

Social Vulnerability, Resilience, and Equity

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This paper is part of a series of background papers from the Center for Sustainability Education at Dickinson College that assess climate change vulnerability, adaptation, and resilience in Cumberland County for selected sectors, resources, and activities. The Background Papers draw and expand on *Climate Change in Cumberland County, An Assessment of Vulnerabilities and Adaptation Strategies*, a report produced by Dickinson College’s 2021 Baird Sustainability Fellows (Bonaccoursi et al, 2021).

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1. Introduction

Climate hazards and climate change do not and will not impact all people and communities equally (USEPA, 2021, p. 9; PA DEP, 2021a, p xiii). The impacts are strongly shaped by geography, environment, social and economic conditions, and other factors that influence biophysical exposures to climate hazards and the sensitivities, vulnerabilities, and resilience of people and communities with respect to climate hazards (Juntunen, 2006, p. 2; Cutter et al, 2003, p. 243; and White and Haas, 1975). This Background Paper examines who is vulnerable and resilient to climate hazards and where vulnerable and resilient populations reside in the County. Knowing who is vulnerable, who is resilient, and where they reside can support development of effective adaptation strategies that address social inequities and highlight potential leverage points for building resilience to climate hazards.

Social vulnerability is the propensity for individuals, populations, demographic groups, or communities to suffer harm in the event they are exposed to a hazard. The concept focuses attention on people with characteristics that correlate with high levels of harm when a hazardous event occurs. Resilience, a related concept, is sometimes considered to be the inverse of vulnerability. It represents the capacities of individuals, populations, groups, or communities to anticipate, prepare for, prevent, limit, absorb, withstand, recover from, and adapt to impacts of the hazards. It focuses attention on abilities for managing and responding to risks from climate hazards that can be sources of strength.

Vulnerability and resilience can be characteristics of both individuals and communities. The focus in this paper is primarily on vulnerability and resilience at the community level, but vulnerability and resilience at the level of individuals are also touched on. Communities with high proportions of individuals who are vulnerable to climate hazards are more vulnerable than communities with low proportions of vulnerable individuals. Conversely, communities with high proportions of individuals who are resilient to climate hazards are more resilient than communities with lower proportions. It should be recognized that resilience is present in all groups and communities, even those with high levels of vulnerability, and that members of vulnerable communities can bring knowledge, expertise, and experience that are essential for effective responses to climate change.

Differences in social vulnerability and community resilience raise issues of equity regarding the potential impacts of climate change. As noted in Pennsylvania's most recent climate impacts assessment and climate action plan, disproportionate impacts across populations and communities are not random and are often consequences of discriminatory practices such as redlining, disinvestment in communities of color, and disenfranchisement of rights (PA DEP, 2021a, pp. xiii and 70-71; PA DEP 2021b, p. 157 and 203). Both documents call for addressing inequitable impacts of climate change, ensuring that adaptation efforts do not exacerbate inequities, and prioritizing actions that reduce impacts on vulnerable populations (PA DEP, 2021a, p. xii; PA DEP 2021b, pp. 5 and 111).

More broadly, taking account of both mitigation and adaptation actions, the *Pennsylvania Climate Action Plan* emphasizes environmental justice and equity concerns and favors an implementation approach designed to improve the lives of all Pennsylvanians, distribute benefits and costs of climate action equitably, and avoid unfairly burdening some communities or disproportionately favoring others (PA DEP 2021b, pp. 156-157 and 202). This assessment of social vulnerability in Cumberland County, includes observations concerning equity and environmental justice.

2. Vulnerable Populations and Resilient Communities

The impacts of Hurricane Katrina in 2005, superstorm Sandy in 2012, the 1995 Chicago heat wave, and other climate-related disasters give evidence that people living in close geographic proximity can suffer very different impacts from hazard events. The differences correlate strongly with social, economic, health, and other characteristics of the exposed individuals, households, populations, and communities (Cagney et al, 2016; Flanagan et al, 2011; Klinenberg, 2002; Klinenberg, 2012; Williams, n.d.; Zoraster, 2010). Generally, studies of climate hazards indicate that the elderly, children, people with disabilities, people with low incomes, people of color, and people living in nursing homes, high rise apartments, and mobile homes can be socially vulnerable to climate hazards and “more likely to die in a disaster event and less likely to recover after one” (Juntunen, 2005, pp. 2-3).

Indices to measure social vulnerability and community resilience with respect to climate hazards have been constructed by a number of researchers. The indices have been used for multiple purposes that include identifying and mapping communities that will most likely need support before, during, and after a disaster; strategically targeting resources to build resilience where most needed; measuring progress in building resilience; estimating where and how much supplies of food, water, medicine, and bedding will be needed to respond to a disaster; allocating emergency preparedness funding based on community need; identifying areas in need of emergency shelters; and planning for more efficient evacuation for people with special needs or who lack transportation (Bakkensen et al, 2017; United Nations, 2014; CDC, 2015, pp. 14-16; Flanagan et al, 2011, p. 14; and Cutter et al, 2014, pp. 74 and 76).

A variety of methods and variables have been used to construct the indices, and there is no consensus on a method or set of variables that best measure social vulnerability or community resilience. Indeed, it is likely that what is best will vary with the intended use of an index and the context in which it is used (Bakkensen et al, 2017, p. 999). Yet, despite the lack of consensus, there is general agreement among natural disaster researchers and managers about major factors that influence vulnerability and resilience. These factors can generally be mapped to categories of community capital.

Community capitals are assets that community members can access and mobilize to serve individual and community interests, including responding to climate and other hazards. Categories of community capitals include human, social, financial, built, natural, cultural, and political capital (see Box 3.1 for definitions). Conceptually, communities with high levels of community capitals have greater assets for managing and responding to climate hazards and are consequently less vulnerable and more resilient than communities with low levels of community capitals.

Examples of indices that have been constructed to measure and compare vulnerability and resilience by county in the United States include the Social Vulnerability Index (SoVI) and the Baseline Resilience Indicator for Communities (BRIC), both developed by the University of South Carolina’s Hazards Vulnerability and Resilience Institute, and the Social Vulnerability Index (SVI) developed by the Centers for Disease Control and Prevention (University of South Carolina, nd; Cutter et al, 2014; CDC,

2015). SoVI and BRIC are used by the Federal Emergency Management Agency (FEMA), along with estimates of expected annual losses, in calculations of their National Risk Index for 18 natural hazards

Community Capitals

Human capital: skills, knowledge, and experience possessed by community residents.

Social capital: networks of relationships among people and organizations that can be mobilized for community purposes; social glue that makes things happen.

Financial capital: Financial resources available to invest in the community.

Built capital: Infrastructure that serves a community such as transportation, electric grid, water and sewer systems, telecommunications, public spaces, and flood controls.

Natural capital: Natural resources such as rivers, lakes, wetlands, forests, trails, wildlife, fertile soils, clean air, tree canopy, green infrastructure, and natural beauty.

Cultural capital: Traditions, heritage, values, beliefs, festivals, arts, languages, foods, and other cultural assets that connect and nurture people.

Political capital: Relationships and power to influence public policies, decisions, allocation of resources, rules, and regulations.

Adapted from Emery, Fey, and Flora, 2016.

(FEMA, 2020). While these indices are intended to measure social vulnerability, community resilience, and risk with respect to natural hazards, the same or similar variables used in their construction are plausibly also correlated with vulnerability and resilience with respect to climate change.

In what follows, the CDC's Social Vulnerability Index is used to identify areas of high and low vulnerability in Cumberland County. But first, causal relationships between variables used in the construction of the CDC's index and social vulnerability to climate hazards are reviewed. The variables are grouped into four categories by the CDC: socioeconomic status; household characteristics; race, ethnicity, and language; and housing and transportation.

2.1. Socioeconomic Status

Socioeconomic status influences the resources that a person or household can marshal to prepare for, cope with, respond to, and recover from climate-related and other stresses. Persons of low socioeconomic status may struggle, for example, to stockpile food and supplies to prepare for an event, take time off from work, evacuate during an emergency, pay for temporary shelter, pay for health care, repair or replace damaged property, or pay bills if income is lost due to an employer being closed by an event. They are less likely to have health, home, or renters' insurance, or have less insurance coverage than persons of higher economic status, resulting in having to pay significant costs out of pocket. Examples of metrics that are used as indicators of socioeconomic status include per capita income, income relative to the federal poverty level, employment or unemployment status, education level, and household wealth. (CDC, 2015, p. 2; Flanagan et al, 2011, pp. 4-5).

Low socioeconomic status often intersects with indicators that are included in other categories of vulnerability, such as physical or mental disability, chronic health problems, lack of health insurance, poor housing quality, lack of access to a car, lack of access to information from the internet, and limited proficiency with English-language. These intersections can amplify the vulnerability of a

person or household. Gender also intersects with socioeconomic status in complex ways and female gender is sometimes used as an indicator of vulnerability but is not used as an indicator in the CDC's SVI.

Putting this into a community capitals framework, a place with a high percentage of people and households with low socioeconomic status may have low human and financial capital to mobilize for responding to climate hazards. This can correlate with limited built and social capital as well. A deficit of human, financial, built, and social capital in a community can create conditions of high social vulnerability.

2.2. Household Composition

The composition of a household influences the ability of the household to respond to climate and other stresses. Households with members with medical problems and limited mobility, sight, hearing, or cognitive ability may have difficulty caring for all its members, following instructions from emergency personnel, evacuating, coping with stress, receiving needed assistance with hygiene and daily functions during a crisis, accessing needed medical care, and recovering from impacts. Persons with medical problems may have medical equipment that is inoperable during a power outage, or that is difficult to transport in an emergency.

These conditions are more common among older adults than the general population, resulting in older adults being at greater risk on average. Older adults living alone can be socially isolated, adding to their vulnerability. Young children lack knowledge, experience, resources, decision-making abilities, and agency for responding appropriately in a disaster and can be more susceptible to injury and disease. Also, children may be at school or in daycare during an emergency and their separation from parents or guardians can complicate protecting them from harm. Single-parent households with children can face greater challenges in responding to an emergency than do households with two parents. (CDC, 2015, pp. 2-3; Flanagan et al, 2011, p. 5).

Examples of household composition metrics that are used as indicators of lesser abilities to manage stresses include number of members who are 65 years of age and older, number who are 17 years and younger, number with a disability, and single-parent households. These factors often intersect with conditions of low socioeconomic status, which exacerbates risks for a household. From a community capitals perspective, a place with high percentages of households with older adults, single-parent families with young children, people with disabilities, and people with chronic illness can have low human capital. This in turn can correlate with low financial, built, and social capital, adding to the vulnerability of the community.

2.3. Race, Ethnicity, and Language

Race and ethnicity are strongly correlated with socioeconomic disparities and with impacts from climate hazards. Median household incomes of African Americans, Latino Americans, and Native Americans are below median incomes of White Americans, and poverty rates are higher for these groups than for White Americans. There are also racial disparities in wealth, life expectancy, health care, health status, education, unemployment rates, homeownership, and other metrics of wellbeing. Additionally, non-white Americans have faced historical and present-day discrimination.

A study of 108 urban areas in the United States found that areas with a history of redlining, a practice of refusing home loans and insurance to neighborhoods based on racial biases, are disproportionately exposed to extreme heat through urban heat island effects (Hoffman et al, 2020). Most of these neighborhoods continue to be places where residents are predominantly people of color. Nationally, redlined areas are estimated to be 4.7°F warmer than non-redlined areas, and some redlined areas can be 12.6°F warmer, posing substantial health risks to people of color that are a manifestation of racial discrimination. For these reasons, race and ethnicity are often used as indicators for measuring social vulnerability to climate hazards. (CDC, 2015, p. 3; Flanagan, 2011, p. 5-6).

People who do not speak and read English, or who have limited English-language proficiency, can face barriers in accessing and understanding communications during an emergency. Consequently, they can have higher social vulnerability than people who are proficient in English (CDC, 2015, p. 3; Flanagan, 2011, p. 5-6). Emergency communications in Spanish are common in some areas of the United States but are not standard in Cumberland County. Spanish-English translators and translation services are available in the County and can be utilized to help Spanish-speaking households during emergencies. The barriers are even greater, however, for households that are not proficient in either English nor Spanish, which can be the case for recent immigrants from Afghanistan and Syria, for example. Translation services for languages other than Spanish are very limited in the County.

Places with high percentages of non-white households or households that are not proficient in English can face deficits in human, financial and social capital that translate to lack resources in the community for responding to climate hazards, social isolation, and lack of access to emergency communications.

2.4. Housing and Transportation

The nature and quality of housing is another determinant of a household's vulnerability to climate hazards. People living in poorly constructed housing, housing in need of significant repairs, and mobile homes can be highly vulnerable to strong winds, flooding, and extreme heat. Overcrowded housing, defined as housing with more people than rooms, present their occupants with potentially dangerous conditions. Multi-unit housing and group quarters such as apartment buildings, nursing homes, long-term care facilities, hospitals, prisons, and college dormitories can also create vulnerable conditions because of congestion that can interfere with orderly evacuations and difficulties in providing emergency services.

Transportation is a critical service for accessing medical care, food, supplies, and jobs and for emergency evacuations. Households that live in communities that lack or have very limited public transportation and who do not own or have ready access to an automobile are at a disadvantage and are vulnerable to hazards. Households can also be at risk if their residences or workplaces are distant from essential services or are served by sparse roadways in which closing of a locally important roadway or bridge, due to flooding for example, would add substantial travel time to access essential services. Evacuation can be particularly problematic for nursing homes and other institutions that require specialized vehicles to transport residents. (Flanagan et al, 2011, p. 6).

Examples of metrics that are used as indicators of vulnerability related to housing include living in crowded housing, multi-unit housing, mobile homes, or group quarters. Households that do not own a motor vehicle is also an indicator of vulnerability. Communities with high percentages of households that live in vulnerable housing types, or that lack access to a car, face deficits in built capital that can add to the vulnerability of the community.

2.5. Social Capital

Indices that are used to measure social vulnerability can be useful tools for identifying and mapping places with high proportions of people with characteristics that are associated with vulnerability to climate hazards. But often missed in these analyses are assets of the communities themselves that enable collective action to respond to hazards and build resilience. These community assets, or community capitals, include human, financial, built, natural, and social capital that can be mobilized for the benefit of the community. Of particular importance for building resilience and reducing vulnerability is social capital.

In a study of the 1995 Chicago heat wave that killed 739 people, Eric Klinenberg compared mortality rates across Chicago's neighborhoods and sought explanations for the differences (Klinenberg, 2002). He found that the geography of high death rates matched the geography of racial segregation and inequality in Chicago. Of the 10 neighborhoods with the highest death rates per 100,000 residents, 8 had very high proportions of residents who were African American and were plagued by concentrated poverty, elderly residents living alone, and violent crime. But Klinenberg also found that 3 of the 10 neighborhoods with the lowest death rates were poor and predominantly African American too. The key difference between poor African American neighborhoods with low death rates in the heat wave versus those that had high death rates was social capital. African American neighborhoods that had not lost population and businesses in the decades before 1995, had vibrant sidewalks with people walking to local stores and restaurants, and had active community organizations that brought people in contact with their friends and neighbors, had markedly lower death rates than neighborhoods in which these indicators of social capital had declined. (Klinenberg, 2012, pp. 1-2 and 6).

Similarly, Eric Williams, in his assessment of community responses in New York City to Superstorm Sandy, also found social capital to be critical for effective community responses that protected and benefited residents. Networks of formal and informal community-based organizations, which had built social capital of trust, respect, and reliability through years of work in their neighborhoods, responded to the crisis by identifying and coordinating sources of aid, distributing supplies to high need areas, and assisting vulnerable people. "Communities where residents had stronger and more active social ties were better able to utilize these social networks to adapt, respond, and recover from Sandy." (Williams, 2011, p. 1).

Recognizing the value of social capital, officials and community stakeholders in Chicago, New York, and cities around the world are giving increasing attention to investing in social capital – people, places, and institutions that foster cohesion and support – as a means to build resilience to climate hazards. For example, since the tragic Chicago heatwave, Chicago officials have engaged local media in campaigns to advise neighbors, friends, and family to check on one another during heat waves, while civic organizations and churches deliver the same messages to their members and networks. The city has also established a database with names, addresses, and phone numbers of people who are chronically ill or otherwise vulnerable, which city workers use to contact and visit people who may be at risk. These measures appear to have helped reduce the impacts of subsequent extreme heat events. (Klinenberg, 2012, pp. 6-7). Cumberland County can learn from these and similar efforts in other places, starting by inventorying existing organizations that connect and support people in different parts of the County.

3. Social Vulnerability – a National View

The U.S. Environmental Protection Agency (EPA) completed a national assessment of social vulnerability to climate change in 2021 (USEPA, 2021). In the EPA assessment, regions in the United States are identified for which impacts of climate change and sea level rise are projected to be highest for six categories of impacts and estimates are presented of whether socially vulnerable groups are over or underrepresented in the populations of those regions. The vulnerable groups considered by the EPA are defined based on income, race, education, and age. Summarized below findings of the EPA study for health impacts from diminished air quality, health and labor impacts from extreme temperatures, and impacts of inland flooding on human lives and property.

Climate change will alter processes that create, remove, and transport air pollution. In many regions of the U.S., the changes are expected to increase atmospheric concentrations of fine particulate matter and ground level ozone, increasing exposures to these pollutants and increasing their respiratory and cardiovascular health effects. Studies of social vulnerability from air pollution find that neighborhoods with high poverty rates, low incomes, and high proportions of racial minorities have higher exposures to fine particulate matter and ozone and greater health impacts from air pollution and that persons 65 years and older suffer exacerbated health effects from air pollution (USEPA, 2021, p. 21).

The EPA analysis estimates that, in a scenario of 2°C (3.6°F) global warming, increases in fine particulate matter concentrations would result in nationwide increases of 2,100 premature deaths per year among persons 65-years of age and older and 2,500 additional diagnoses of childhood asthma. In a scenario of 4°C (7.2°F) global warming, the annual increase in premature deaths among older adults would be 5,800 and the annual increase in childhood asthma diagnoses would be 7,000. African Americans 65-years and older are estimated to be 60% more likely to live in regions with high increases in death rates from air pollution than non-African Americans. African American children ages 0 to 17 are estimated to be 41% more likely to live in regions with high increases in asthma rates from air pollution than non-African American children. (USEPA, 2021, p. 5).

Projected increases in temperatures will lead to increases in the frequency and severity of extreme temperature days and increases in heat-related illnesses and deaths. Low-income neighborhoods, racial minorities, and older adults experience high rates of heat-related mortality and death in the current climate and will be at greater risk as the climate warms. EPA's analysis finds that non-white Americans are more likely than White Americans to live in areas with the highest projected increases in heat-related deaths, with African Americans over 40% more likely than non-African Americans to live in high impact areas. EPA also found that people with low incomes are more likely than people with higher incomes to live in areas with the highest projected increases in heat-related deaths. (USEPA, 2021, pp. 33-35).

Extreme high temperatures are also expected to adversely impact the health of people who work outdoors or in indoor environments without air conditioning. In addition to impacting their health, temperature extremes can result in physical and cognitive effects that diminish labor productivity, require shifts in work schedules, and cause reductions in hours worked. Low-income, non-white, and elderly populations, and people without a high school diploma, can be more vulnerable than others to the effects of high temperatures on labor. (USEPA, 2015, p. 38).

EPA estimated labor hours expected to be lost from rising temperatures in weather-exposed industries that include agriculture, forestry, fishing, and hunting; mining; construction; manufacturing; and

transportation and utilities. They found that, for a scenario of 2°C (3.6°F) warming, increases in high-temperature days would reduce labor hours worked by an average of 14 hours per worker per year. For a scenario of 4°C (7.2°F) warming, 34 hours per worker per year would be lost. Non-white Americans are found to be 35% more likely than White Americans to live in areas with the highest projected losses in labor hours. Latino individuals are estimated to be 43% more likely than non-Latino individuals to live in these high-impact areas, while those with low income or no high school diploma are approximately 25% more likely than reference populations to live in high-impact areas.

Nationally, inland flooding caused over 600 deaths and nearly \$3.7 billion in damages between 1980 and 2020. These impacts have fallen disproportionately on low-income, non-white, elderly, and low education populations. These populations also often have less resources to prepare for, cope with, and recover from flood impacts. As the global climate warms, more frequent heavy rainfall events with greater rainfall are projected for much of the United States, which is likely to increase risks from inland flooding in many regions. The greatest impacts from inland flooding are estimated to occur in the Northwest, Southwest, and Northern Great Plains. EPA's analysis does not find that the vulnerable populations they studied are more likely than others to live in heavily impacted regions. Not addressed by the EPA study is whether low-income, non-white, elderly, or low education populations are likely to be more negatively impacted than others in the regions in which they live. (USEPA, 2021, pp. 68-73).

4. Social Vulnerability in Pennsylvania

The Pennsylvania Department of Environmental Protection (PA DEP) first assessed climate change impacts in the state in 2009 and has published updated assessments in 2013, 2015, 2020, and 2021. The 2021 assessment, unlike previous assessments, took a risk-based approach, calculating risk as the product of the likelihood of a climate hazard occurring and the severity of its expected impacts. This is done for six different climate hazards and seven categories of impacts. Environmental justice and equity is included as one of the seven impact categories in an effort to identify places with high proportions of already overburdened, disadvantaged, and vulnerable people who are most exposed to climate hazards. This is the first-time environmental justice and equity have been formally considered in a Pennsylvania climate impacts assessment. (PA DEP, 2021a, pp. xi-xii and 24).

Environmental Justice Areas are used in the Pennsylvania impacts assessment report to represent already overburdened and disadvantaged populations in Pennsylvania that are vulnerable to climate hazards. An Environmental Justice Area is defined by PA DEP as any census tract or block group where 20% or more of individuals live at or below the federal poverty line, and/or 30% or more of the population identifies as non-white. Exposure of Environmental Justice Areas to climate hazards serves as a proxy for exposure of already overburdened, disadvantaged, and vulnerable populations. This approach does not capture all aspects of the vulnerability of overburdened populations and equity concerns and additional information is used to supplement the Environmental Justice Area analysis. (PA DEP, 2021a, pp. 29-30).

Overall risks (likelihood multiplied by the expected severity of consequences) of environmental justice and equity impacts in Pennsylvania are found to be *extreme* for rising average temperatures and heat waves; *high* for inland flooding and landslides; and *medium* for sea level rise and cyclones (PA DEP, 2021a, p. 34). Increasing average temperatures and more frequent and hotter heat waves are rated as *highly likely* and their impact on Environmental Justice Areas is rated as *critical* in Pennsylvania, for a

combined overall risk of *extreme*. Environmental Justice Areas will be nearly twice as exposed to extreme heat as the overall population in the state. Populations in Environmental Justice Areas constitute less than one-third of Pennsylvania’s population but represent over one-half of the population that will be exposed to extreme heat. The impacts assessment report also notes that the disproportionate burden is a manifestation of a history of redlining, substandard housing in communities of color, and disinvestment in communities of color. People who are particularly vulnerable to extreme heat include the elderly, seniors living alone, people with cardiovascular disease, children, construction workers, and athletes. (PA DEP, 2021a, pp. 42-43 and 70-71).

Increasing heavy precipitation and inland flooding are rated as *highly likely* and their impacts to Environmental Justice Areas is rated as *limited*, for a combined overall risk of *high*. Inland flooding risks are greatest for areas located within 100-year floodplains. Environmental Justice Areas are slightly overrepresented in 100-year floodplains. An estimated 6.5% of Environmental Justice Areas are located in floodplains, compared to 5.5% for Pennsylvania as a whole. (PA DEP, 2021a, p. 55).

Stronger tropical and extra-tropical storms with heavier rainfall are rated as *possible* and their impacts to Environmental Justice Areas is rated as *limited*, for a combined overall risk of *medium*. As with inland flooding, Environmental Justice Areas are slightly more exposed to impacts from cyclones than the state as a whole. Note, however, that low-income households often live in substandard housing and lack resources to cope with and recover from the impacts of floods and severe storms, making them vulnerable to these hazards. For those living within floodplains, the risks can be critical or even catastrophic. (PA DEP, 2021a, p. 102).

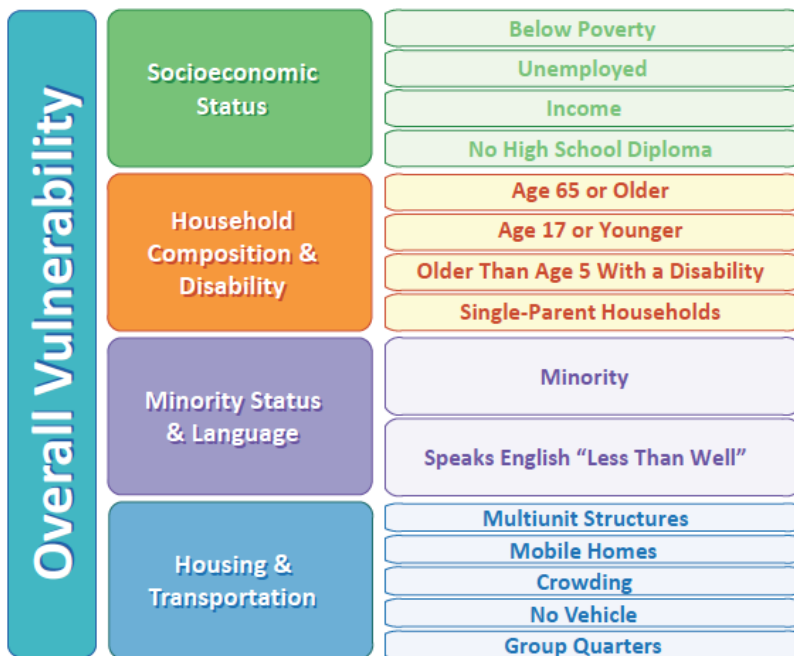
5. Social Vulnerability in Cumberland County

This assessment of social vulnerability in Cumberland County uses the Social Vulnerability Index (SVI) and associated database for 2018. The SVI is a free, web-based tool created by the Centers for Disease Control and Prevention to help emergency managers identify and map communities that are most likely to need support before, during, and after public health emergencies. The SVI uses county and census tract level data from the U.S. Census and the American Community Survey for 15 variables grouped into 4 thematic categories to identify places with high proportions of residents considered to be socially vulnerable to public health emergencies because of socioeconomic status, household composition and disability, race, ethnicity, and English language proficiency, and housing type and transportation access. The variables and thematic categories used to construct the SVI are identified in Figure 3.1. (CDC, 2015, pp. 14-16).

Most of the SVI variables correspond to percentages of populations, households, or housing units in a census tract corresponding to characteristics of households that are associated with vulnerability to disasters. To construct the index, all census tracts in Pennsylvania are ranked from lowest to highest for each variable and a percentile rank is calculated. The percentile rankings are summed across variables included in each thematic category and percentile rankings are calculated for each census tract by theme. Finally, the thematic rankings are aggregated to calculate an overall percentile ranking of social vulnerability by census tract. The resulting index value for a census tract lies between 0 and 1 and corresponds to the tract’s percentile ranking relative to all census tracts in the state. (Flanagan et al, 2018, p. 35).

While the SVI is designed to identify places with populations who are socially vulnerable to disasters, it has also been used to identify places with populations who are socially vulnerable to climate hazards and climate change. The same variables that are indicative of low capacity for preparing for, coping with, responding to, and recovering from disasters are also indicative of low capacity for managing the impacts of climate change, some of which may take the form of quick-onset disasters and others of which may take the form of pressures that accumulate over time.

Figure 3.1. Social Vulnerability Index Variables and Themes. Source: CDC, 2015, p. 14)



5.1. Overall Social Vulnerability

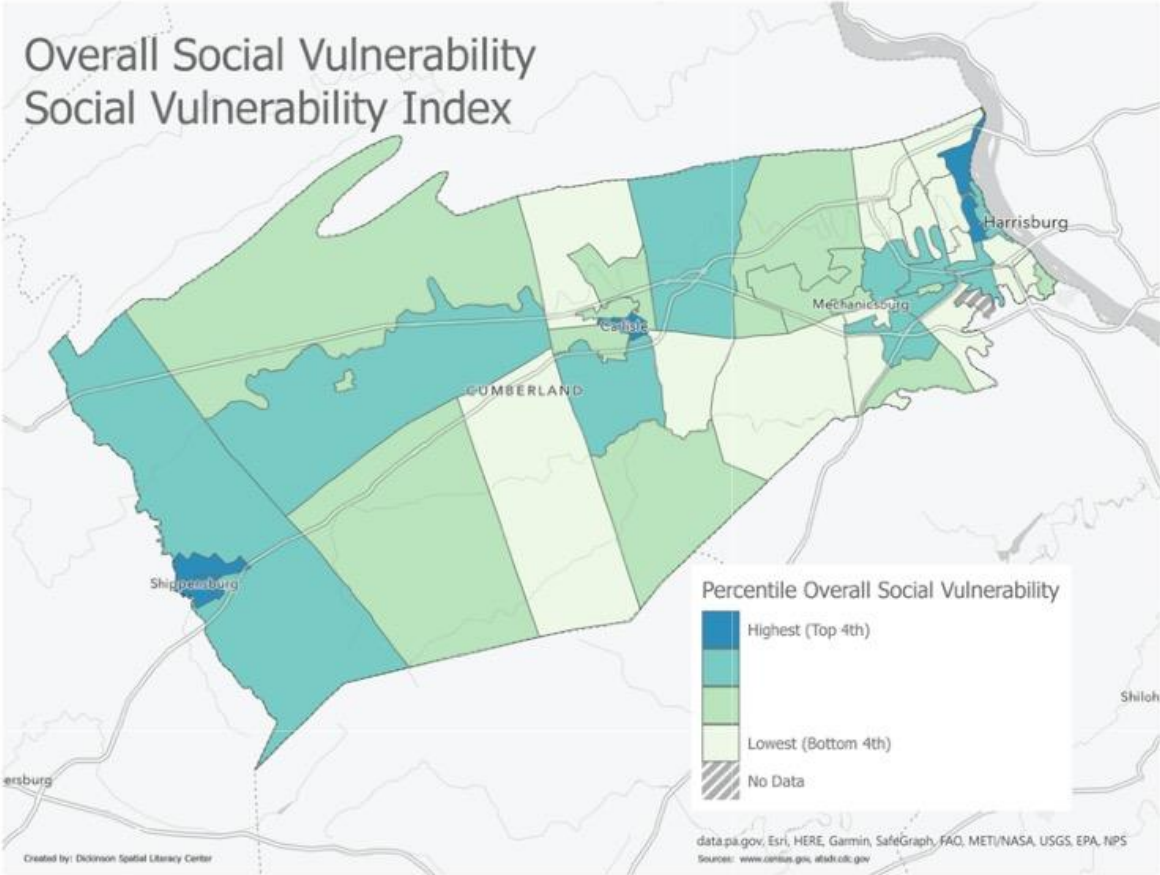
When ranked against other counties in Pennsylvania, Cumberland County’s overall SVI score is 0.11, an 11th percentile ranking, which indicates social vulnerability in Cumberland County is lower than all but about 10% of counties in the state (CDC, SVI Interactive Map). This reflects the low percentages of the County’s population, relative to other counties in Pennsylvania, that have characteristics associated with high social vulnerability.

Within the County, however, there are census tracts with significant percentages of socially vulnerable populations and these tracts rank among the most socially vulnerable tracts in the state. Map 3.1 displays overall social vulnerability by census tract in Cumberland County. There are 49 census tracts in Cumberland County. Forty-eight of the 49 tracts are ranked for vulnerability. One census tract in Lowe Allen Township could not be ranked because of missing data.

Values for SVI range from a low of 0.004 in census tract 116.02 in Upper Allen Township to a high of 0.91 in census tract 122.00 in central Carlisle. The SVI scores indicate that the western side of Upper Allen Township is among the 1% least vulnerable census tracts in Pennsylvania and that central Carlisle is among the 10% most vulnerable census tracts in the state. Of the 49 census tracts in the County, 18 are in the lowest quartile for estimated overall social vulnerability statewide and 7 are in

the highest quartile. Shippensburg Township and Borough, central Carlisle, Enola, and parts of East Pennsboro are among the 25% of census tracts in Pennsylvania with the highest overall social vulnerability. Areas with moderate overall social vulnerability (third-quartile) include Southampton, Hopewell, Newburg, North Newton, and West Pennsboro in the western part of the County, Middlesex and northern areas of South Middleton in the center of the County, and parts of Upper Allen, Lower Allen, and Hampden townships, Camp Hill, and Wormleysburg in the east of the County.

Map 3.1. Overall Social Vulnerability in Cumberland County. Map created by Gordon Cromley, Spatial Literacy Center, Dickinson College. Data source: CDC/ATSDR, Social Vulnerability Index Data and Documentation, https://www.atsdr.cdc.gov/placeandhealth/svi/data_documentation_download.html.



Areas of the County with low overall social vulnerability (second-quartile) include Upper Mifflin, Lower Mifflin, Upper Frankford, Lower Frankford, Penn, Cooke, and South Newton townships in the west, parts of Carlisle, South Middleton, and North Middleton in the center, and Silver Spring, New Kingston, New Cumberland, Shiresmantown, and parts of Mechanicsburg and Upper Allen Township in the east. Areas with the lowest overall social vulnerability (first-quartile) include Dickinson, parts of North Middleton, parts of South Middleton, and Monroe in the center of the County, and Lemoyne and parts of Mechanicsburg, Camp Hill, Hampden, East Pennsboro, and Lower Allen in the east.

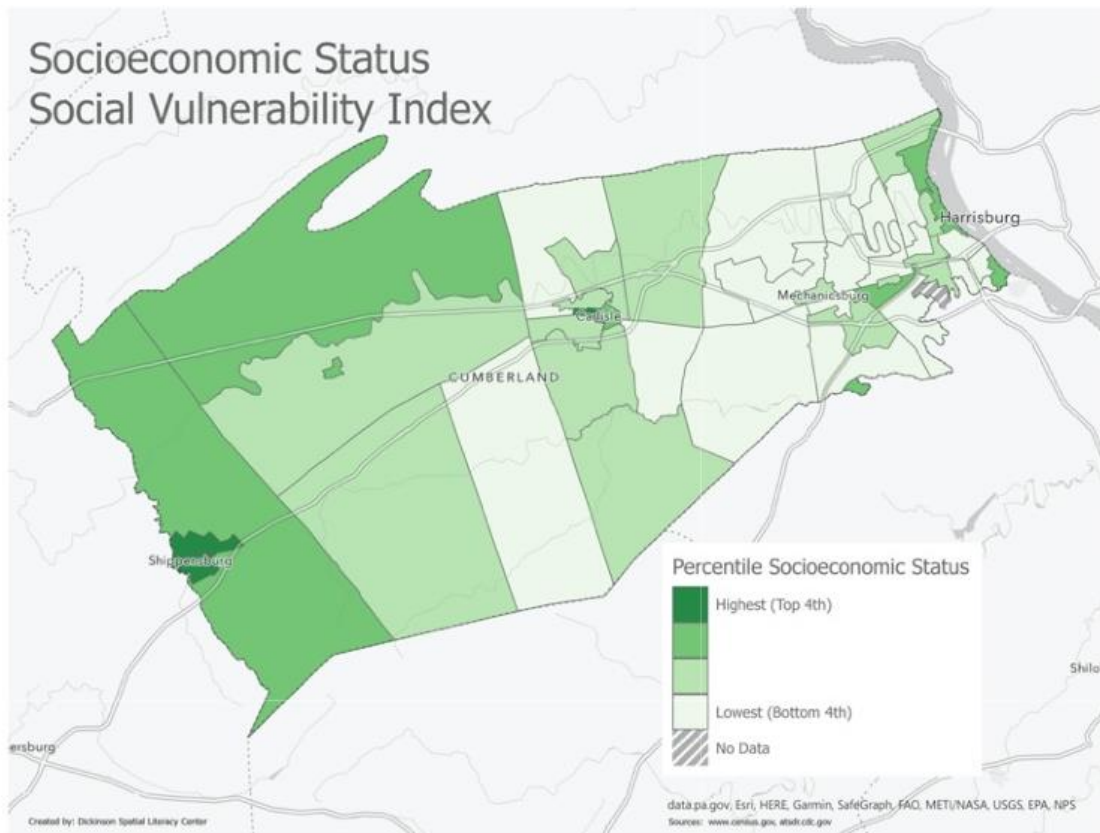
5.2. Social Vulnerability by Thematic Category

Maps 3.2 through 3.5 decompose overall social vulnerability to show the contributions of the four thematic categories of the SVI. Most census tracts show considerable variability in their social

vulnerability ranking across the four themes. For 36 of the 49 census tracts, social vulnerability is low or very low (first or second quartile) for at least one theme and moderate or high (third or fourth quartile) for at least one theme. Nine of the census tracts are ranked as having low or very low vulnerability for all four themes. These are tracts in Dickinson, Monroe, North Middleton, and South Middleton townships in the center of the county and tracts in Upper Allen, Lower Allen, Camp Hill, New Cumberland, and East Pennsboro in the east. Four census tracts are ranked as having moderate or high vulnerability for all four themes. These are tracts in Shippensburg Borough in the west, Carlisle in the center, and Enola in the east.

Map 3.2 shows the spatial distribution of social vulnerability for the socioeconomic status theme in Cumberland County. Areas ranked in the highest quartile for socioeconomic vulnerability across all census tracts in Pennsylvania include Shippensburg Township and Borough and the central area of Carlisle. Census tracts in the third quartile with moderate socioeconomic vulnerability include Newville, Upper Mifflin, Lower Mifflin, Upper Frankford, Lower Frankford, and Southampton in the west, parts of Carlisle in the center, and Enola, Wormleysburg, and parts of Lower Allen Township and New Cumberland in the east. Census tracts in the lowest quartile for socioeconomic vulnerability include Dickinson, South Middleton, North Middleton, and Monroe in the center of the county, and Silver Spring, Hampden, Mechanicsburg, Camp Hill, and other areas in the east of the county.

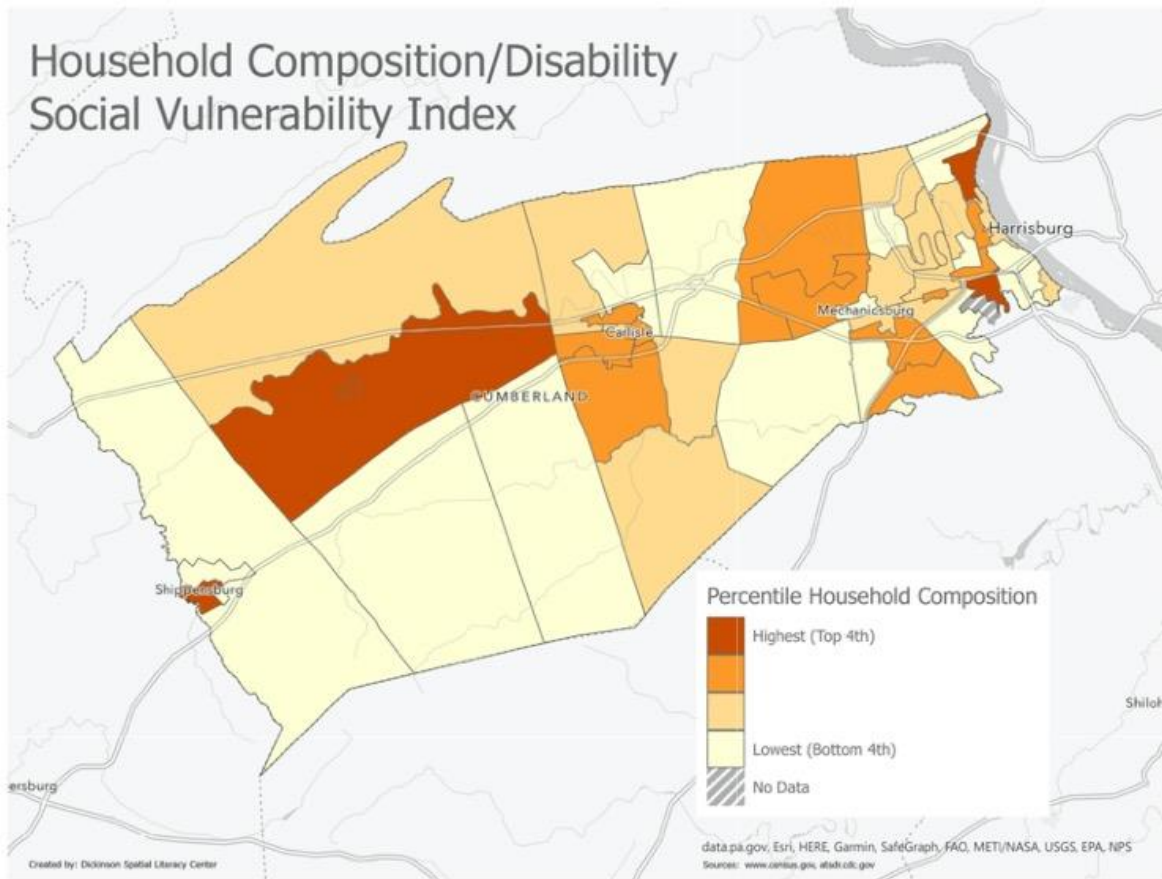
Map 3.2. Social Vulnerability – Socioeconomic Status Theme, Cumberland County. Map created by Gordon Cromley, Spatial Literacy Center, Dickinson College. Data source: CDC/ATSDR, Social Vulnerability Index Data and Documentation, https://www.atsdr.cdc.gov/placeandhealth/svi/data_documentation_download.html.



Map 3.3 shows social vulnerability for the household composition and disability theme. Areas ranked in the highest quartile for vulnerability based on household composition and disability include North

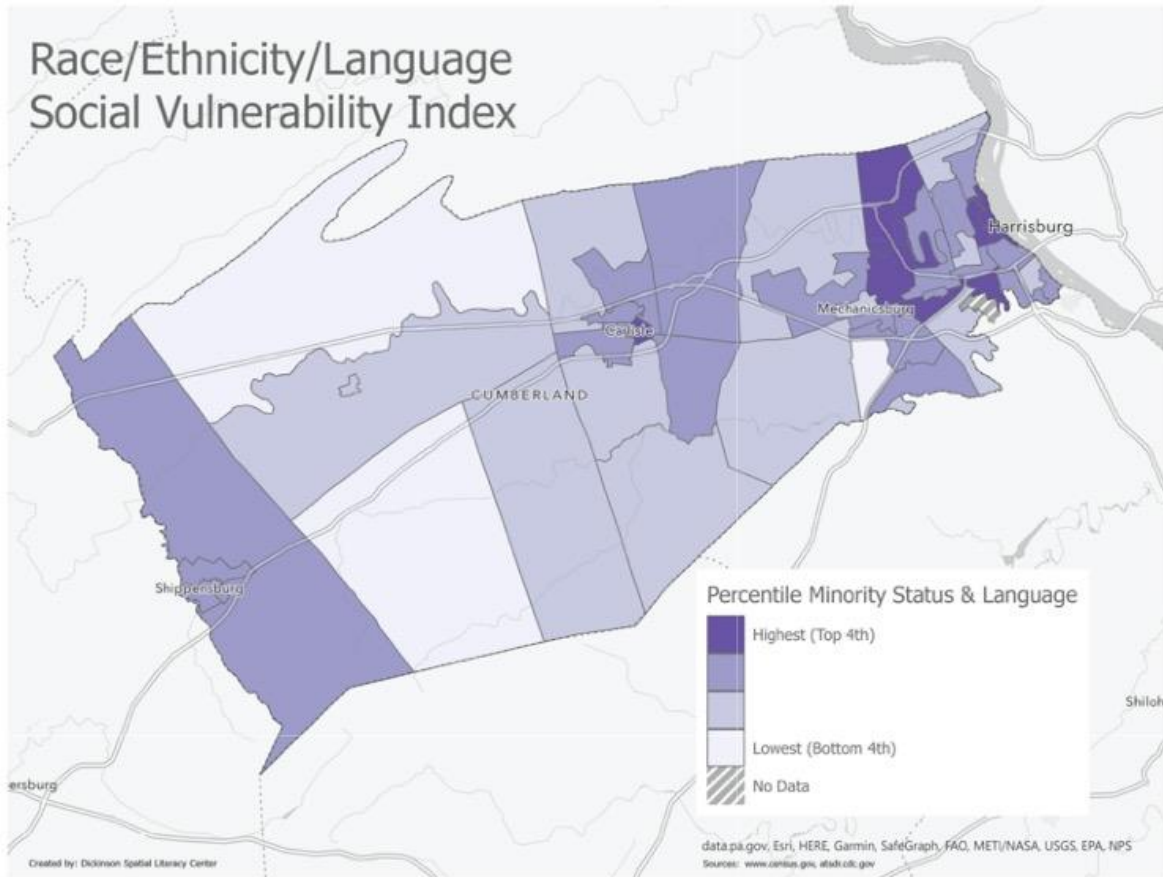
Newton, West Pennsboro, Newville, Shippensburg Borough, and West Pennsboro in the west of the county, and Enola and parts of Lower Allen Township in the east. Areas ranked as lowest vulnerability for this theme are Shippensburg, Penn, Cooke, and South Hampton townships in the west, Monroe, Middlesex and the southern part of North Middleton in the center, and parts of Lower Allen, Upper Allen, East Pennsboro, Hampden, Mechanicsburg, Camp Hill, New Cumberland, and Lemoyne in the east.

Map 3.3. Social Vulnerability – Household Composition and Disability Theme, Cumberland County. Map created by Gordon Cromley, Spatial Literacy Center, Dickinson College. Data source: CDC/ATSDR, Social Vulnerability Index Data and Documentation, <https://www.atsdr.cdc>.



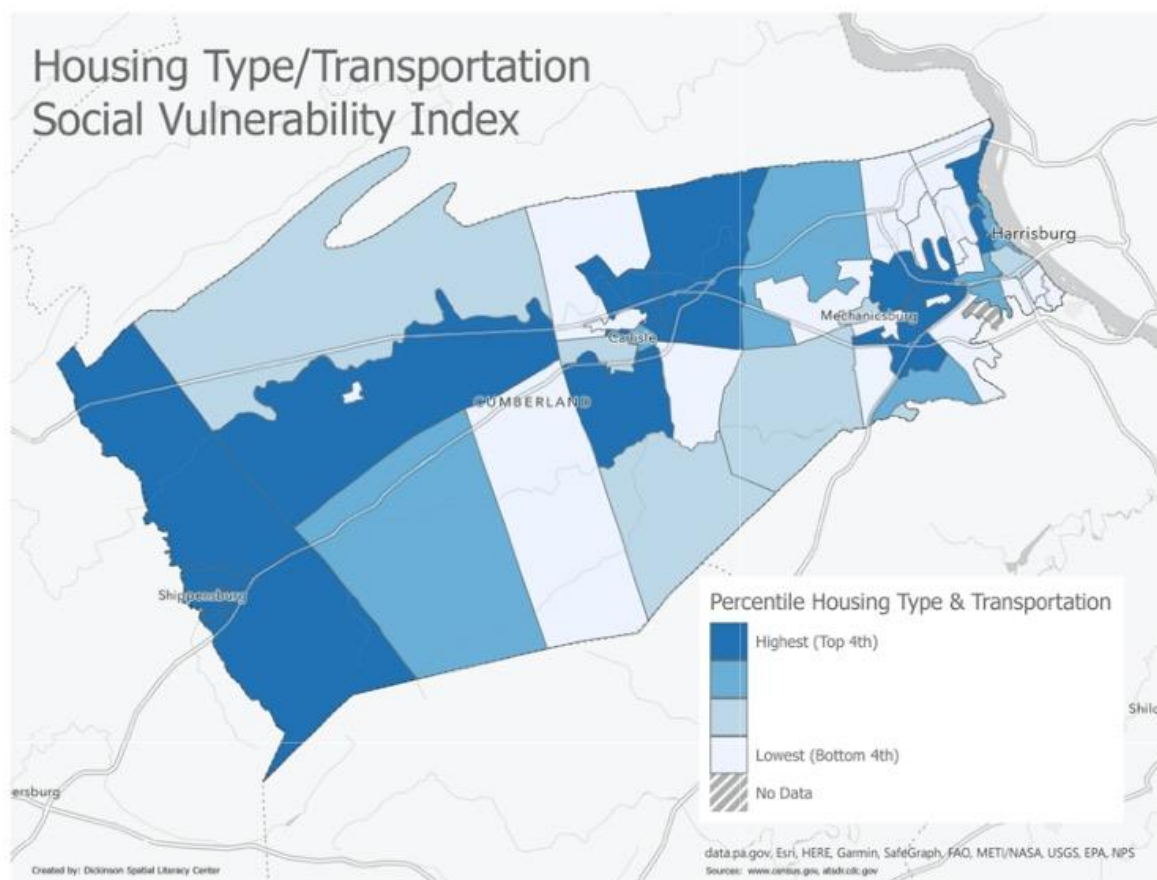
Social vulnerability for the race, ethnicity, and English language proficiency theme is displayed in Map 3.4. Areas ranked in the highest quartile of vulnerability for race, ethnicity, and language are eastern census tracts of Carlisle and parts of East Pennsboro, Lower Allen, Hamden, and Wormleysburg. Areas ranked as the lowest vulnerability for this theme are Penn, Cooke, Lower Mifflin, Upper Mifflin, Lower Frankford, and Upper Frankford in the west and parts of Upper Allen in the east.

Map 3.4. Social Vulnerability – Race, Ethnicity, and English Language Proficiency Theme, Cumberland County. Map created by Gordon Cromley, Spatial Literacy Center, Dickinson College. Data source: CDC/ATSDR, Social Vulnerability Index Data and Documentation, <https://www.atsdr.cdc>



Social vulnerability by housing type and access to transportation is shown in Map 3.5. Areas ranked with the highest vulnerability for this theme are Shippensburg Borough and Township, Southampton, North Newton and West Pennsboro in the west, Middlesex and parts of Carlisle, South Middleton, and North Middleton in the center, and Enola and parts of East Pennsboro, Hampden, Upper Allen, and Lower Allen in the east. Areas ranked with the lowest vulnerability for housing type and transportation access are Newville in the west, Dickinson and parts of Carlisle, North Middleton, and South Middleton in the center, and parts of Silver Spring, Hampden, East Pennsboro, Upper Allen, Lower Allen, Camp Hill, Mechanicsburg, and New Cumberland in the east.

Map 3.5. Social Vulnerability – Housing Type and Transportation Access Theme, Cumberland County. Map created by Gordon Cromley, Spatial Literacy Center, Dickinson College. Data source: CDC/ATSDR, Social Vulnerability Index Data and Documentation, <https://www.atsdr.cdc>



6. Adaptation Options

Selected adaptation options are reviewed below for reducing social vulnerability broadly across different sectors and systems. Options that are relevant to specific sectors or systems are addressed in other Background Papers. The options are organized into five categories: policy, planning, and management; capacity building; technology and infrastructure; practices and behaviors; and financing.

6.1. Policy, Planning, and Management

The consequences of climate change for the most socially vulnerable populations have been addressed in some jurisdictions by adopting climate action plans that have well-developed equity, environmental justice, and climate resilience goals and strategies. In other instances, these issues are integrated into existing planning efforts to “mainstream” equitable climate action as part of comprehensive, hazard mitigation, and other planning activities. Another possible approach is to follow both tracks, adopting climate-focused policies and plans while also integrating climate resilience, equity, and environmental justice into comprehensive plans and other plans of local jurisdictions.

Reviewing local government policies, plans, and programs through lenses of climate resilience, social vulnerability, and equity can identify opportunities for supporting people who are at greatest risk from climate change to prepare, cope, adapt, and recover. For example, while Cumberland County has a strong hazard mitigation plan, like most such plans it focuses on risks to county residents, infrastructure, resources, and services broadly, with relatively limited attention to the needs of specific populations who may lack resources and capacity to act to limit their risk or to recover after an event. Limited attention is also given to places where the most socially vulnerable populations reside in the county.

Applying a social vulnerability lens to the hazard mitigation plan can help with planning to protect communities that are most vulnerable and have special needs, as well as targeting support to locations where significant numbers of highly vulnerable people reside. These can include, for example, older adults, people with disabilities, chronic illness, and limited mobility, people living in substandard housing, people who lack transportation, and other vulnerable populations who are exposed to extreme heat, flooding, or severe storms. Similar reviews of county and municipal plans for economic development, infrastructure, public services, and other needs can help identify opportunities for addressing disparities and inequities experienced by people and places with high social vulnerability and histories of being disproportionately burdened by environmental and other risks. Reducing and ending disparities and inequities can yield wide ranging benefits, including increased resilience to a changing climate.

Beyond planning, prioritizing reductions in social vulnerability and improvements in equity and environmental justice in the implementation, monitoring, and evaluation of plans can enhance their effectiveness. The *Pennsylvania Climate Action Plan* recommends that the public be actively engaged in integrating equity and environmental justice considerations into climate action planning efforts, with particular emphasis on including residents and organizations from highly vulnerable and marginalized communities. The state plan also recommends development of metrics and establishment of processes for tracking the equity of impacts and actions. (PA DEP, 2021b, p. 123).

6.2. Capacity Building

Disparities in social vulnerability to climate change is, at its core, a problem of disparities in the capacities of people and communities to respond effectively to climate hazards to limit the harms they suffer and to recover. Low incomes and limited wealth, which are correlated with age, race, disabilities, chronic illness, education, and other factors, are important determinants of people's capacities. A wide range of policies and programs, while not motivated by climate concerns, nonetheless limit the climate risks of socially vulnerable people by adding to their general capacities. These include, for example, programs for poverty reduction, workforce development, affordable housing, access to health care, food security, education, childcare, and other services. Also important are communities' efforts to identify, develop, and mobilize their members' knowledge, expertise, and experiences to benefit themselves and the community.

These and other programs provide people with access to and command of greater resources to use in putting food on the table, getting medical care, paying for rent and utilities, maintaining homes, owning a car, caring for children, and meeting other needs. In doing so, the programs contribute to people's resilience and resources for managing climate and other stresses. Continued support of these programs, and expansion when feasible, is an essential lifeline for many people who are socially vulnerable to climate change.

In addition to building the capacities of individuals, the capacities of communities to manage climate hazards also can be increased by building social capital. Communities in which people feel connected with each other, experience respect, and have learned that they can trust and rely on neighbors and local organizations, businesses, and government agencies have strong social capital. As demonstrated in the Chicago heatwave, superstorm Sandy, and other climate-related crises, strong social capital can help mitigate the worst impacts and facilitate faster and fuller recovery. Supporting, strengthening, and connecting organizations, churches, and businesses with roots in the communities they serve can add to social capital that will pay dividends for building resilience to climate change and other pressures that affect our communities. This is a critical dimension for preparing effectively for climate change that is often overlooked.

Learning who is vulnerable, where they reside, and what knowledge, expertise, experience, and needs they have for managing climate risks adds to the capacities of community organizations and government agencies for preparing and responding to climate change. In this background paper, information has been presented about social vulnerability in Cumberland County using the CDC's Social Vulnerability Index (SVI), but this is only a first step. More in-depth assessment is needed. At the population-level, the SVI or similar tools can be combined with other spatial data to map where vulnerable people reside in relation to, for example, flood plains, urban heat islands, cooling shelters, transportation corridors, medical services, nursing homes, schools, parks, and other features that represent risks or resources for mitigating risks in Cumberland County's communities. Information from the SVI can be supplemented, as was done by Easton, PA, with information about locally relevant risk factors such as people living alone and renters who may be isolated and less connected with sources of information and assistance in the community (Nurture Nature Center, 2018, p. 37).

In addition to population-level information, information about individuals who may be socially vulnerable to climate hazards is also helpful for preparing for and responding to climate hazards. The CDC describes two approaches for collecting information about individuals – voluntary registries and networks of community organizations. Voluntary registries are created by inviting people to provide information about, for example, their abilities and disabilities, medical conditions, medications, medical equipment, access to transportation, and needs for special assistance. This type of individual data can be used to provide targeted assistance during emergencies. The CDC provides guidance for developing registries and methods for collecting information. They also identify challenges, which include relying on people to voluntarily provide the requested information, protecting confidential information, communicating how the information will be used, managing expectations for the help that people can expect, and maintaining and updating registries. (CDC, 2015, p. 7).

Another approach for collecting individual information is to develop and engage a grassroots network of community leaders and organizations who serve the community and are knowledgeable about people who are likely to be at risk from climate and other hazards, as well as people who have capacities to assist others. The CDC has created a process to develop networks, which they call Community Outreach Information Networks (COIN), for public health planners to define, locate, and reach at-risk groups in emergencies. These networks can provide information about vulnerable people, where they reside, their needs, information sources they trust, and gathering places. They can also help with planning effective support for at-risk groups and assist with delivery of information to at-risk groups before, during, and after an emergency. (CDC, 2015, pp. 8-13).

6.3. Technology and Infrastructure

Socially vulnerable people often live in areas with less infrastructure, or infrastructure that is in poorer condition, than is available to serve other areas. This can add to their risks from climate hazards. For example, rural populations typically live in places that are more distant from infrastructure for health care, water and sanitation, transportation, and other services than populations who live in more developed areas. Broadband internet and mobile phone service can be less available in rural areas. Climate events that disrupt access to critical services can cause significant hardship. In more developed locations, the density of buildings, extensive paved areas, and limited tree canopy can create urban heat islands that can be very dangerous places during extreme temperature events. Often, these same areas correspond to places where many socially vulnerable people reside. In low-income communities, there is often a lack of cooling centers and temperature-moderating greenspaces, the absence of which adds to the risks to people in these communities.

Overlaying maps of the locations of important infrastructure with maps of places where socially vulnerable people live would enable planners to identify areas where socially vulnerable people may be inadequately served. Further investigation of underserved areas to learn where and how people in these areas access services, the quality of the services, and challenges in accessing services would yield a more detailed picture of possible mismatches between existing infrastructure and needs. The more detailed information would aid planners in setting priorities for infrastructure investments that would close disparities and inequities while adding to climate resilience of vulnerable communities.

6.4. Practices and Behavior

Well-designed education and outreach can promote practices and behaviors that enable people to reduce their risks from climate threats and other hazards. To be effective, education campaigns and materials should bear in mind the particular needs of socially vulnerable populations. For example, the Ready Campaign of the U.S. Department of Homeland Security is designed to “educate and empower the American people to prepare for, respond to, and mitigate emergencies, including natural and man-made disasters” (U.S. Department of Homeland Security, 2022). Examples of disasters covered by the guide include climate-related disasters such as floods and severe storms. The Ready Campaign’s emergency preparedness guide includes specific considerations for people with disabilities, seniors, children, responsibilities for assisting others, medical needs, languages other than English, and pets and service animals. They also provide recommendations for preparedness plans that are low or no cost and steps that can be taken to prepare for the potential financial impacts of an emergency.

These and other aspects of the federal Ready Campaign respond very directly to factors that contribute to social vulnerability to hazards. Pennsylvania used materials from the federal Ready Campaign to prepare its own Pennsylvania Emergency Preparedness Guide, and Cumberland County’s Emergency Preparedness webpage (<https://www.ccpa.net/90/Guide-to-Emergency-Preparedness>) links to Ready PA’s Emergency Preparedness Guide and other materials. The Ready PA guide is available in six languages – English, Spanish, German, Russian, Simplified Chinese, and Traditional Chinese. But not included are guides in languages spoken in countries from which many of Pennsylvania’s newest immigrants have come. For people with vision impairments, the guide is available in large print and audio versions. Information specific to children in school and seniors can also be accessed from the County Emergency Preparedness webpage.

The emergency preparedness materials that are accessible through the County’s website are valuable resources that can promote risk reducing practices and behaviors – for the general population as well as for people with special needs and people who are socially vulnerable. But there are important questions about the extent to which residents are aware of these resources, how visible and accessible they are to residents, and whether answers to these questions differ for different populations.

Information was not found for any outreach campaigns that may have been conducted in recent years to draw attention to the county and state emergency preparedness materials. Good practice would be to conduct periodic campaigns to raise awareness of the risks and resources, designing and implementing the campaigns to use media that are readily available to and accessible by socially vulnerable populations. Community organizations that serve socially vulnerable groups can be valuable partners in helping to disseminate emergency preparedness information. Periodic campaigns should also include processes and metrics to measure their effectiveness.

Extreme heat is one of the leading weather-related killers in the United States (National Weather Service). Health impacts of extreme heat events was found by the Pennsylvania climate impacts assessment to pose the highest risk of adverse consequences from climate change for equity and environmental justice in Pennsylvania (PA DEP, 2021a, pp. xii). As demonstrated by heat waves in recent years, there is an urgency for creating and implementing a more robust system for educating all County residents, but particularly socially vulnerable residents, about preparing for extreme heat, preventing heat-related illnesses during heat events, and recognizing and treating heat-related illnesses. Extreme heat was identified on July 22, 2022, by READY.PA.GOV as the most popular topic on its website for the previous 7 days, a week of excessive heat warnings for much of Pennsylvania. It is noteworthy, however, that extreme heat is not listed among the top 10 emergencies in the Pennsylvania Emergency Preparedness Guide and the guide does not provide information that is specific to extreme heat events. Extreme heat risks and responses will be addressed in more depth in a separate Background Paper.

6.5. Financing

Reducing social vulnerability to climate hazards in Cumberland County will require financial and human resources. External funding for county-level development from state and federal grant and loan programs are typically oversubscribed, the amount of available funding has declined for many, and new funding opportunities can be rare and highly competitive. Efforts to build resilience and reduce social vulnerability in the County may qualify for external funding, but it is likely that support would need to come to a large extent from creative uses of existing programs. Reviews of existing programs in the County could identify if and where there are opportunities to reorient activities under existing programs to both serve their original purposes while also reducing climate risks to socially vulnerable populations.

State and federal funding programs should be monitored and evaluated for opportunities to apply for grants and loans to support eligible organizations in the County, including government agencies and non-profit organizations. Pennsylvania’s Department of Community and Economic Development administers funding programs that might be appropriate for climate resilience and social vulnerability projects, including the Community Services Block Grant Program, Greenways, Trails, and Recreation, Home Investment Partnership Program, and Weatherization Assistance Program. The Community Conservation Partnerships Program of the Pennsylvania Department of Conservation and Natural Resources may also be relevant.

At the federal level, the recently enacted Infrastructure Investment and Jobs Act and the Inflation Reduction Act may provide opportunities for accessing federal funds to help support local efforts to limit climate change risks (White House, 2021; White House, 2023). Additionally, the Department of Health and Human Services administers more than 100 grant programs to protect American’s health and provide essential human services, many of which can contribute to the capacities of people to manage climate related risks. The USDA administers the Rural Community Development Initiative and the USEPA administers the Environmental Justice Small Grants Program. Federal Community Development Block Grant funds for use in Cumberland County and Carlisle can be applied for through the Cumberland County Housing and Redevelopment Authority.

7. Recommendations

The following recommendations are offered to the Cumberland County Planning Department and others to consider as initial steps toward building climate resilience, protecting people who are most vulnerable to climate hazards, and reducing inequities with respect to the burdens of climate impacts and benefits from climate actions.

1. **Convene a county-wide working group on community climate resilience, social vulnerability, and equity.** Residents and representatives of community organizations, businesses, and government agencies should be convened to discuss and develop goals, broad strategies, and processes and metrics for tracking progress for addressing climate resilience, social vulnerability, and equity in Cumberland County. The working group could also serve as a forum to share information about existing efforts that are helping to advance the goals as well as relevant funding opportunities to continue and build on the efforts. These actions are highlighted in the Pennsylvania Climate Action Plan as foundational to understanding and preparing to address vulnerabilities to climate hazards (PA DEP, 2021b, p. 123).
2. **Reduce social and economic disparities.** Social vulnerability to climate and other stresses is, to a substantial degree, a product of social and economic disparities. Continuing to support, and expanding as feasible, programs that increase the capacities of vulnerable people to prepare for, respond to, and recover from climatic and other hazards will reduce vulnerabilities and increase resilience. These include programs for poverty reduction, workforce development, affordable housing, access to healthcare, food security, education, and childcare.
3. **Conduct an in-depth assessment of social vulnerability to climate hazards.** This Background Paper provides a general assessment of locations of potentially vulnerable communities within Cumberland County. Learning more about who is likely more vulnerable, the nature of their vulnerability, their capacities for managing climate risks, their specific needs for assistance, and their access to services and infrastructure can enable more effective responses to aid vulnerable groups and individuals. Maps of potentially vulnerable communities in the County like those presented in this paper can be integrated with other data to examine additional dimensions of social vulnerability or display where vulnerable communities are located in relation to specific climate hazards, essential services, and infrastructure. A new, more in-depth assessment could also explore approaches, potential uses, and challenges for collecting information about individuals through registries or Community

Outreach Information Networks. Findings should be utilized to inform comprehensive planning, hazard mitigation planning, and other planning processes.

4. **Review existing policies, plans, and programs through lenses of climate resilience, social vulnerability, and equity.** Understanding how existing policies, plans, and programs are currently contributing to the capacities of communities to cope with climate risks is an important starting point for adding to climate resilience and advancing equity. The review should also examine funding levels and sources for existing efforts, unmet needs, and opportunities to improve protections for potentially vulnerable populations. Relevant policies, plans, and programs to review include comprehensive plans, hazard mitigation plans, emergency response plans, economic development plans, infrastructure investments, affordable housing programs, financial assistance for low-income households, and health and human services.
5. **Build capacities of local communities.** Communities with high levels of community capital, encompassing human, financial, built, natural, and social capital, have greater capacities than communities with low community capital for managing risks and are more resilient to wide-ranging stresses, including climate change. Particularly important is social capital – the histories, relationships, and mutual trust among individuals and organizations in a community that can be used to mobilize people and resources toward common purposes. Supporting, strengthening, and connecting community organizations, neighborhood associations, churches, and businesses with roots in Cumberland County’s communities can add to social capital and local capacities. A community asset map, or inventory of organizations and other assets that can be mobilized to manage climate risks, should be developed and maintained. As a next step, community organizations should establish linkages and be provided resources to work together on community initiatives that strengthen relationships that will add to climate resilience.
6. **Launch a campaign for emergency preparedness that addresses differences in social vulnerability.** Emergency preparedness is an important and very concrete arena in which people who are socially vulnerable to climate hazards can be benefited. Cumberland County, Pennsylvania, and the U.S. Department of Homeland Security have well-designed emergency preparedness materials that address a variety of special needs. But it is likely that relatively few County residents are aware of the resources, and those who are aware may struggle to find them when they have a need. Cumberland County’s Department of Public Safety should partner with other agencies and community organizations to design and implement a program of periodic education campaigns to promote emergency preparedness. Preparedness for extreme heat events should be an early focus of this effort.

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