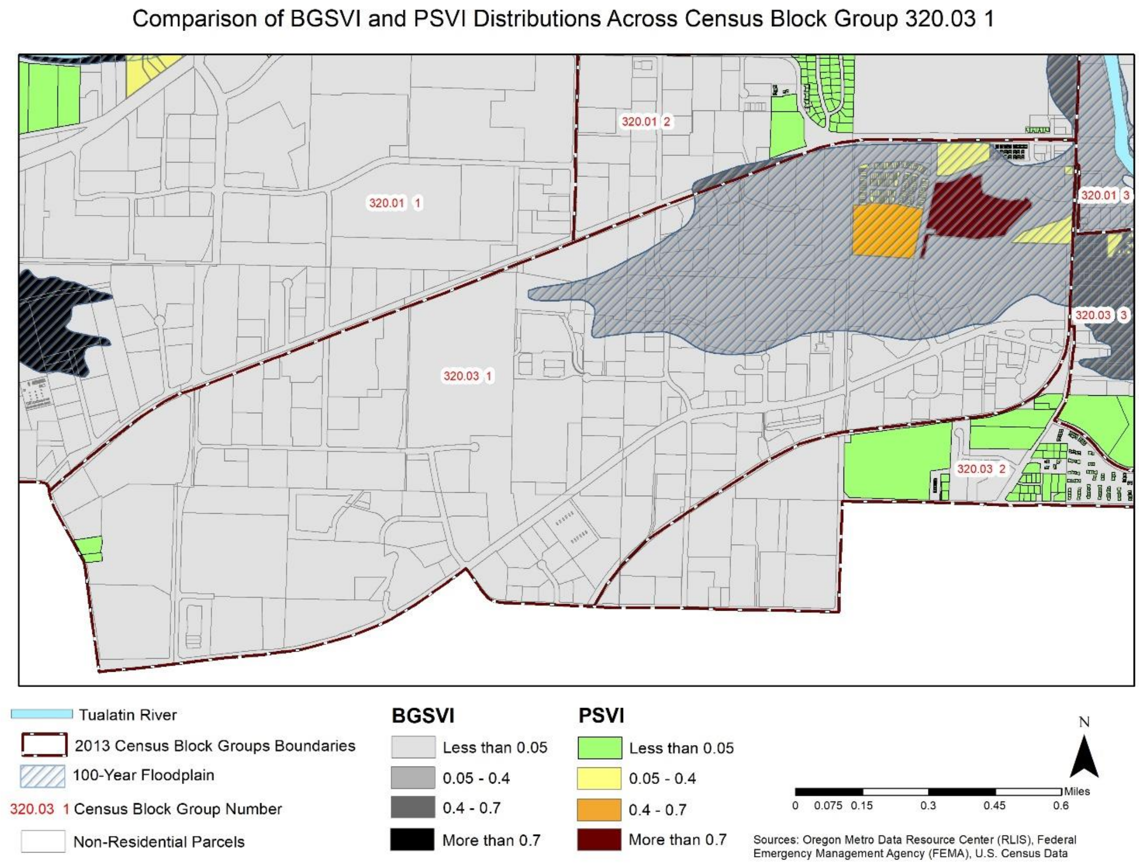

Figure 13: Comparison of BGSVI and PSVI Across Census Block Group 320.03 1

Figure 14 illustrates the differences in BGSVI and PSVI distribution within census block group 320.03 3. At the block group level, almost 63% of the whole block group area has a moderate vulnerability index (SVI = 0.445). However, at the parcel level, 27 parcels are occupied by single-family residences and two parcels have small apartment complexes. All the other parcels within block group 320.03 3 have zero level of social vulnerability to the potential flooding hazard because these parcels' assigned land use is "commercial" (COM).

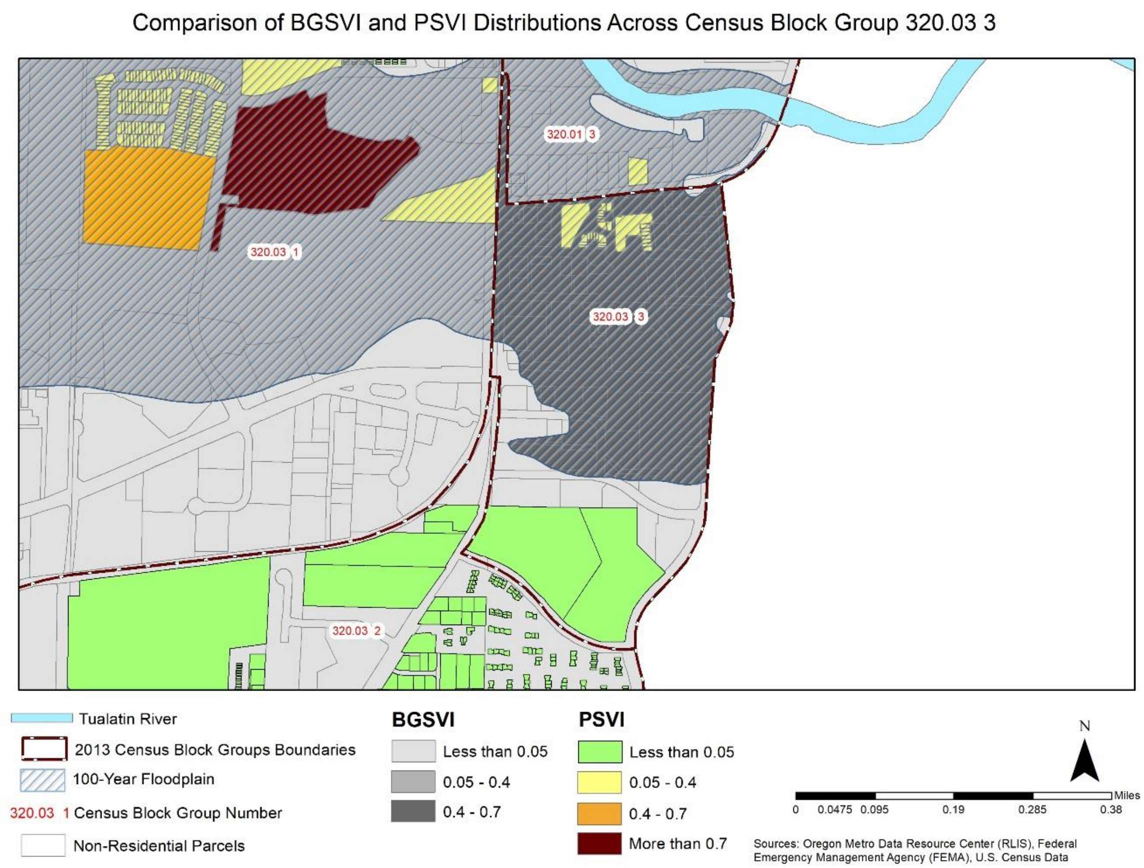

Figure 14: Comparison of BGSVI and PSVI Across Census Block Group 320.03 3

Table 7 summarizes the differences between the distribution of BGSVI and PSVI over the study area. Compared to the dasymetric method, the areal apportionment method significantly overestimates the number of parcels with vulnerable populations. However, there is a moderate difference between the estimations of vulnerable populations according to the areal apportionment and dasymetric methods.

Table 7: Coincidences Between the Distributions of BGSVI and the PSVI

Social Vulnerability Index	Number of Parcels		Percent of all Parcels in the Research Area		Estimated Resident Population		Percent of Total Population in the Research Area		Proportional Difference Between Parcel Level and Block Group Level
	Block Group Level	Parcel Level	Block Group Level	Parcel Level	Block Group Level	Parcel Level	Block Group Level	Parcel Level	
Index Score < 3	639	275	24.76	10.65	2589	1024	28.84	11.40	0.4
Index Score 3 - 5	393	2	15.23	0.08	557	529	6.20	5.89	0.9
Index Score > 5	136	1	5.27	0.04	268	514	2.98	5.73	1.9

Evaluation

After the SVI analysis at the block group and parcel levels, an expert evaluation was applied to the research results. I presented my results to Martin Loring, the Database and GIS Administrator of the city of Tualatin, and requested him to review them. He compared the existing data about the spatial patterns of the vulnerable population collected by the city of Tualatin with the cartographic results of my research. Loring found the research to be relevant and noted that its methodology could be used by several local authorities for social vulnerability estimations. He also suggested expanding the study to evaluate the social vulnerability of the population in respect to other natural and man-made hazards. In his opinion, such further research can improve the complete understanding of the social vulnerability of a population.

In his results evaluation (Appendix B), Loring noted that mapping methods have the greatest impact on the spatial distribution of the population. According to him, although both methods are not absolutely accurate in the distribution of the population, areal apportionment distributes the population less accurately than the dasymetric method. After comparing the presented SVI maps at the census block group level and the parcel level with existing data collected by the city of Tualatin, he concluded that the dasymetric method illustrates more realistic results in the distribution of SVIs (Loring, n.d.).

Figure 15 illustrates the summary of the expert’s opinion about the areas on the presented BGSVI and PSVI maps that do not match the spatial patterns of the SVI.

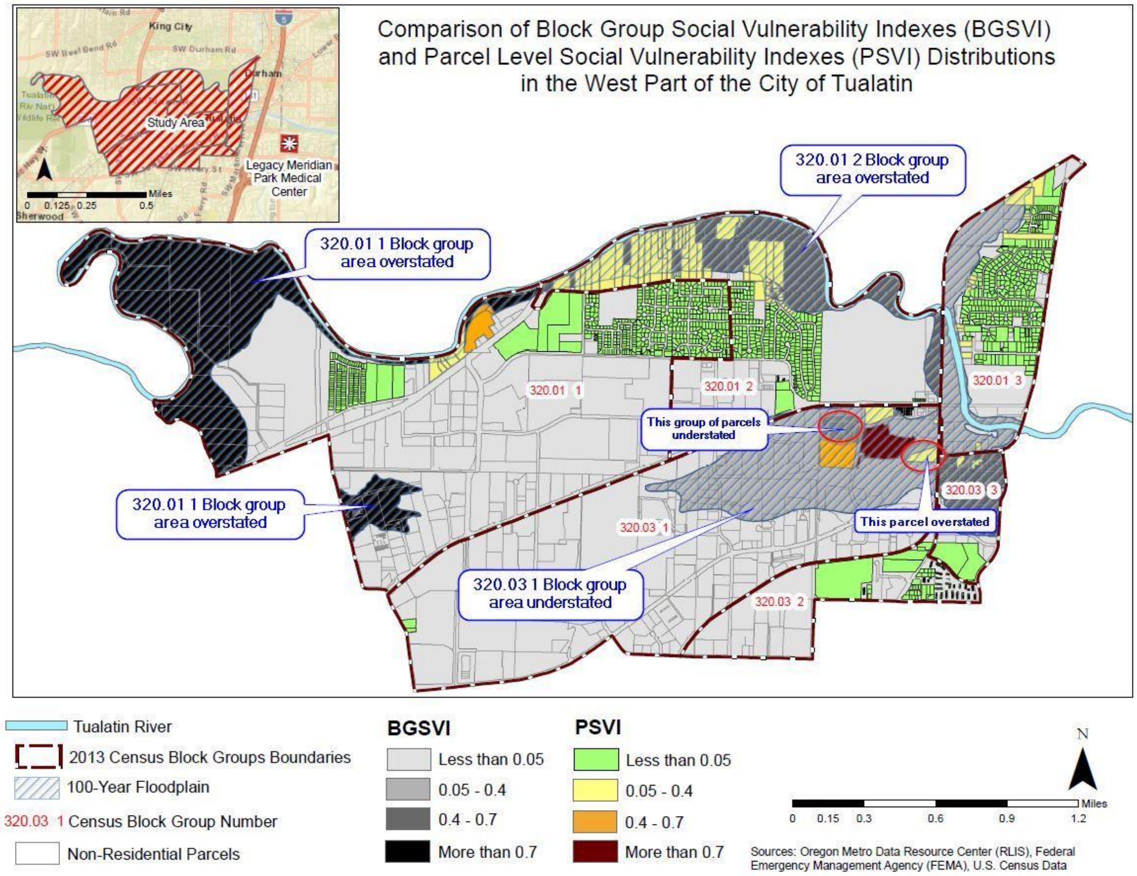

Figure 15: Presented for Evaluation Map with Highlighted Areas that Do Not Match Spatial Distributions of SVIs According to the City of Tualatin

As provided, the expert's evaluation of the results of the comparison of the areal apportionment and the dasymetric methods in assessing and mapping social vulnerability is highly detailed, and I agree with most of this evaluation. The expert found that the BGSVI values for block groups 320.01 1 and 320.01 2 are overestimated compared to the PSVI values for parcels within the same block groups. According to him, block group 320.03 1 has an underestimated BGSVI value because most of the SVIs on the parcel level have higher values than the SVIs at the block group level. The expert also found that the SVI values for some parcels in block group 320.03 1 do not match his estimation.

Despite the depth of the expert's evaluation, further explanations should be added. First, the expert did not find a difference between the block group and the parcel level within the census block group 320.03 3. For this block group, at the block group level, the SVI has a value between 0.4 and 0.7, but at the parcel level, the SVI has values between 0.05 - 0.4. This finding makes it impossible to compare SVI indexes for the block group 320.03 3.

Second, the expert did not agree with the PSVI indexes for a group of parcels within the marked area at the north border of block group 320.03 1, which have townhouses. The expert suggested that this group of parcels should have similar characteristics to multi-family parcels. However, in my opinion, townhouses share the same characteristics as single-family houses. For instance, each townhouse is located within a single parcel and is usually occupied by a single family; therefore, townhouses should be compared to single-family houses.

Table 8 presents a numerical value for the expert's qualitative evaluation of the map, from which I have calculated the percentage of correct locations of vulnerable areas. According to the expert, the average percentage of correct BGSVI area locations is 60%, and the average percentage of correct PSVI area locations is 95%.

Table 8: Comparison of Correct Locations of Vulnerable Areas Based on the Areal Apportionment Method (BGSVI) and the Dasymetric Method (PSVI)

Block Group	320.01 1	320.01 2	320.01 3	320.03 1	320.03 3	Average, %
Correct BGSVI Area	0	8331524	4249468	0	2385339	
Incorrect BGSVI Area	13491528	0	0	10786988	0	
% of Correct Evaluation	0%	100%	100%	0%	100%	60%
Correct PSVI Area	751279	3925597	745524	1359832	105654	
Incorrect PSVI Area	0	0	0	431905	0	
% of Correct Evaluation	100%	100%	100%	76%	100%	95%

Comparing the calculated values of the correct locations, I found that using the dasymetric method in assessing and mapping social vulnerability, provides more accurate results. To answer the research question, I conclude that the estimation of vulnerable populations and SVI is sensitive to a GIS method.

Conclusion

To answer the research question about which GIS method provides more accurate results, I have applied two different GIS mapping methods – the areal apportionment method and the dasymetric method – to the SVI distribution on the block group level and the parcel level using the 2013 ACS data and the auxiliary dataset described in the methodology chapter. Moreover, in this study, I disaggregated social-demographic data to the parcel level and calculated the SVI through the simple averaging method. In the final stage of my research, I created a map to compare the two different GIS methods in the application of SVI mapping. The differenced map reflects the correlation of vulnerable populations with natural hazards in affected areas on two different levels: census block groups and parcels, which is presented in Figure 7.

This map identifies the differences in the results of applying the areal apportionment and dasymetric methods for mapping the distribution of vulnerable populations. I conclude that using the dasymetric method for mapping SVI at the parcel level provides more precision in the description the population's social vulnerability. Furthermore, I conclude that the dasymetric method of population disaggregation provides a more accurate spatial distribution of the population for the assessment of social vulnerability analysis. However, the dasymetric method has a significant limitation: it assumes that population spreads evenly over a disaggregation area, which is not true; population is never distributed evenly. While using some auxiliary data, such as the residential area, allows for mistakes in population disaggregation to be minimized, obtaining absolute accuracy is not feasible. The greatest mistakes occur in the disaggregation of sub-populations (e.g., females, non-white residents, young residents, elder residents, people experiencing poverty) because without reliable supplemental data about the distribution of the different groups of sub-populations, it is not possible to correctly disaggregate them.

Despite the disadvantages, using the dasymetric method for population disaggregation from the census block group level to the parcel level, is recommended as a tool for the spatial assessment of social vulnerability on a local level. This GIS method can be successfully applied for mapping populations potentially impacted by flood risk, and it can be potentially considered for municipal planning. Moreover, the results of applying the dasymetric method can help officials build and improve existing mitigation plans, e.g., in emergency preparedness, the construction of evacuation routes, and community reconstruction.

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Appendix A – Dasymetric Calculation of PSVI

Table A.1

Dasymetric Calculation of PSVI

TLID	Tract	Block Group	Block	Land use Type	Residential Area, sq. ft	Disaggregated Total Population	VI – Total Population	Disaggregated Number of Females	VI – Number of Females	Disaggregated Number of Non-White Residents	VI – Number of Non-White Residents	Disaggregated Number of Population <18	VI – Number of Population <18	Disaggregated Number of Population >65	VI – Number of Population >65	Disaggregated Number of People Living below Poverty Level	VI – Number of People Living below Poverty Level	Distance to the Nearest Hospital, mi	VI – Distance to the Nearest Hospital	Average PSVI
2S115C002300	32001	1	1011	MFR	162156	242.31	0.471	136.11	0.490	21.40	0.48	67.56	0.621	27.45	0.862	57.89	0.517	4.30	1.000	0.635
2S116D001400	32001	1	1013	SFR	2420	3.62	0.007	2.03	0.007	0.32	0.01	1.01	0.009	0.41	0.013	0.86	0.008	4.30	1.000	0.150
2S121A000101	32001	1	1013	SFR	1100	1.64	0.003	0.92	0.003	0.15	0.00	0.46	0.004	0.19	0.006	0.39	0.004	4.30	1.000	0.146
2S121A000102	32001	1	1013	SFR	3240	4.84	0.009	2.72	0.010	0.43	0.01	1.35	0.012	0.55	0.017	1.16	0.010	4.30	1.000	0.153
2S121A000200	32001	1	1013	SFR	0	0.00	0.000	0.00	0.000	0.00	0.00	0.00	0.000	0.00	0.000	0.00	0.000	4.30	1.000	0.143
2S121A000300	32001	1	1014	MHP	7965	11.90	0.023	6.69	0.024	1.05	0.02	3.32	0.031	1.35	0.042	2.84	0.025	4.20	0.977	0.164
2S114CA00100	32001	2	2000	SFR	2759	3.47	0.007	1.95	0.007	0.09	0.00	0.77	0.007	0.49	0.015	0.91	0.008	3.00	0.698	0.106
2S114CA00200	32001	2	2000	SFR	2878	3.62	0.007	2.04	0.007	0.09	0.00	0.80	0.007	0.51	0.016	0.95	0.008	3.00	0.698	0.107
2S114CA00400	32001	2	2000	SFR	2358	2.97	0.006	1.67	0.006	0.07	0.00	0.66	0.006	0.42	0.013	0.78	0.007	2.90	0.674	0.102
2S114CA00500	32001	2	2000	SFR	1980	2.49	0.005	1.40	0.005	0.06	0.00	0.55	0.005	0.35	0.011	0.65	0.006	2.90	0.674	0.101
2S114CA00600	32001	2	2000	SFR	1690	2.13	0.004	1.20	0.004	0.05	0.00	0.47	0.004	0.30	0.009	0.56	0.005	2.90	0.674	0.100
2S114CA00700	32001	2	2000	SFR	1939	2.44	0.005	1.37	0.005	0.06	0.00	0.54	0.005	0.34	0.011	0.64	0.006	2.90	0.674	0.101
2S114CA00800	32001	2	2000	SFR	2006	2.53	0.005	1.42	0.005	0.06	0.00	0.56	0.005	0.35	0.011	0.66	0.006	3.00	0.698	0.104

TLID	Tract	Block Group	Block	Land use Type	Residential Area, sq. ft	Disaggregated Total Population	VI – Total Population	Disaggregated Number of Females	VI – Number of Females	Disaggregated Number of Non-White Residents	VI – Number of Non-White Residents	Disaggregated Number of Population <18	VI – Number of Population <18	Disaggregated Number of Population >65	VI – Number of Population >65	Disaggregated Number of People Living below Poverty Level	VI – Number of People Living below Poverty Level	Distance to the Nearest Hospital, mi	VI – Distance to the Nearest Hospital	Average PSVI
2S114CA01000	32001	2	2000	SFR	1736	2.19	0.004	1.23	0.004	0.05	0.00	0.48	0.004	0.31	0.010	0.57	0.005	3.00	0.698	0.104
2S114CD07900	32001	2	2000	SFR	2386	3.00	0.006	1.69	0.006	0.07	0.00	0.66	0.006	0.42	0.013	0.79	0.007	2.90	0.674	0.102
2S114CD08000	32001	2	2000	SFR	3230	4.07	0.008	2.28	0.008	0.10	0.00	0.90	0.008	0.57	0.018	1.06	0.010	2.90	0.674	0.104
2S114CD08100	32001	2	2000	SFR	3859	4.86	0.009	2.73	0.010	0.12	0.00	1.07	0.010	0.68	0.021	1.27	0.011	2.80	0.651	0.102
2S114CD08200	32001	2	2000	SFR	2200	2.77	0.005	1.56	0.006	0.07	0.00	0.61	0.006	0.39	0.012	0.72	0.006	2.80	0.651	0.098
2S114CD08301	32001	2	2000	SFR	1971	2.48	0.005	1.39	0.005	0.06	0.00	0.55	0.005	0.35	0.011	0.65	0.006	2.80	0.651	0.098
2S114BC01900	32001	2	2004	SFR	1320	1.66	0.003	0.93	0.003	0.04	0.00	0.37	0.003	0.23	0.007	0.43	0.004	3.50	0.814	0.119
2S114BC01901	32001	2	2004	SFR	0	0.00	0.000	0.00	0.000	0.00	0.00	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.000
2S114BC02000	32001	2	2004	SFR	396	0.50	0.001	0.28	0.001	0.01	0.00	0.11	0.001	0.07	0.002	0.13	0.001	3.50	0.814	0.117
2S114CB00200	32001	2	2004	SFR	3352	4.22	0.008	2.37	0.009	0.11	0.00	0.93	0.009	0.59	0.019	1.10	0.010	3.30	0.767	0.118
2S114CB00300	32001	2	2004	SFR	3320	4.18	0.008	2.35	0.008	0.10	0.00	0.92	0.008	0.59	0.018	1.09	0.010	3.40	0.791	0.121
2S114CB00500	32001	2	2004	SFR	2786	3.51	0.007	1.97	0.007	0.09	0.00	0.78	0.007	0.49	0.015	0.92	0.008	3.30	0.767	0.116
2S114CB01000	32001	2	2005	SFR	4072	5.13	0.010	2.88	0.010	0.13	0.00	1.13	0.010	0.72	0.023	1.34	0.012	3.30	0.767	0.119
2S115AD01100	32001	2	2006	SFR	2580	3.25	0.006	1.82	0.007	0.08	0.00	0.72	0.007	0.46	0.014	0.85	0.008	3.60	0.837	0.126
2S115AD01300	32001	2	2006	SFR	2635	3.32	0.006	1.86	0.007	0.08	0.00	0.73	0.007	0.47	0.015	0.87	0.008	3.60	0.837	0.126
2S115AD01400	32001	2	2006	SFR	3347	4.21	0.008	2.37	0.009	0.10	0.00	0.93	0.009	0.59	0.019	1.10	0.010	3.60	0.837	0.128
2S115AD01500	32001	2	2006	SFR	2592	3.26	0.006	1.83	0.007	0.08	0.00	0.72	0.007	0.46	0.014	0.85	0.008	3.60	0.837	0.126

TLID	Tract	Block Group	Block	Land use Type	Residential Area, sq. ft	Disaggregated Total Population	VI – Total Population	Disaggregated Number of Females	VI – Number of Females	Disaggregated Number of Non-White Residents	VI – Number of Non-White Residents	Disaggregated Number of Population <18	VI – Number of Population <18	Disaggregated Number of Population >65	VI – Number of Population >65	Disaggregated Number of People Living below Poverty Level	VI – Number of People Living below Poverty Level	Distance to the Nearest Hospital, mi	VI – Distance to the Nearest Hospital	Average PSVI
2S115AD01600	32001	2	2006	SFR	2047	2.58	0.005	1.45	0.005	0.06	0.00	0.57	0.005	0.36	0.011	0.67	0.006	3.60	0.837	0.124
2S115AD01700	32001	2	2006	SFR	3184	4.01	0.008	2.25	0.008	0.10	0.00	0.89	0.008	0.56	0.018	1.05	0.009	3.70	0.860	0.131
2S115C001400	32001	2	2006	SFR	2146	2.70	0.005	1.52	0.005	0.07	0.00	0.60	0.005	0.38	0.012	0.71	0.006	3.90	0.907	0.135
2S115C001500	32001	2	2006	SFR	2014	2.54	0.005	1.42	0.005	0.06	0.00	0.56	0.005	0.36	0.011	0.66	0.006	3.80	0.884	0.131
2S115C001501	32001	2	2006	SFR	3618	4.56	0.009	2.56	0.009	0.11	0.00	1.01	0.009	0.64	0.020	1.19	0.011	3.80	0.884	0.135
2S115D001401	32001	2	2006	SFR	2830	3.56	0.007	2.00	0.007	0.09	0.00	0.79	0.007	0.50	0.016	0.93	0.008	3.60	0.837	0.126
2S115D001402	32001	2	2006	SFR	2796	3.52	0.007	1.98	0.007	0.09	0.00	0.78	0.007	0.49	0.015	0.92	0.008	3.70	0.860	0.130
2S115D001405	32001	2	2006	SFR	2877	3.62	0.007	2.03	0.007	0.09	0.00	0.80	0.007	0.51	0.016	0.95	0.008	3.70	0.860	0.130
2S115D001500	32001	2	2006	SFR	3082	3.88	0.008	2.18	0.008	0.10	0.00	0.86	0.008	0.54	0.017	1.02	0.009	3.70	0.860	0.130
2S115D001600	32001	2	2006	SFR	2808	3.54	0.007	1.99	0.007	0.09	0.00	0.78	0.007	0.50	0.016	0.93	0.008	3.80	0.884	0.133
2S115D001700	32001	2	2006	SFR	2691	3.39	0.007	1.90	0.007	0.08	0.00	0.75	0.007	0.48	0.015	0.89	0.008	3.80	0.884	0.133
2S115DA00200	32001	2	2006	SFR	3178	4.00	0.008	2.25	0.008	0.10	0.00	0.89	0.008	0.56	0.018	1.05	0.009	3.30	0.767	0.117
2S115DA00300	32001	2	2006	SFR	3652	4.60	0.009	2.58	0.009	0.11	0.00	1.02	0.009	0.64	0.020	1.20	0.011	3.40	0.791	0.122
2S115DA00800	32001	2	2006	SFR	3538	4.46	0.009	2.50	0.009	0.11	0.00	0.99	0.009	0.62	0.020	1.17	0.010	3.50	0.814	0.125
2S115DA00900	32001	2	2006	SFR	3232	4.07	0.008	2.29	0.008	0.10	0.00	0.90	0.008	0.57	0.018	1.07	0.010	3.60	0.837	0.127
2S115DA01100	32001	2	2006	SFR	3113	3.92	0.008	2.20	0.008	0.10	0.00	0.87	0.008	0.55	0.017	1.03	0.009	3.60	0.837	0.127
2S115AD01800	32001	2	2007	SFR	1967	2.48	0.005	1.39	0.005	0.06	0.00	0.55	0.005	0.35	0.011	0.65	0.006	3.70	0.860	0.128

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2S115DA00400	32001	2	2007	SFR	1776	2.24	0.004	1.26	0.005	0.06	0.00	0.49	0.005	0.31	0.010	0.59	0.005	3.40	0.791	0.117
2S115DA05500	32001	2	2007	SFR	2793	3.52	0.007	1.98	0.007	0.09	0.00	0.78	0.007	0.49	0.015	0.92	0.008	3.50	0.814	0.123
2S115DA05600	32001	2	2007	SFR	2827	3.56	0.007	2.00	0.007	0.09	0.00	0.79	0.007	0.50	0.016	0.93	0.008	3.50	0.814	0.123
2S115DA00600	32001	2	2008	SFR	4651	5.86	0.011	3.29	0.012	0.15	0.00	1.30	0.012	0.82	0.026	1.53	0.014	3.50	0.814	0.127
2S115DA00700	32001	2	2008	SFR	1985	2.50	0.005	1.40	0.005	0.06	0.00	0.55	0.005	0.35	0.011	0.65	0.006	3.50	0.814	0.121
2S114CA01100	32001	2	2011	SFR	1667	2.10	0.004	1.18	0.004	0.05	0.00	0.46	0.004	0.29	0.009	0.55	0.005	3.00	0.698	0.104
2S114CA01201	32001	2	2011	SFR	1897	2.39	0.005	1.34	0.005	0.06	0.00	0.53	0.005	0.33	0.011	0.63	0.006	3.00	0.698	0.104
2S114CA01300	32001	2	2011	SFR	1695	2.13	0.004	1.20	0.004	0.05	0.00	0.47	0.004	0.30	0.009	0.56	0.005	2.90	0.674	0.100
2S114CA01400	32001	2	2011	SFR	1690	2.13	0.004	1.20	0.004	0.05	0.00	0.47	0.004	0.30	0.009	0.56	0.005	2.90	0.674	0.100
2S114CA01500	32001	2	2011	SFR	1627	2.05	0.004	1.15	0.004	0.05	0.00	0.45	0.004	0.29	0.009	0.54	0.005	2.90	0.674	0.100
2S114CA01600	32001	2	2011	SFR	1586	2.00	0.004	1.12	0.004	0.05	0.00	0.44	0.004	0.28	0.009	0.52	0.005	2.90	0.674	0.100
2S114CA01700	32001	2	2011	SFR	2153	2.71	0.005	1.52	0.005	0.07	0.00	0.60	0.006	0.38	0.012	0.71	0.006	2.90	0.674	0.101
2S113BA00700	32001	3	3000	SFR	1756	1.86	0.004	0.94	0.003	0.20	0.00	0.33	0.003	0.36	0.011	0.57	0.005	2.70	0.628	0.094
2S113BD00200	32001	3	3000	SFR	2496	2.64	0.005	1.34	0.005	0.28	0.01	0.46	0.004	0.51	0.016	0.81	0.007	2.60	0.605	0.093
2S113BD00400	32001	3	3000	SFR	2501	2.65	0.005	1.34	0.005	0.28	0.01	0.46	0.004	0.51	0.016	0.81	0.007	2.60	0.605	0.093
2S113BD00500	32001	3	3000	SFR	2548	2.70	0.005	1.37	0.005	0.29	0.01	0.47	0.004	0.52	0.016	0.83	0.007	2.60	0.605	0.093
2S113BD03500	32001	3	3000	SFR	2022	2.14	0.004	1.09	0.004	0.23	0.01	0.37	0.003	0.42	0.013	0.65	0.006	2.30	0.535	0.081
2S113CB06400	32001	3	3000	SFR	3557	3.77	0.007	1.91	0.007	0.40	0.01	0.66	0.006	0.73	0.023	1.15	0.010	2.40	0.558	0.089
2S113CB06500	32001	3	3000	SFR	2277	2.41	0.005	1.22	0.004	0.26	0.01	0.42	0.004	0.47	0.015	0.74	0.007	2.40	0.558	0.085
2S113CB06900	32001	3	3000	SFR	2172	2.30	0.004	1.17	0.004	0.25	0.01	0.40	0.004	0.45	0.014	0.70	0.006	2.40	0.558	0.085
2S113CB06300	32001	3	3003	SFR	2571	2.72	0.005	1.38	0.005	0.29	0.01	0.48	0.004	0.53	0.017	0.83	0.007	2.40	0.558	0.086

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2S113CC00200	32001	3	3006	SFR	4006	4.24	0.008	2.15	0.008	0.45	0.01	0.74	0.007	0.82	0.026	1.30	0.012	2.20	0.512	0.083
2S113CC00300	32001	3	3006	SFR	1554	1.65	0.003	0.83	0.003	0.18	0.00	0.29	0.003	0.32	0.010	0.50	0.004	2.40	0.558	0.084
2S113CC01400	32001	3	3006	SFR	2504	2.65	0.005	1.34	0.005	0.28	0.01	0.46	0.004	0.52	0.016	0.81	0.007	2.20	0.512	0.079
2S113CC01600	32001	3	3006	SFR	1746	1.85	0.004	0.94	0.003	0.20	0.00	0.32	0.003	0.36	0.011	0.57	0.005	2.10	0.488	0.074
2S124BC01300	32001	3	3011	MFR	9328	9.88	0.019	5.01	0.018	1.06	0.02	1.73	0.016	1.92	0.060	3.02	0.027	1.50	0.349	0.073
2S123A000300	32003	1	1001	MFR	108948	163.82	0.319	88.47	0.319	14.14	0.32	34.66	0.319	10.15	0.319	35.68	0.319	2.10	0.488	0.343
2S123AA81001	32003	1	1001	SFR	1237	1.86	0.004	1.00	0.004	0.16	0.00	0.39	0.004	0.12	0.004	0.41	0.004	2.00	0.465	0.070
2S123AA81011	32003	1	1001	SFR	1074	1.61	0.003	0.87	0.003	0.14	0.00	0.34	0.003	0.10	0.003	0.35	0.003	2.00	0.465	0.069
2S123AA81021	32003	1	1001	SFR	761	1.14	0.002	0.62	0.002	0.10	0.00	0.24	0.002	0.07	0.002	0.25	0.002	2.00	0.465	0.068
2S123AA81031	32003	1	1001	SFR	761	1.14	0.002	0.62	0.002	0.10	0.00	0.24	0.002	0.07	0.002	0.25	0.002	2.00	0.465	0.068
2S123AA81081	32003	1	1001	SFR	1022	1.54	0.003	0.83	0.003	0.13	0.00	0.33	0.003	0.10	0.003	0.33	0.003	2.00	0.465	0.069
2S123AA81091	32003	1	1001	SFR	1022	1.54	0.003	0.83	0.003	0.13	0.00	0.33	0.003	0.10	0.003	0.33	0.003	2.00	0.465	0.069
2S123AA81101	32003	1	1001	SFR	939	1.41	0.003	0.76	0.003	0.12	0.00	0.30	0.003	0.09	0.003	0.31	0.003	2.00	0.465	0.069
2S123AA81161	32003	1	1001	SFR	1022	1.54	0.003	0.83	0.003	0.13	0.00	0.33	0.003	0.10	0.003	0.33	0.003	2.00	0.465	0.069
2S123AA82002	32003	1	1001	SFR	1237	1.86	0.004	1.00	0.004	0.16	0.00	0.39	0.004	0.12	0.004	0.41	0.004	2.00	0.465	0.070
2S123AA82012	32003	1	1001	SFR	1074	1.61	0.003	0.87	0.003	0.14	0.00	0.34	0.003	0.10	0.003	0.35	0.003	2.00	0.465	0.069
2S123AA82022	32003	1	1001	SFR	761	1.14	0.002	0.62	0.002	0.10	0.00	0.24	0.002	0.07	0.002	0.25	0.002	2.00	0.465	0.068
2S123AA82032	32003	1	1001	SFR	761	1.14	0.002	0.62	0.002	0.10	0.00	0.24	0.002	0.07	0.002	0.25	0.002	2.00	0.465	0.068
2S123AA82082	32003	1	1001	SFR	1022	1.54	0.003	0.83	0.003	0.13	0.00	0.33	0.003	0.10	0.003	0.33	0.003	2.00	0.465	0.069
2S123AA82092	32003	1	1001	SFR	1022	1.54	0.003	0.83	0.003	0.13	0.00	0.33	0.003	0.10	0.003	0.33	0.003	2.00	0.465	0.069

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2S123AA82162	32003	1	1001	SFR	1022	1.54	0.003	0.83	0.003	0.13	0.00	0.33	0.003	0.10	0.003	0.33	0.003	2.00	0.465	0.069
2S123AA83003	32003	1	1001	SFR	1267	1.91	0.004	1.03	0.004	0.16	0.00	0.40	0.004	0.12	0.004	0.41	0.004	2.00	0.465	0.070
2S123AA83013	32003	1	1001	SFR	1101	1.66	0.003	0.89	0.003	0.14	0.00	0.35	0.003	0.10	0.003	0.36	0.003	2.00	0.465	0.069
2S123AA83023	32003	1	1001	SFR	768	1.15	0.002	0.62	0.002	0.10	0.00	0.24	0.002	0.07	0.002	0.25	0.002	2.00	0.465	0.068
2S123AA83083	32003	1	1001	SFR	1038	1.56	0.003	0.84	0.003	0.13	0.00	0.33	0.003	0.10	0.003	0.34	0.003	2.00	0.465	0.069
2S123AA83093	32003	1	1001	SFR	1038	1.56	0.003	0.84	0.003	0.13	0.00	0.33	0.003	0.10	0.003	0.34	0.003	2.00	0.465	0.069
2S123AA83163	32003	1	1001	SFR	1038	1.56	0.003	0.84	0.003	0.13	0.00	0.33	0.003	0.10	0.003	0.34	0.003	2.00	0.465	0.069
2S123A000400	32003	1	1004	MFR	342030	514.30	1.000	277.73	1.000	44.38	1.00	108.80	1.000	31.85	1.000	112.02	1.000	2.20	0.512	0.930
2S123A001100	32003	1	1004	SFR	1068	1.61	0.003	0.87	0.003	0.14	0.00	0.34	0.003	0.10	0.003	0.35	0.003	1.80	0.419	0.062
2S123D003400	32003	1	1004	SFR	5250	7.89	0.015	4.26	0.015	0.68	0.02	1.67	0.015	0.49	0.015	1.72	0.015	1.70	0.395	0.070
2S123AB00500	32003	1	1006	SFR	1430	2.15	0.004	1.16	0.004	0.19	0.00	0.45	0.004	0.13	0.004	0.47	0.004	2.20	0.512	0.077
2S123AB00600	32003	1	1006	SFR	1322	1.99	0.004	1.07	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.20	0.512	0.076
2S123AB00700	32003	1	1006	SFR	1456	2.19	0.004	1.18	0.004	0.19	0.00	0.46	0.004	0.14	0.004	0.48	0.004	2.20	0.512	0.077
2S123AB00800	32003	1	1006	SFR	1416	2.13	0.004	1.15	0.004	0.18	0.00	0.45	0.004	0.13	0.004	0.46	0.004	2.20	0.512	0.077
2S123AB00900	32003	1	1006	SFR	1870	2.81	0.005	1.52	0.005	0.24	0.01	0.59	0.005	0.17	0.005	0.61	0.005	2.20	0.512	0.078
2S123AB01000	32003	1	1006	SFR	1830	2.75	0.005	1.49	0.005	0.24	0.01	0.58	0.005	0.17	0.005	0.60	0.005	2.20	0.512	0.078
2S123AB01100	32003	1	1006	SFR	1416	2.13	0.004	1.15	0.004	0.18	0.00	0.45	0.004	0.13	0.004	0.46	0.004	2.10	0.488	0.073
2S123AB01200	32003	1	1006	SFR	1376	2.07	0.004	1.12	0.004	0.18	0.00	0.44	0.004	0.13	0.004	0.45	0.004	2.10	0.488	0.073
2S123AB01300	32003	1	1006	SFR	1378	2.07	0.004	1.12	0.004	0.18	0.00	0.44	0.004	0.13	0.004	0.45	0.004	2.10	0.488	0.073
2S123AB01400	32003	1	1006	SFR	1378	2.07	0.004	1.12	0.004	0.18	0.00	0.44	0.004	0.13	0.004	0.45	0.004	2.10	0.488	0.073
2S123AB01500	32003	1	1006	SFR	1376	2.07	0.004	1.12	0.004	0.18	0.00	0.44	0.004	0.13	0.004	0.45	0.004	2.10	0.488	0.073

TLID	Tract	Block Group	Block	Land use Type	Residential Area, sq. ft	Disaggregated Total Population	VI – Total Population	Disaggregated Number of Females	VI – Number of Females	Disaggregated Number of Non-White Residents	VI – Number of Non-White Residents	Disaggregated Number of Population <18	VI – Number of Population <18	Disaggregated Number of Population >65	VI – Number of Population >65	Disaggregated Number of People Living below Poverty Level	VI – Number of People Living below Poverty Level	Distance to the Nearest Hospital, mi	VI – Distance to the Nearest Hospital	Average PSVI
2S123AB01600	32003	1	1006	SFR	1376	2.07	0.004	1.12	0.004	0.18	0.00	0.44	0.004	0.13	0.004	0.45	0.004	2.10	0.488	0.073
2S123AB01700	32003	1	1006	SFR	1826	2.75	0.005	1.48	0.005	0.24	0.01	0.58	0.005	0.17	0.005	0.60	0.005	2.10	0.488	0.074
2S123AB01800	32003	1	1006	SFR	1826	2.75	0.005	1.48	0.005	0.24	0.01	0.58	0.005	0.17	0.005	0.60	0.005	2.10	0.488	0.074
2S123AB01900	32003	1	1006	SFR	1384	2.08	0.004	1.12	0.004	0.18	0.00	0.44	0.004	0.13	0.004	0.45	0.004	2.10	0.488	0.073
2S123AB00100	32003	1	1007	MFR	190368	286.25	0.557	154.58	0.557	24.70	0.56	60.56	0.557	17.73	0.557	62.35	0.557	2.10	0.488	0.547
2S123AB11000	32003	1	1007	SFR	1443	2.17	0.004	1.17	0.004	0.19	0.00	0.46	0.004	0.13	0.004	0.47	0.004	2.20	0.512	0.077
2S123AB11100	32003	1	1007	SFR	1322	1.99	0.004	1.07	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.20	0.512	0.076
2S123AB11200	32003	1	1007	SFR	1436	2.16	0.004	1.17	0.004	0.19	0.00	0.46	0.004	0.13	0.004	0.47	0.004	2.20	0.512	0.077
2S123AB11300	32003	1	1007	SFR	1443	2.17	0.004	1.17	0.004	0.19	0.00	0.46	0.004	0.13	0.004	0.47	0.004	2.20	0.512	0.077
2S123AB11400	32003	1	1007	SFR	1443	2.17	0.004	1.17	0.004	0.19	0.00	0.46	0.004	0.13	0.004	0.47	0.004	2.30	0.535	0.080
2S123AB11500	32003	1	1007	SFR	1322	1.99	0.004	1.07	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.20	0.512	0.076
2S123AB11600	32003	1	1007	SFR	1322	1.99	0.004	1.07	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.20	0.512	0.076
2S123AB11700	32003	1	1007	SFR	1443	2.17	0.004	1.17	0.004	0.19	0.00	0.46	0.004	0.13	0.004	0.47	0.004	2.20	0.512	0.077
2S123AB11800	32003	1	1007	SFR	1443	2.17	0.004	1.17	0.004	0.19	0.00	0.46	0.004	0.13	0.004	0.47	0.004	2.20	0.512	0.077
2S123AB11900	32003	1	1007	SFR	1322	1.99	0.004	1.07	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.30	0.535	0.080
2S123AB12000	32003	1	1007	SFR	1322	1.99	0.004	1.07	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.30	0.535	0.080
2S123AB12100	32003	1	1007	SFR	1322	1.99	0.004	1.07	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.30	0.535	0.080
2S123AB12200	32003	1	1007	SFR	1443	2.17	0.004	1.17	0.004	0.19	0.00	0.46	0.004	0.13	0.004	0.47	0.004	2.30	0.535	0.080
2S123AB12300	32003	1	1007	SFR	1430	2.15	0.004	1.16	0.004	0.19	0.00	0.45	0.004	0.13	0.004	0.47	0.004	2.30	0.535	0.080
2S123AB12400	32003	1	1007	SFR	1322	1.99	0.004	1.07	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.30	0.535	0.080
2S123AB12500	32003	1	1007	SFR	1436	2.16	0.004	1.17	0.004	0.19	0.00	0.46	0.004	0.13	0.004	0.47	0.004	2.30	0.535	0.080

TLID	Tract	Block Group	Block	Land use Type	Residential Area, sq. ft	Disaggregated Total Population	VI – Total Population	Disaggregated Number of Females	VI – Number of Females	Disaggregated Number of Non-White Residents	VI – Number of Non-White Residents	Disaggregated Number of Population <18	VI – Number of Population <18	Disaggregated Number of Population >65	VI – Number of Population >65	Disaggregated Number of People Living below Poverty Level	VI – Number of People Living below Poverty Level	Distance to the Nearest Hospital, mi	VI – Distance to the Nearest Hospital	Average PSVI
2S123AB12600	32003	1	1007	SFR	1430	2.15	0.004	1.16	0.004	0.19	0.00	0.45	0.004	0.13	0.004	0.47	0.004	2.30	0.535	0.080
2S123AB12700	32003	1	1007	SFR	1440	2.17	0.004	1.17	0.004	0.19	0.00	0.46	0.004	0.13	0.004	0.47	0.004	2.30	0.535	0.080
2S123AB12800	32003	1	1007	SFR	1318	1.98	0.004	1.07	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.30	0.535	0.080
2S123AB12900	32003	1	1007	SFR	1436	2.16	0.004	1.17	0.004	0.19	0.00	0.46	0.004	0.13	0.004	0.47	0.004	2.30	0.535	0.080
2S123AB13000	32003	1	1007	SFR	1440	2.17	0.004	1.17	0.004	0.19	0.00	0.46	0.004	0.13	0.004	0.47	0.004	2.30	0.535	0.080
2S123AB13100	32003	1	1007	SFR	1810	2.72	0.005	1.47	0.005	0.23	0.01	0.58	0.005	0.17	0.005	0.59	0.005	2.30	0.535	0.081
2S123AB13200	32003	1	1007	SFR	1810	2.72	0.005	1.47	0.005	0.23	0.01	0.58	0.005	0.17	0.005	0.59	0.005	2.30	0.535	0.081
2S123AB13300	32003	1	1007	SFR	1810	2.72	0.005	1.47	0.005	0.23	0.01	0.58	0.005	0.17	0.005	0.59	0.005	2.30	0.535	0.081
2S123AB13400	32003	1	1007	SFR	1810	2.72	0.005	1.47	0.005	0.23	0.01	0.58	0.005	0.17	0.005	0.59	0.005	2.30	0.535	0.081
2S123AB13500	32003	1	1007	SFR	1810	2.72	0.005	1.47	0.005	0.23	0.01	0.58	0.005	0.17	0.005	0.59	0.005	2.30	0.535	0.081
2S123AB13600	32003	1	1007	SFR	1810	2.72	0.005	1.47	0.005	0.23	0.01	0.58	0.005	0.17	0.005	0.59	0.005	2.30	0.535	0.081
2S123AB13700	32003	1	1007	SFR	1404	2.11	0.004	1.14	0.004	0.18	0.00	0.45	0.004	0.13	0.004	0.46	0.004	2.30	0.535	0.080
2S123AB13800	32003	1	1007	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.30	0.535	0.081
2S123AB13900	32003	1	1007	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.20	0.512	0.078
2S123AB14000	32003	1	1007	SFR	1404	2.11	0.004	1.14	0.004	0.18	0.00	0.45	0.004	0.13	0.004	0.46	0.004	2.20	0.512	0.077
2S123AB14100	32003	1	1007	SFR	2150	3.23	0.006	1.75	0.006	0.28	0.01	0.68	0.006	0.20	0.006	0.70	0.006	2.20	0.512	0.078
2S123AB14200	32003	1	1007	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.20	0.512	0.078
2S123AB14300	32003	1	1007	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.20	0.512	0.078
2S123AB14400	32003	1	1007	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.20	0.512	0.078
2S123AB14500	32003	1	1007	SFR	1404	2.11	0.004	1.14	0.004	0.18	0.00	0.45	0.004	0.13	0.004	0.46	0.004	2.20	0.512	0.077

TLID	Tract	Block Group	Block	Land use Type	Residential Area, sq. ft	Disaggregated Total Population	VI – Total Population	Disaggregated Number of Females	VI – Number of Females	Disaggregated Number of Non-White Residents	VI – Number of Non-White Residents	Disaggregated Number of Population <18	VI – Number of Population <18	Disaggregated Number of Population >65	VI – Number of Population >65	Disaggregated Number of People Living below Poverty Level	VI – Number of People Living below Poverty Level	Distance to the Nearest Hospital, mi	VI – Distance to the Nearest Hospital	Average PSVI
2S123AB14600	32003	1	1007	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.20	0.512	0.078
2S123AB14700	32003	1	1007	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.20	0.512	0.078
2S123AB14800	32003	1	1007	SFR	1404	2.11	0.004	1.14	0.004	0.18	0.00	0.45	0.004	0.13	0.004	0.46	0.004	2.20	0.512	0.077
2S123AB14900	32003	1	1007	SFR	1404	2.11	0.004	1.14	0.004	0.18	0.00	0.45	0.004	0.13	0.004	0.46	0.004	2.20	0.512	0.077
2S123AB15000	32003	1	1007	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.20	0.512	0.078
2S123AB15100	32003	1	1007	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.20	0.512	0.078
2S123AB15200	32003	1	1007	SFR	1404	2.11	0.004	1.14	0.004	0.18	0.00	0.45	0.004	0.13	0.004	0.46	0.004	2.20	0.512	0.077
2S123AB15300	32003	1	1007	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.20	0.512	0.078
2S123AB15400	32003	1	1007	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.20	0.512	0.078
2S123AB15500	32003	1	1007	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.20	0.512	0.078
2S123AB15600	32003	1	1007	SFR	1404	2.11	0.004	1.14	0.004	0.18	0.00	0.45	0.004	0.13	0.004	0.46	0.004	2.30	0.535	0.080
2S123AB02000	32003	1	1008	SFR	1310	1.97	0.004	1.06	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.10	0.488	0.073
2S123AB02100	32003	1	1008	SFR	1296	1.95	0.004	1.05	0.004	0.17	0.00	0.41	0.004	0.12	0.004	0.42	0.004	2.10	0.488	0.073
2S123AB02200	32003	1	1008	SFR	1216	1.83	0.004	0.99	0.004	0.16	0.00	0.39	0.004	0.11	0.004	0.40	0.004	2.10	0.488	0.073
2S123AB02300	32003	1	1008	SFR	1216	1.83	0.004	0.99	0.004	0.16	0.00	0.39	0.004	0.11	0.004	0.40	0.004	2.10	0.488	0.073
2S123AB02400	32003	1	1008	SFR	1296	1.95	0.004	1.05	0.004	0.17	0.00	0.41	0.004	0.12	0.004	0.42	0.004	2.10	0.488	0.073
2S123AB02500	32003	1	1008	SFR	1296	1.95	0.004	1.05	0.004	0.17	0.00	0.41	0.004	0.12	0.004	0.42	0.004	2.10	0.488	0.073
2S123AB02600	32003	1	1008	SFR	1381	2.08	0.004	1.12	0.004	0.18	0.00	0.44	0.004	0.13	0.004	0.45	0.004	2.10	0.488	0.073
2S123AB02700	32003	1	1008	SFR	1381	2.08	0.004	1.12	0.004	0.18	0.00	0.44	0.004	0.13	0.004	0.45	0.004	2.10	0.488	0.073
2S123AB02800	32003	1	1008	SFR	1746	2.63	0.005	1.42	0.005	0.23	0.01	0.56	0.005	0.16	0.005	0.57	0.005	2.10	0.488	0.074
2S123AB02900	32003	1	1008	SFR	1746	2.63	0.005	1.42	0.005	0.23	0.01	0.56	0.005	0.16	0.005	0.57	0.005	2.10	0.488	0.074

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2S123AB03000	32003	1	1008	SFR	1381	2.08	0.004	1.12	0.004	0.18	0.00	0.44	0.004	0.13	0.004	0.45	0.004	2.20	0.512	0.077
2S123AB03100	32003	1	1008	SFR	1381	2.08	0.004	1.12	0.004	0.18	0.00	0.44	0.004	0.13	0.004	0.45	0.004	2.20	0.512	0.077
2S123AB03200	32003	1	1008	SFR	1360	2.04	0.004	1.10	0.004	0.18	0.00	0.43	0.004	0.13	0.004	0.45	0.004	2.20	0.512	0.076
2S123AB03300	32003	1	1008	SFR	1360	2.04	0.004	1.10	0.004	0.18	0.00	0.43	0.004	0.13	0.004	0.45	0.004	2.20	0.512	0.076
2S123AB03400	32003	1	1008	SFR	1280	1.92	0.004	1.04	0.004	0.17	0.00	0.41	0.004	0.12	0.004	0.42	0.004	2.20	0.512	0.076
2S123AB03500	32003	1	1008	SFR	1280	1.92	0.004	1.04	0.004	0.17	0.00	0.41	0.004	0.12	0.004	0.42	0.004	2.20	0.512	0.076
2S123AB03600	32003	1	1008	SFR	1360	2.04	0.004	1.10	0.004	0.18	0.00	0.43	0.004	0.13	0.004	0.45	0.004	2.20	0.512	0.076
2S123AB03700	32003	1	1008	SFR	1380	2.08	0.004	1.12	0.004	0.18	0.00	0.44	0.004	0.13	0.004	0.45	0.004	2.20	0.512	0.077
2S123AB03800	32003	1	1008	SFR	1704	2.56	0.005	1.38	0.005	0.22	0.00	0.54	0.005	0.16	0.005	0.56	0.005	2.20	0.512	0.077
2S123AB03900	32003	1	1008	SFR	1280	1.92	0.004	1.04	0.004	0.17	0.00	0.41	0.004	0.12	0.004	0.42	0.004	2.20	0.512	0.076
2S123AB04000	32003	1	1008	SFR	1746	2.63	0.005	1.42	0.005	0.23	0.01	0.56	0.005	0.16	0.005	0.57	0.005	2.20	0.512	0.077
2S123AB04100	32003	1	1008	SFR	1750	2.63	0.005	1.42	0.005	0.23	0.01	0.56	0.005	0.16	0.005	0.57	0.005	2.20	0.512	0.077
2S123AB04200	32003	1	1008	SFR	1320	1.98	0.004	1.07	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.20	0.512	0.076
2S123AB04300	32003	1	1008	SFR	1320	1.98	0.004	1.07	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.20	0.512	0.076
2S123AB04400	32003	1	1008	SFR	1320	1.98	0.004	1.07	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.20	0.512	0.076
2S123AB04500	32003	1	1008	SFR	1320	1.98	0.004	1.07	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.20	0.512	0.076
2S123AB04600	32003	1	1008	SFR	1746	2.63	0.005	1.42	0.005	0.23	0.01	0.56	0.005	0.16	0.005	0.57	0.005	2.20	0.512	0.077
2S123AB04700	32003	1	1008	SFR	1774	2.67	0.005	1.44	0.005	0.23	0.01	0.56	0.005	0.17	0.005	0.58	0.005	2.20	0.512	0.078
2S123AB04800	32003	1	1008	SFR	1320	1.98	0.004	1.07	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.20	0.512	0.076
2S123AB04900	32003	1	1008	SFR	1320	1.98	0.004	1.07	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.20	0.512	0.076

TLID	Tract	Block Group	Block	Land use Type	Residential Area, sq. ft	Disaggregated Total Population	VI – Total Population	Disaggregated Number of Females	VI – Number of Females	Disaggregated Number of Non-White Residents	VI – Number of Non-White Residents	Disaggregated Number of Population <18	VI – Number of Population <18	Disaggregated Number of Population >65	VI – Number of Population >65	Disaggregated Number of People Living below Poverty Level	VI – Number of People Living below Poverty Level	Distance to the Nearest Hospital, mi	VI – Distance to the Nearest Hospital	Average PSVI
2S123AB05000	32003	1	1008	SFR	1320	1.98	0.004	1.07	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.20	0.512	0.076
2S123AB05100	32003	1	1008	SFR	1766	2.66	0.005	1.43	0.005	0.23	0.01	0.56	0.005	0.16	0.005	0.58	0.005	2.20	0.512	0.078
2S123AB05200	32003	1	1008	SFR	1766	2.66	0.005	1.43	0.005	0.23	0.01	0.56	0.005	0.16	0.005	0.58	0.005	2.20	0.512	0.078
2S123AB05300	32003	1	1008	SFR	1766	2.66	0.005	1.43	0.005	0.23	0.01	0.56	0.005	0.16	0.005	0.58	0.005	2.20	0.512	0.078
2S123AB05400	32003	1	1008	SFR	1766	2.66	0.005	1.43	0.005	0.23	0.01	0.56	0.005	0.16	0.005	0.58	0.005	2.20	0.512	0.078
2S123AB05500	32003	1	1008	SFR	1708	2.57	0.005	1.39	0.005	0.22	0.00	0.54	0.005	0.16	0.005	0.56	0.005	2.20	0.512	0.077
2S123AB08100	32003	1	1009	SFR	1408	2.12	0.004	1.14	0.004	0.18	0.00	0.45	0.004	0.13	0.004	0.46	0.004	2.20	0.512	0.077
2S123AB08200	32003	1	1009	SFR	1322	1.99	0.004	1.07	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.20	0.512	0.076
2S123AB08300	32003	1	1009	SFR	1322	1.99	0.004	1.07	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.20	0.512	0.076
2S123AB08400	32003	1	1009	SFR	1430	2.15	0.004	1.16	0.004	0.19	0.00	0.45	0.004	0.13	0.004	0.47	0.004	2.20	0.512	0.077
2S123AB08500	32003	1	1009	SFR	1430	2.15	0.004	1.16	0.004	0.19	0.00	0.45	0.004	0.13	0.004	0.47	0.004	2.20	0.512	0.077
2S123AB08600	32003	1	1009	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.20	0.512	0.078
2S123AB08700	32003	1	1009	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.20	0.512	0.078
2S123AB08800	32003	1	1009	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.20	0.512	0.078
2S123AB08900	32003	1	1009	SFR	1430	2.15	0.004	1.16	0.004	0.19	0.00	0.45	0.004	0.13	0.004	0.47	0.004	2.20	0.512	0.077
2S123AB09000	32003	1	1009	SFR	1434	2.16	0.004	1.16	0.004	0.19	0.00	0.46	0.004	0.13	0.004	0.47	0.004	2.20	0.512	0.077
2S123AB09100	32003	1	1009	SFR	1818	2.73	0.005	1.48	0.005	0.24	0.01	0.58	0.005	0.17	0.005	0.60	0.005	2.20	0.512	0.078
2S123AB09200	32003	1	1009	SFR	1818	2.73	0.005	1.48	0.005	0.24	0.01	0.58	0.005	0.17	0.005	0.60	0.005	2.20	0.512	0.078
2S123AB09300	32003	1	1009	SFR	1818	2.73	0.005	1.48	0.005	0.24	0.01	0.58	0.005	0.17	0.005	0.60	0.005	2.20	0.512	0.078
2S123AB09400	32003	1	1009	SFR	1404	2.11	0.004	1.14	0.004	0.18	0.00	0.45	0.004	0.13	0.004	0.46	0.004	2.20	0.512	0.077

TLID	Tract	Block Group	Block	Land use Type	Residential Area, sq. ft	Disaggregated Total Population	VI – Total Population	Disaggregated Number of Females	VI – Number of Females	Disaggregated Number of Non-White Residents	VI – Number of Non-White Residents	Disaggregated Number of Population <18	VI – Number of Population <18	Disaggregated Number of Population >65	VI – Number of Population >65	Disaggregated Number of People Living below Poverty Level	VI – Number of People Living below Poverty Level	Distance to the Nearest Hospital, mi	VI – Distance to the Nearest Hospital	Average PSVI
2S123AB09500	32003	1	1009	SFR	1430	2.15	0.004	1.16	0.004	0.19	0.00	0.45	0.004	0.13	0.004	0.47	0.004	2.30	0.535	0.080
2S123AB09600	32003	1	1009	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.30	0.535	0.081
2S123AB09700	32003	1	1009	SFR	1794	2.70	0.005	1.46	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.30	0.535	0.081
2S123AB09800	32003	1	1009	SFR	1430	2.15	0.004	1.16	0.004	0.19	0.00	0.45	0.004	0.13	0.004	0.47	0.004	2.30	0.535	0.080
2S123AB09900	32003	1	1009	SFR	1430	2.15	0.004	1.16	0.004	0.19	0.00	0.45	0.004	0.13	0.004	0.47	0.004	2.30	0.535	0.080
2S123AB10000	32003	1	1009	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.30	0.535	0.081
2S123AB10100	32003	1	1009	SFR	1826	2.75	0.005	1.48	0.005	0.24	0.01	0.58	0.005	0.17	0.005	0.60	0.005	2.30	0.535	0.081
2S123AB10200	32003	1	1009	SFR	1430	2.15	0.004	1.16	0.004	0.19	0.00	0.45	0.004	0.13	0.004	0.47	0.004	2.30	0.535	0.080
2S123AB10300	32003	1	1009	SFR	1430	2.15	0.004	1.16	0.004	0.19	0.00	0.45	0.004	0.13	0.004	0.47	0.004	2.30	0.535	0.080
2S123AB10400	32003	1	1009	SFR	1322	1.99	0.004	1.07	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.30	0.535	0.080
2S123AB10500	32003	1	1009	SFR	1430	2.15	0.004	1.16	0.004	0.19	0.00	0.45	0.004	0.13	0.004	0.47	0.004	2.30	0.535	0.080
2S123AB10600	32003	1	1009	SFR	1430	2.15	0.004	1.16	0.004	0.19	0.00	0.45	0.004	0.13	0.004	0.47	0.004	2.20	0.512	0.077
2S123AB10700	32003	1	1009	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.20	0.512	0.078
2S123AB10800	32003	1	1009	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.20	0.512	0.078
2S123AB10900	32003	1	1009	SFR	1408	2.12	0.004	1.14	0.004	0.18	0.00	0.45	0.004	0.13	0.004	0.46	0.004	2.20	0.512	0.077
2S123AB05600	32003	1	1010	SFR	1404	2.11	0.004	1.14	0.004	0.18	0.00	0.45	0.004	0.13	0.004	0.46	0.004	2.20	0.512	0.077
2S123AB05700	32003	1	1010	SFR	1322	1.99	0.004	1.07	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.20	0.512	0.076
2S123AB05800	32003	1	1010	SFR	1322	1.99	0.004	1.07	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.20	0.512	0.076
2S123AB05900	32003	1	1010	SFR	1430	2.15	0.004	1.16	0.004	0.19	0.00	0.45	0.004	0.13	0.004	0.47	0.004	2.20	0.512	0.077
2S123AB06000	32003	1	1010	SFR	1430	2.15	0.004	1.16	0.004	0.19	0.00	0.45	0.004	0.13	0.004	0.47	0.004	2.20	0.512	0.077

TLID	Tract	Block Group	Block	Land use Type	Residential Area, sq. ft	Disaggregated Total Population	VI – Total Population	Disaggregated Number of Females	VI – Number of Females	Disaggregated Number of Non-White Residents	VI – Number of Non-White Residents	Disaggregated Number of Population <18	VI – Number of Population <18	Disaggregated Number of Population >65	VI – Number of Population >65	Disaggregated Number of People Living below Poverty Level	VI – Number of People Living below Poverty Level	Distance to the Nearest Hospital, mi	VI – Distance to the Nearest Hospital	Average PSVI
2S123AB06100	32003	1	1010	SFR	1378	2.07	0.004	1.12	0.004	0.18	0.00	0.44	0.004	0.13	0.004	0.45	0.004	2.20	0.512	0.077
2S123AB06200	32003	1	1010	SFR	1378	2.07	0.004	1.12	0.004	0.18	0.00	0.44	0.004	0.13	0.004	0.45	0.004	2.20	0.512	0.077
2S123AB06300	32003	1	1010	SFR	1440	2.17	0.004	1.17	0.004	0.19	0.00	0.46	0.004	0.13	0.004	0.47	0.004	2.20	0.512	0.077
2S123AB06400	32003	1	1010	SFR	1430	2.15	0.004	1.16	0.004	0.19	0.00	0.45	0.004	0.13	0.004	0.47	0.004	2.20	0.512	0.077
2S123AB06500	32003	1	1010	SFR	1322	1.99	0.004	1.07	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.20	0.512	0.076
2S123AB06600	32003	1	1010	SFR	1322	1.99	0.004	1.07	0.004	0.17	0.00	0.42	0.004	0.12	0.004	0.43	0.004	2.20	0.512	0.076
2S123AB06700	32003	1	1010	SFR	1404	2.11	0.004	1.14	0.004	0.18	0.00	0.45	0.004	0.13	0.004	0.46	0.004	2.20	0.512	0.077
2S123AB06800	32003	1	1010	SFR	1408	2.12	0.004	1.14	0.004	0.18	0.00	0.45	0.004	0.13	0.004	0.46	0.004	2.20	0.512	0.077
2S123AB06900	32003	1	1010	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.20	0.512	0.078
2S123AB07000	32003	1	1010	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.20	0.512	0.078
2S123AB07100	32003	1	1010	SFR	1430	2.15	0.004	1.16	0.004	0.19	0.00	0.45	0.004	0.13	0.004	0.47	0.004	2.20	0.512	0.077
2S123AB07200	32003	1	1010	SFR	1430	2.15	0.004	1.16	0.004	0.19	0.00	0.45	0.004	0.13	0.004	0.47	0.004	2.20	0.512	0.077
2S123AB07300	32003	1	1010	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.20	0.512	0.078
2S123AB07400	32003	1	1010	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.20	0.512	0.078
2S123AB07500	32003	1	1010	SFR	1806	2.72	0.005	1.47	0.005	0.23	0.01	0.57	0.005	0.17	0.005	0.59	0.005	2.20	0.512	0.078
2S123AB07600	32003	1	1010	SFR	1818	2.73	0.005	1.48	0.005	0.24	0.01	0.58	0.005	0.17	0.005	0.60	0.005	2.20	0.512	0.078
2S123AB07700	32003	1	1010	SFR	1434	2.16	0.004	1.16	0.004	0.19	0.00	0.46	0.004	0.13	0.004	0.47	0.004	2.20	0.512	0.077
2S123AB07800	32003	1	1010	SFR	1430	2.15	0.004	1.16	0.004	0.19	0.00	0.45	0.004	0.13	0.004	0.47	0.004	2.20	0.512	0.077
2S123AB07900	32003	1	1010	SFR	1430	2.15	0.004	1.16	0.004	0.19	0.00	0.45	0.004	0.13	0.004	0.47	0.004	2.20	0.512	0.077
2S123AB08000	32003	1	1010	SFR	1384	2.08	0.004	1.12	0.004	0.18	0.00	0.44	0.004	0.13	0.004	0.45	0.004	2.20	0.512	0.077

TLID	Tract	Block Group	Block	Land use Type	Residential Area, sq. ft	Disaggregated Total Population	VI – Total Population	Disaggregated Number of Females	VI – Number of Females	Disaggregated Number of Non-White Residents	VI – Number of Non-White Residents	Disaggregated Number of Population <18	VI – Number of Population <18	Disaggregated Number of Population >65	VI – Number of Population >65	Disaggregated Number of People Living below Poverty Level	VI – Number of People Living below Poverty Level	Distance to the Nearest Hospital, mi	VI – Distance to the Nearest Hospital	Average PSVI
2S124BC01708	32003	3	3001	MFR	28665	49.31	0.096	19.85	0.071	11.39	0.26	11.39	0.105	1.16	0.036	10.16	0.091	1.60	0.372	0.147
2S124BC05300	32003	3	3001	SFR	1270	2.18	0.004	0.88	0.003	0.50	0.01	0.50	0.005	0.05	0.002	0.45	0.004	1.70	0.395	0.061
2S124BC05400	32003	3	3001	SFR	1270	2.18	0.004	0.88	0.003	0.50	0.01	0.50	0.005	0.05	0.002	0.45	0.004	1.70	0.395	0.061
2S124BC05500	32003	3	3001	SFR	1460	2.51	0.005	1.01	0.004	0.58	0.01	0.58	0.005	0.06	0.002	0.52	0.005	1.70	0.395	0.061
2S124BC05600	32003	3	3001	SFR	1270	2.18	0.004	0.88	0.003	0.50	0.01	0.50	0.005	0.05	0.002	0.45	0.004	1.70	0.395	0.061
2S124BC05700	32003	3	3001	SFR	1270	2.18	0.004	0.88	0.003	0.50	0.01	0.50	0.005	0.05	0.002	0.45	0.004	1.70	0.395	0.061
2S124BC05800	32003	3	3001	SFR	1270	2.18	0.004	0.88	0.003	0.50	0.01	0.50	0.005	0.05	0.002	0.45	0.004	1.70	0.395	0.061
2S124BC05900	32003	3	3001	SFR	1270	2.18	0.004	0.88	0.003	0.50	0.01	0.50	0.005	0.05	0.002	0.45	0.004	1.70	0.395	0.061
2S124BC06000	32003	3	3001	SFR	1460	2.51	0.005	1.01	0.004	0.58	0.01	0.58	0.005	0.06	0.002	0.52	0.005	1.70	0.395	0.061
2S124BC06100	32003	3	3001	SFR	1270	2.18	0.004	0.88	0.003	0.50	0.01	0.50	0.005	0.05	0.002	0.45	0.004	1.70	0.395	0.061
2S124BC06200	32003	3	3001	SFR	1270	2.18	0.004	0.88	0.003	0.50	0.01	0.50	0.005	0.05	0.002	0.45	0.004	1.70	0.395	0.061
2S124BC06500	32003	3	3001	MFR	64212	110.46	0.215	44.46	0.160	25.52	0.57	25.52	0.235	2.60	0.082	22.77	0.203	1.50	0.349	0.260
2S124BC06700	32003	3	3001	SFR	2829	4.87	0.009	1.96	0.007	1.12	0.03	1.12	0.010	0.11	0.004	1.00	0.009	1.50	0.349	0.059
2S124BC06800	32003	3	3001	SFR	2715	4.67	0.009	1.88	0.007	1.08	0.02	1.08	0.010	0.11	0.003	0.96	0.009	1.50	0.349	0.059
2S124BC06900	32003	3	3001	SFR	2712	4.67	0.009	1.88	0.007	1.08	0.02	1.08	0.010	0.11	0.003	0.96	0.009	1.40	0.326	0.055
2S124BC07000	32003	3	3001	SFR	2838	4.88	0.009	1.97	0.007	1.13	0.03	1.13	0.010	0.11	0.004	1.01	0.009	1.50	0.349	0.059
2S124BC07100	32003	3	3001	SFR	2715	4.67	0.009	1.88	0.007	1.08	0.02	1.08	0.010	0.11	0.003	0.96	0.009	1.50	0.349	0.059
2S124BC07200	32003	3	3001	SFR	2630	4.52	0.009	1.82	0.007	1.05	0.02	1.05	0.010	0.11	0.003	0.93	0.008	1.50	0.349	0.058
2S124BC07300	32003	3	3001	SFR	2668	4.59	0.009	1.85	0.007	1.06	0.02	1.06	0.010	0.11	0.003	0.95	0.008	1.50	0.349	0.059
2S124BC07500	32003	3	3001	SFR	2204	3.79	0.007	1.53	0.005	0.88	0.02	0.88	0.008	0.09	0.003	0.78	0.007	1.50	0.349	0.057

TLID	Tract	Block Group	Block	Land use Type	Residential Area, sq. ft	Disaggregated Total Population	VI – Total Population	Disaggregated Number of Females	VI – Number of Females	Disaggregated Number of Non-White Residents	VI – Number of Non-White Residents	Disaggregated Number of Population <18	VI – Number of Population <18	Disaggregated Number of Population >65	VI – Number of Population >65	Disaggregated Number of People Living below Poverty Level	VI – Number of People Living below Poverty Level	Distance to the Nearest Hospital, mi	VI – Distance to the Nearest Hospital	Average PSVI
2S124BC07600	32003	3	3001	SFR	1763	3.03	0.006	1.22	0.004	0.70	0.02	0.70	0.006	0.07	0.002	0.63	0.006	1.50	0.349	0.056
2S124BC07700	32003	3	3001	SFR	1271	2.19	0.004	0.88	0.003	0.51	0.01	0.51	0.005	0.05	0.002	0.45	0.004	1.50	0.349	0.054
2S124BC07800	32003	3	3001	SFR	1271	2.19	0.004	0.88	0.003	0.51	0.01	0.51	0.005	0.05	0.002	0.45	0.004	1.50	0.349	0.054
2S124BC07900	32003	3	3001	SFR	1271	2.19	0.004	0.88	0.003	0.51	0.01	0.51	0.005	0.05	0.002	0.45	0.004	1.50	0.349	0.054
2S124BC08000	32003	3	3001	SFR	1271	2.19	0.004	0.88	0.003	0.51	0.01	0.51	0.005	0.05	0.002	0.45	0.004	1.50	0.349	0.054
2S124BC08100	32003	3	3001	SFR	1788	3.08	0.006	1.24	0.004	0.71	0.02	0.71	0.007	0.07	0.002	0.63	0.006	1.50	0.349	0.056
2S124BC08200	32003	3	3001	SFR	2204	3.79	0.007	1.53	0.005	0.88	0.02	0.88	0.008	0.09	0.003	0.78	0.007	1.50	0.349	0.057

Appendix B – The Expert Evaluation of the Research Results

The City of Tualatin

04/28/2023

1. List the factors that can affect the social vulnerability of the study area.

The biggest factor, I'd say, is the spatial distribution of the population over the study area. The areal apportionment method assumes population distribution evenly over the given census geography, and this is often not true (i.e., the population density is not evenly distributed across the geography). Your study illustrates this point well, as some of the census tracts studied have large areas devoid of population. When the flood plain is overlaid, these areas are the most affected by flooding, with the population within the census block groups being mostly outside the flood plain.

The dasymetric method does a better job of modeling actual population density by focusing on residential parcels and assigning higher population totals to larger parcels (e.g., bigger residential parcels are more likely to be multi-family). This method comes closer to capturing the actual population density across a census geography, but like the areal apportionment method, it is also limited when it comes to disaggregating the demographic data available at that same census geography.

Other typical factors of social vulnerability include things such as poverty, lack of access to transportation, age, etc. These demographic factors are difficult (to near impossible) to disaggregate from census data by geography into parcels or areas affected by disaster. We may know the numbers within a census geography but it’s difficult to know “where” within the census geography.

2. Compare the presented maps of SVI at the census black group levels and at the parcel level with the existing data collected by the City of Tualatin. What mapping method provides the best quality result?

For the Tualatin study area, the dasymetric method provided a more accurate result. The census block groups in the study area are adjacent to or near the Tualatin River, with flooding being the disaster studied. Tualatin is a relatively newer city, with a lot of its development occurring after floodplain development regulations were put in place. Most of the land within the study area with the potential to be affected by a 100-year flood is lightly developed or even undeveloped (including a wildlife refuge). This made the areal apportionment method a poor choice for determining social vulnerability within this geography as it outstated the vulnerability of some of the block groups (i.e., they had population and flooding, but the population is mostly outside the floodplain). The dasymetric method improved upon this by giving a more accurate representation of the spatial distribution of the population over the study area.

3. Use the presented map to highlight areas on the map that do not match the spatial patterns of SVI, according to the City of Tualatin.

The areal apportionment method’s areas highlighted in dark gray and black (indicating high social vulnerability) have very few people living in them. The only residential area in those high-social-vulnerability areas is between Hazelbrook Road and the Tualatin River. Most of these properties are outside the city limits and have only one house on a large lot. The population density in this area is low. The two black areas (highest vulnerability) have no residences within them. The areal apportionment method greatly overstates the social vulnerability of block group 320.01 1, overstates the vulnerability of block group 320.01 2, and greatly understates the vulnerability of block group 320.03 1.

The dasymetric method does a better job of identifying areas of potential vulnerability, especially within census block group 320.03 1. Here, the entire population within the block group is located in one small part of the geography that also happens to be entirely in the 100-year floodplain. While more accurate within the study area, the method still shows its limitations. The dasymetric method overstates the social vulnerability (estimated at .005 - .4) of one particular parcel located at the eastern boundary of the block group. This is a large parcel, so I'm assuming it was allocated a higher potential population. In reality, there is only one old farmhouse on the property. The dasymetric method also understated the vulnerability of the Liberty Oaks townhomes (directly north of the orange area identified in the block group). Here the "parcel level" analysis also shows its limitations. The townhouse development is parceled not unlike a condominium development. This makes for very small parcels that probably don't get much population per parcel in the dasymetric method. However, when the population of this development is taken as a whole it is not unlike that of other multi-family developments. If there were rental units all on the same parcel, it would have shown much higher vulnerability under the dasymetric method.

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