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Appendix IV. Technical Methodology

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TECHNICAL PAPER FOR VULNERABILITY AND OPPORTUNITY INDICES CALCULATION

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1. Background

The Center for Regional Change (CRC) was responsible for developing the vulnerability and opportunity index, as part of SACOGs sustainable communities initiative. The work builds on previous social equity analysis conducted by the Center for Regional Change, both in the Sacramento Region and the San Joaquin Valley. Publications that have emerged from this previous work include SCORECARD: *The Sacramento Coalition on Regional Equity Collaborative Assessment of Regional Development Baseline Regional Report* `http://regionalchange.ucdavis.edu/publications/Report_Final.pdf` and *Cumulative Environmental Impacts and Social Vulnerability In the San Joaquin Valley, California*, by Ganlin Huang and Jonathan London (Available on request from the Center for Regional Change).

The specific components of the analysis presented here were developed in a broad consultative process coordinated by the Equity, Housing and Health Working Group of the Sacramento Sustainable Communities Consortium. Three specific meetings of the working group were held to discuss this analysis:

- April 1, 2011: Here the agenda was focused on providing an overview of the project and the CRCs work, and to stimulate a conversation about the broad factors and processes that participants considered most important in explaining the vulnerability of populations in the region, and in building high-opportunity neighborhoods. CRC researchers then used this information to develop a draft set of specific indicators to be included in the final indices. The criteria for selecting these indicators were the following: a) is the indicator directly linked to the values and goals identified by participations; b) is the indicator understandable and usable to a broad audience, including both SACOG and community stakeholders; and c) is the data for the indicator reliable and consistent, to facilitate comparison over-time and between places.
- April 26, 2011: At this meeting, the proposed final indicators for the index components were presented, with the goal of soliciting feedback on these indicators and any proposed modifications. This meeting was also used to discuss the implications of the social equity analysis for TPA selection.
- June 1, 2011: This meeting was used as an opportunity to present the vulnerability and opportunity characteristics of the 11 proposed TPA sites, and to discuss the social equity considerations in selecting any of the sites for priority action.

Full details of the agenda of these meetings, along with the material presented and discussed there, is available online at: `http://www.sacog.org/sustainable/working-groups/eqhousinghealth/`

In what follows, we present the detailed methods for calculating the indices.

2. Source of data

The data used to calculate the indices are from the American Community Survey (ACS) 2005-2009 database and from the National Employment Time-Series (NETS) database. (Please see Appendix 1 for more details on the indicators used in the indices, and other indicators that were considered, some of which are likely to be incorporated into future versions of this index).

3. Calculation of Indices

The Vulnerability and Opportunity Indices are unweighted averages of the z-scores of indicators which are determined to contribute towards vulnerability and opportunity in a census tract respectively. The components of the indices are the following:

- Vulnerability Index
  - *Measures of inadequate economic opportunity*
    - Proportion of population aged 16 years and up unemployed
    - Percent of families with incomes at or below 200 percent of the poverty level
  - *Measures of poor neighborhood business opportunities*
    - Proportion of businesses with lower sales in 2008 than 2001
    - Proportion of businesses that closes between 2001 and 2008
  - *Measures of inadequate housing opportunities*
    - Percentage of owner-occupied and renter-occupied units with 1.01 or more occupants per room
    - Percent of renter and owner-occupied housing units paying more than 0.5 of household income in housing costs
  - *Measures of social vulnerabilities*
    - Percentage of family households with own children under 18 years with single householder (i.e. single parent households)
    - Percentage of households linguistically isolated
  - *Measure of poor neighborhood quality*
    - Percentage of housing units vacant
- Opportunity Index
  - *Measures of good and balanced economic opportunities*
    - Total number of jobs in census tract 2008
    - Job change 2001-2008 in industries paying above average wages
    - Proportion of households in middle-income brackets
  - *Measures of good neighborhood business climate*

    - 2001-2008 change in total sales of businesses with 50 or fewer employees in 2001
    - Job change 2001-2008 in industries paying above average wages
  - *Measure of affordable and decent housing*
    - Home ownership rate
  - *Measure of diverse, accessible and affordable transportation opportunities*
    - Percent of workers using other means of transportation to work beside driving alone

The detailed calculation for each variable is the following:

3.1. Vulnerability index= $\frac{\sum_{k=1}^{9} v_k}{10}$ where

v_1 = Z-Score of proportion of adult population (aged 16+) unemployed

v_2 = Z-Score of percent of Families with incomes at or Below 200 percent of the poverty level

v_3 = Z-Score of proportion of businesses with lower sales in 2008 than 2001

v_4 = Z-Score of proportion of businesses that closed between 2001 and 2008

v_5 = Z-Score of percentage of owner-occupied and renter-occupied units with 1.51 or more occupants per room

v_6 = Z-Score of percent of owner-occupied and renter-occupied housing units paying more than 0.5 of household income in housing costs

v_7 = Z-Score of percentage of Family Households with own children under 18 years with single householder

v_8 = Z-Score of percentage of households linguistically isolated

v_9 = Z-Score of percentage of housing units vacant

3.2. Opportunity index= $\frac{\sum_{k=1}^{6} p_k}{6}$ where

p_1 = Z-Score of total number of jobs in 2008

p_2 = Z-Score of job change 2001-2008 in industries with above average wages

p_3 = Z-Score of proportion of households in middle-income brackets

p_4 = Z-Score of 2001-2008 change in total sales of businesses with 50 or fewer employees in 2001

p_5 = Z-Score of home ownership rate

p_6 = Z-Score of percent of workers using other means of transportation to work beside drive alone

4. Calculation of Z-Score

The Z-score for each tract and each variable is derived by subtracting the mean for all tracts in the region from the individual tract raw score of each variable and dividing the difference by the standard deviation across all census tracts for that variable. A tract is defined as much lower than average if a z-score is below -1.5, lower than average as between -1.5 and -0.5, close to average as between -0.5 and 0.5, higher than average as between 0.5 and 1.5 and much higher than average as above 1.5.

When the zscores were calculated, the values of the indicators which were determined to have a high margin of error were not taken into consideration. Thus the cases which had (a) a margin of error of 20 percent or more, and which had (b) a denominator (i.e. x_tot) of 50 or less were recoded as missing values before calculating the zscores and the indices.

5. Calculation of the indicators

5.1. Note that to calculate many of the indicators we included in our index, we had to combine a range of values, due to the way that the ACS data is reported at a tract level from the Census. What follows describes in detail the specific variables from the ACS that were used in the construction of each indicator. The values were calculated for each census tract in the 6-county SACOG region.

In addition to the components of the vulnerability and opportunity indicators, discussed below, we also included the following basic demographic indicators for each census tract:

5.2. **Calculation of Demographic Indicators.**

5.2.1. Percentage of the population non-Hispanic white = $\frac{x_1}{x_{tot}}$ where
x_1 = number of persons who are non-Hispanic white
x_{tot} = total population

5.2.2. Percentage of the population Hispanic= $\frac{x_1}{x_{tot}}$ where
x_1 = number of persons who are Hispanic
x_{tot} = total population

5.2.3. Percentage of the population non-Hispanic black = $\frac{x_1}{x_{tot}}$ where
x_1 = number of persons who are Hispanic black
x_{tot} = total population

5.2.4. Percentage of the population non-Hispanic American Indian and Alaskan native = $\frac{x_1}{x_{tot}}$ where
x_1 = Number of persons who are non-Hispanic American Indian and Alaskan native
x_{tot} = total population

5.2.5. Percentage of the population non-Hispanic Asian = $\frac{x_1}{x_{tot}}$ where
x_1 = number of persons who are non-Hispanic Asian
x_{tot} = total population

5.2.6. Percentage of the population non-Hispanic Native Hawaiian or Other Pacific Islander = $\frac{x_1}{x_{tot}}$ where
x_1 = Number of persons non-Hispanic Native Hawaiian or Other Pacific Islander
x_{tot} = total population

5.2.7. Percentage of the population non-Hispanic some other race = $\frac{x_1}{x_{tot}}$ where
x_1 = Number of persons who are non-Hispanic some other race
x_{tot} = total population

5.2.8. Percentage of the population non-Hispanic two or more races = $\frac{x_1}{x_{tot}}$ where
x_1 = number of persons who are non-Hispanic Two or more races
x_{tot} = total population

5.2.9. Percentage of the population seventeen years and younger = $\frac{\sum_{k=1}^{8} x_{k,j}}{x_{tot}}$ where
x_1 = female population under 5 years
x_2 = female population 5 to 9 years
x_3 = female population 10 to 14 years
x_4 = female population 15 to 17 years
x_1 = male population under 5 years
x_2 = male population 5 to 9 years
x_3 = male population 10 to 14 years
x_4 = male population 15 to 17 years
x_{tot} = total population

5.2.10. Percentage of the population 65 years and older = $\frac{\sum_{k=1}^{12} x_{k,j}}{x_{tot}}$ where
x_1 = female population 65 to 66 years
x_2 = female population 67 to 69 years
x_3 = female population 70 to 74 years
x_4 = female population 75 to 79 years
x_5 = female population 80 to 84 years
x_6 = female population 85 years and over
x_7 = male population 65 to 66 years
x_8 = male population 67 to 69 years
x_9 = male population 70 to 74 years
x_{10} = male population 75 to 79 years
x_{11} = male population 80 to 84 years
x_{12} = male population 85 years and over
x_{tot} = total population

5.2.11. Percentage of the population 25 years and older with a Bachelors' Degree or higher = $\frac{x_1}{x_{tot}}$ where
x_1 = total population 25 years and older with Bachelor's degree or higher
x_{tot} = total population 25 years and older

5.2.12. Percentage of the population 25 years and older with less than a high school degree = $\frac{x_{tot}-x_1}{x_{tot}}$ where
x_1 = total population 25 years and older with a high school degree or higher
x_{tot} = total population 25 years and older

5.2.13. Percentage immigrants (of total population) = $\frac{x_1}{x_{tot}}$ where
x_1 = total foreign born US citizen
x_{tot} = total population

5.3. **Calculation of Indicators for Vulnerability Index.**

5.3.1. Proportion of adult population aged 16 years and up who are unemployed = $\frac{x_1}{x_{tot}}$ where
x_1 = total population 16 years and older who are unemployed
x_{tot} = total population 16 years and older

5.3.2. Percent of Families with incomes at or Below 200 percent of the Poverty Level = $\frac{x_1}{x_{tot}}$ where
x_1 = number of households with income at or below 200 percent of the poverty level
x_{tot} = total households for whom poverty status determined

5.3.3. Proportion of businesses with lower sales in 2008 than 2001= $\frac{x_1}{x_{tot}}$ where
x_1 = number of businesses with lower sales in 2008 compared to 2001
x_{tot} = total number of businesses with sales in both 2001 and 2008

5.3.4. Proportion of businesses that closed between 2001 and 2008 = $\frac{x_1}{x_{tot}}$ where
x_1 = number of businesses that closed between 2001 and 2008
x_{tot} = total number of businesses in 2001

5.3.5. Percentage of Owner-Occupied units with 1.51 or more occupants per room= $\frac{\sum_{k=1}^{2} x_k}{x_{tot}}$ where
x_1 = owner occupied units with 1.51 to 2 occupants per room
x_2 =owner occupied units with 2 or more occupants per room
x_{tot} = total owner owned units

5.3.6. Percentage of Renter-Occupied units with 1.51 or more occupants per room= $\frac{\sum_{k=1}^{2} x_k}{x_{tot}}$ where
x_1 = renter occupied units with 1.51 to 2 occupants per room
x_2 =renter occupied units with 2 or more occupants per room
x_{tot} = total renter occupied units

5.3.7. Percent of Family Households with own children under 18 years with single householder = $\frac{x_1}{x_{tot}}$ where
x_1 = households with own children under 18 years in other families (i.e. in male single householder and female single householder families)
x_{tot} = total households with own children under 18 years

5.3.8. Percentage of households linguistically isolated = $\frac{x_1}{x_{tot}}$ where
x_1 = number of households which are linguistically isolated in any language
x_{tot} = total households surveyed

5.3.9. Percentage of housing units vacant = $\frac{x_1}{x_{tot}}$ where
x_1 = number of housing units which are vacant
x_{tot} = total housing units

5.4. **Calculation of Indicators for Opportunity Index.**

5.4.1. Total Number of Jobs in 2008 were calculated from the NETS data by adding the total number of jobs in all the industries.

5.4.2. Job Change 2001-2008 in Industries with Above Average Wages = $\frac{x_1 - x_2}{x_2}$ where
x_1 = total number of jobs in Industries with Above Average Wages in 2008
x_2 = total number of jobs in Industries with Above Average Wages in 2001

The industries which paid above the Sacramento County average annual private industy wage of $45,082 was determined from the Sacramento 2008 Quarterly Census of Employment and Wages QCEW file. The QCEW Data for Sacramento is available online at `http://www.labormarketinfo.edd.ca.gov/?pageid=173`. (California Regional Economies Employment) . Because the NETS data uses SIC (Standard Industrial Classification) codes, and the QCEW uses the North American Industrial Classification System (NAICS) codes, the data from the QCEW had to be converted from NAICS to SIC. In order to do this calculation, the 6-digit NAICS categories from this QCEW file that pay above $45,082 in 2008 were converted to 4 digit SIC codes using the BLS 2002 NAICS to 1987 SIC cross-walk, as published at the webpage `http://www.census.gov/eos/www/naics/concordances/concordances.html`. The specific 4-digit SIC codes that were included in the NETS data as paying above average wages are the following: 0781, 1081, 1382, 1389, 1481, 1521, 1522, 1531, 1541, 1542, 1611, 1622, 1623, 1629, 1721, 1781, 1799, 2051, 2052, 2394, 2499, 2541, 2675, 2679, 2711, 2721, 2741, 2752, 2771, 2813, 2841, 2844, 2869, 2911, 3069, 3089, 3273, 3291, 3429, 3432, 3441, 3443, 3444, 3449, 3479, 3494, 3497, 3499, 3537, 3569, 3585, 3599, 3672, 3674, 3822, 3823, 3842, 3851, 3911, 3914, 3999, 4212, 4213, 4225, 4226, 4581, 4731, 4813, 4822, 4832, 4899, 4959, 5012, 5013, 5014, 5015, 5021, 5023, 5031, 5032, 5033, 5039, 5043, 5044, 5045, 5046, 5047, 5048, 5049, 5051, 5052, 5063, 5064, 5065, 5072, 5074, 5075, 5078, 5082, 5083, 5084, 5085, 5087, 5088, 5091, 5092, 5093, 5094, 5099, 5111, 5112, 5113, 5122, 5131, 5136, 5137, 5139, 5141, 5142, 5143, 5143, 5144, 5145, 5146, 5147, 5148, 5149, 5153, 5154, 5159, 5162, 5169, 5172, 5181, 5182, 5191, 5192, 5193, 5194, 5198, 5199, 5211, 5231, 5511, 5734, 5932, 5999, 6019, 6021, 6022, 6029, 6081, 6082, 6091, 6099, 6111, 6141, 6153, 6159, 6162, 6163, 6211, 6282, 6289, 6311, 6321, 6324, 6331, 6351, 6371, 6411, 6512, 6531, 6541, 6552, 6733, 6792, 6794, 6799, 7311, 7313, 7323, 7331, 7336, 7352, 7353, 7359, 7361, 7371, 7372, 7373, 7374, 7376, 7378, 7379, 7382, 7383, 7384, 7389, 7623, 7623, 7629, 7692, 7694, 7699, 7819, 7822, 7922, 8011, 8021, 8031, 8062, 8069, 8071, 8092, 8099, 8111, 8299, 8399, 8611, 8621, 8631, 8641, 8651, 8699, 8711, 8712, 8713, 8721, 8732, 8733, 8734, 8741, 8742, 8743, 8748, 8999.

5.4.3. Proportion of households in middle-income brackets = $\frac{\sum_{k=1}^{8} x_k}{x_{tot}}$ where
x_1 = number of households with income in 25,000 to 29,999 range
x_2 =number of households with income in 30,000 to 34,999 range
x_3 = number of households with income in 35,000 to 39,999 range
x_4 = number of households with income in 40,000 to 44,999 range
x_5 = number of households with income in 45,000 to 49,999 range
x_6 = number of households with income in 50,000 to 59,999 range

x_7 = number of households with income in 60,000 to 74,999 range
x_8 = number of households with income in 75,000 to 99,999 range
x_{tot} = total households

Note that the number of households with income in the middle-income bracket (from $25,000 to $99,999) which was determined by taking the income level of the middle 50 percent of the population in the entire SACOG region.

5.4.4. 2001-2008 change in total sales of businesses with 50 or fewer employees in 2001 = $x_1 - x_2$ where
x_1 = total sales in 2008 of businesses that had 50 or fewer employees in 2001
x_2 = total sales in 2001 of businesses that had 50 or fewer employees in 2001

5.4.5. Home ownership rate = $\frac{x_1}{x_{tot}}$ where
x_1 = Number of owner-occupied units
x_{tot} = total housing units occupied

5.4.6. Percent of workers using other means of transportation to work beside drive alone = $\frac{x_{tot}-x_1}{x_{tot}}$ where
x_1 = workers 16 years and over who drove alone
x_{tot} = total workers 16 years and over

6. Margin of error

Margin of error (MOE) was calculated using the following formulae from Appendix 3 of the US Census Bureau (October 2008) manual *A Compass for Understanding and Using the American Community Survey Data: What General Data Users Need to Know*, i available at the webpage `http://www.census.gov/acs/www/guidance_for_data_users/handbooks/`.

6.1. **Calculating MOEs for Aggregated Count Data.** To calculate the MOE for aggregated count data we used the following method:

(1) Taking the MOE of each component estimate.
(2) Squaring the MOE of each component estimate.
(3) Summing the squared MOEs.
(4) And then taking the square root of the sum of the squared MOEs.

6.2. **Calculating MOEs for Derived Proportions.** To calculate the MOE for derived proportions, we used the following method:

(1) Obtaining the MOE for the numerator and the MOE for the denominator of the proportion.
(2) Squaring the derived proportion.
(3) Squaring the MOE of the numerator.
(4) Squaring the MOE of the denominator.
(5) Multiplying the squared MOE of the denominator by the squared proportion.
(6) Subtracting the result of (5) from the squared MOE of the numerator.

(7) Taking the square root of the result of (6).
(8) Dividing the result of (7) by the denominator of the proportion.

Please note that many of our indicators combine multiple individual ACS variables, each of which has a MOE, but the resulting calculated MOE for many of our variables grossly over-estimates what the actual MOE would be if we had access to the original raw data (which requires detailed security clearance). For example, the measurement of proportion of households in middle-income brackets combines 8 different income brackets into the broader $25,000-99{,}000$ income bracket, but each of those separate income brackets has an individual reported MOE which only takes into account the specific income bracket, and the calculated combined MOE doesnt take into account the relationships between the different categories (assuming instead they are entirely separate distinct categories, like race). This is an issue in all indicators that have continuous variables with multiple categories (e.g. income, age, measures of housing over-crowding), rather than categorical variables.