DEVELOPMENT OF A SPATIAL MUNICIPAL VULNERABILITY INDEX

TASK 2 REPORT: EVALUATION OF EXISTING TOOLS AND STAKEHOLDER ENGAGEMENT

FINAL REPORT

JULY 31, 2023

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1 Introduction

The Vermont Municipal Vulnerability Index (MVI) being developed under this project is intended to help identify where Vermont communities are most vulnerable to climate change, with a focus on pressures that climate change will place on Vermont's transportation, electric grid, housing, emergency services, and communications infrastructure.[1] The MVI will pay particular attention to the challenges faced by rural communities across the state when addressing these pressures. To inform the framework and methods used to develop the MVI, Eastern Research Group, Inc. (ERG), conducted two background research efforts: the evaluation of existing tools that can be used to inform the MVI and engagement of key partners[2] to ensure the MVI reflects their experiences, expertise, and concerns related to climate vulnerability within their communities and across Vermont. The information identified through evaluating exiting tools was used to inform the selection of engagement participants and discussion topics. Together, evaluating existing tools and engagement will inform the development of the methods and framework used for the MVI (see Figure 1).

Figure 1. Background research tasks within the context of primary project tasks.

This report focuses on the methods and findings on the first phase of the analysis—the evaluation of existing tools and a description of the engagement approach and findings.

The sections of the report are organized as follows:

- **Section 2** provides an overview of the review and evaluation of existing tools.
- **Section 3** summarizes the engagement approach and findings.
- **Section 4** describes the overarching conclusions, recommendations, and next steps.

2 Review and Evaluation of Existing Tools

To inform the development of the MVI, ERG reviewed and evaluated 21 existing web-based geospatial tools and data visualization platforms (hereafter referred to as "tools"). The primary focus of the evaluation was to review tools considered relevant to developing the MVI, along with their objectives and outputs. The secondary focus of the evaluation was to consider the data and information used in each tool and their applicability to the MVI.

[1] According to the Vermont Statutes Annotated (VSA), 1 VSA § 126, the term "municipality" includes "a city, town, town school district, incorporated school or fire district or incorporated village, and all other governmental incorporated units." The terms "town" and "municipality" are used interchangeably throughout this report.

[2] Engagement under this project includes the following groups: expected MVI tool users; entities, communities, or their representatives who will potentially be affected by the tool's use; entities whose work is parallel to, or overlaps with, the MVI tool, and there is a need to align efforts; and Vermont state staff assisting with the tool's development who will be responsible for updating and maintaining the tool over time.

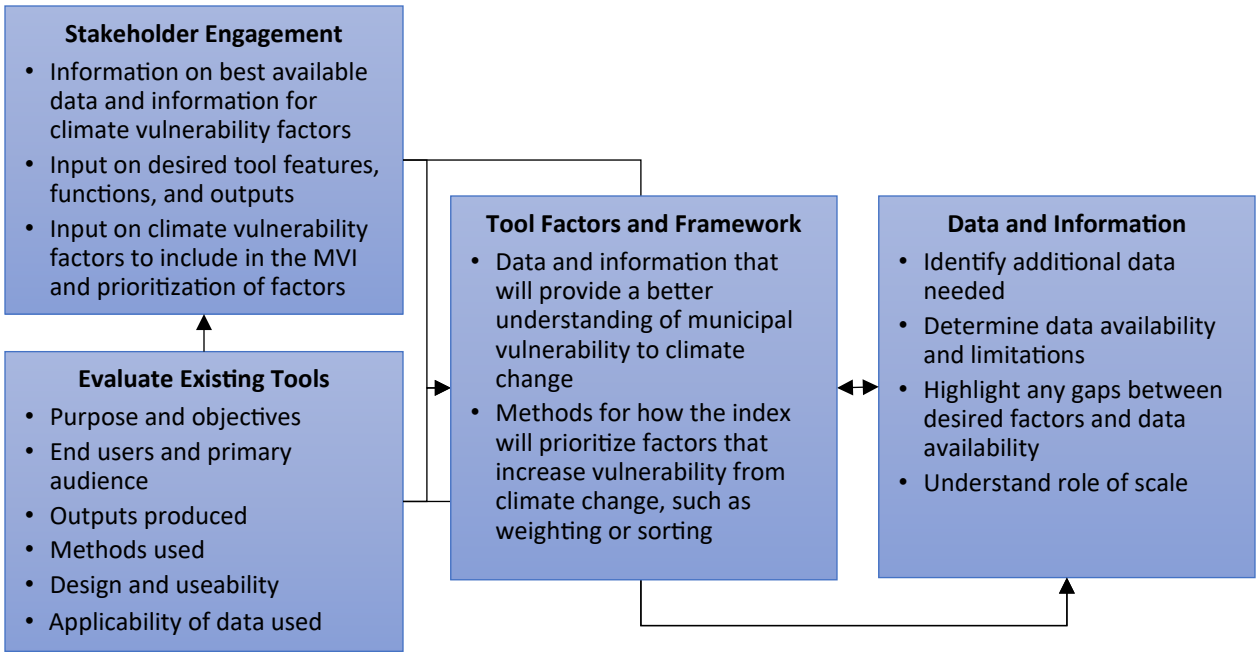


Figure 2. Flow of information and data into the MVI factors and framework.

Figure 2 shows the process steps used to support the development of the MVI framework. The information collected through evaluating existing tools was used to inform engagement, the MVI factors and framework, and the types of data and information available to support tool development. To confirm the findings from the tool evaluation step, ERG presented the draft factors and the framework and refined and revised based on the input and recommendations received by participants.

Tools Reviewed

The VT state team[3] provided initial guidance on tools and methods to consider when developing the MVI factors and framework, including those from the states of California and Maine, in addition to those from Green Mountain Power, the Vermont Department of Health, and Vermont's Agency of Transportation (VTrans), Agency of Commerce and Community Development (ACCD), and Agency of Natural Resources (ANR). Using this guidance, ERG developed an initial set of key tools for review and confirmed the list with the VT state team. ERG then expanded the draft list through feedback from the MVI task group and VT state team. The list of resulting tools is presented in Table 1 below.

[3] The VT state team refers to the representatives from the state of Vermont who comprise the project team.

Table 1. List of tools reviewed.

Tool	Geographic Area	Lead Agency/ Organization	Tool Focus
BioFinder	VT	ANR	Database and online mapping tool that identifies Vermont's lands and waters that support important ecosystems, natural communities, habitats, and species.
Department of Housing and Community Development Planning Atlas	VT	Department of Housing and Community Development	Provides town- and state-level information for use in planning (e.g., community development information, town boundaries).
Flood Ready Atlas	VT	ANR	Online mapping tool to help users identify critical flood hazard areas in a community.
Green Mountain Power 2021 Integrated Resource Plan	VT	Green Mountain Power	Highlights how Green Mountain Power will move forward to satisfy Vermont's energy needs and comply with Vermont's greenhouse gas reduction legislation.
Green Mountain Power Maps	VT	Green Mountain Power	Maps illustrating Green Mountain Power's service area, power outages, solar coverage, and distributed generation siting.
Historic Preservation Online Resource Center	VT	ACCD	Online access to the Division for Historic Preservation's documents related to historical preservation activities throughout the state since the 1960s.
Landslide Hazard Mapping	VT	ANR	Reports and maps documenting instances of landslides, rockfall, and areas of extreme erosion.
Mobile Home Park Registry	VT	ACCD	Provides list of all mobile home parks in Vermont.
Natural Resources Atlas	VT	ANR	Provides geographic information of natural features on land managed by VT ANR.
Vermont Commercial/Industrial Site Locator	VT	ACCD	Identifies optimal business locations by combing real estate listings with demographic and industry analysis.
Statewide Highway Flood Vulnerability and Risk Map	VT	VTrans	Online map of flood vulnerability and risk to support emergency preparedness, capital programming, and hazard mitigation planning.
Vermont Social Vulnerability Index	VT	Department of Health	Online mapping tool to evaluate relative social vulnerability across the state.
Vermont Transportation Flood Resilience Planning Tool	VT	VTrans	Identifies bridges, culverts, and road embankments vulnerable to damage from floods, estimates risk based on how vulnerable and critical roadway segments are, and identifies potential mitigation measures based on the factors driving the vulnerability.
California Climate Change & Health Vulnerability I**ndicators**	CA	Department of Public Health	Interactive data visualization platform for the Climate Change & Health Vulnerability Indicators for California focused on climate exposure, population sensitivity, and adaptive capacity to the impacts of climate change.
Climate Vulnerability in Greater Boston	Boston, MA	Metropolitan Area Planning Council	Online tool used to gage which populations are most vulnerable to the extreme heat and flooding in the Boston metro area.
Maine Coastal Risk Explorer	ME	The Nature Conservancy	Online mapping tool that shows how rising sea levels will impact infrastructure (e.g., roads) in Maine and how these impacts relate to the overall social vulnerability of the community.

Tool	Geographic Area	Lead Agency/ Organization	Tool Focus
Rural Capacity Index	U.S.	Headwaters Economics	Online mapping tool and index that indicates community capacity by incorporating variables based on metrics related to local government staffing, community education and engagement, and socioeconomic trends.
Cooling Site Map	VT	Vermont Department of Health	Map that provides locations of indoor cooling sites open during normal hours; indoor cooling sites open during special hours; indoor cooling sites that are occasionally open; free beaches, pools, splash pads, or swimming holes; and beaches, pools, or splash pads that usually charge an entry fee.
Reducing Repeat Damage Tool	VT	VTrans	This tool depicts the VTrans analysis for reducing repeat damage from major storm events. The tool shows locations across the full Vermont Federal Aid System that have been damaged in multiple governor- or president-declared events between 2007 and 2021.
Vermont Communities Index	VT	Agency of Administration	Data-based tool designed to identify Vermont county subdivisions (i.e., municipalities) and labor market areas that may benefit from additional support to access funding from state, federal, and other sources. Using publicly available data, the Vermont Communities Index estimates each community's need for investment and administrative capacity to implement projects and pursue external support.
Vermont Heat Vulnerability Index	VT	Vermont Department of Health	The online, mapped index shows the overall vulnerability of each Vermont town to heat-related illness. This index is a composite of the following themes: Population, Socioeconomic, Environmental, Acclimatization, and Heat Emergency.

Evaluation Framework

ERG developed an evaluation framework in Microsoft Excel to structure the review of the tools and ensure that the initial assessment was consistent and robust. ERG designed the framework to capture relevant information about each tool or data set that could contribute to the development of the MVI. For example, the evaluation framework includes whether the tool aligned with priority topics of interest that may inform one or more aspects of climate vulnerability (e.g., hazards, built environment, socioeconomic information), the type of data available, outputs produced (e.g., maps, tables), design features, ease of use, and methods used in developing the tool. The VT state team and MVI task group reviewed the draft framework to provide an opportunity for input prior to ERG's evaluation of the tools. Figure 3 below shows the categories of the evaluation framework used for the review. The completed evaluation framework is included as a separate companion document to this report.

Tool/Dataset	Objectives	Audience	Key Users	Key Functions	Outputs	Data Sources
Name of tool/dataset	Goals of the tool/ dataset (e.g., decision-making, prioritize funding, understanding risk)	End users (e.g., emergency responders, community partners, planners)	Municipalities and internal agency users (e.g., Agency of Natural Resources)	Set of services or capabilities that the tool/dataset can provide (e.g., public user interface, zoom in/out of map, etc.)	Information produced from tool/dataset	Location of data that tool/dataset used or will process from

Data Scale	Data Type	Limitations	Maintenance	Potential Area of Alignment to VT MVI (Domains)	Vulnerability Index Design	Equity and Just Transition
Geographic scale of data (e.g., state, regional, Census-tract, town)	Qualitative, quantitative, or both types of data	Constraints of the tool/dataset	Description of any continual updates to the tool/dataset	Hazards, built environment, social/community, natural environment, governance	Description of method of weighting and scoring of vulnerability indicators	Description of any incorporation of equity and just transition aspects in tool/dataset

Figure 3. Evaluation framework.

2.1 Key Findings

This section presents a summary of the findings from the evaluation of existing tools. The subsections that follow present the findings by the following topic areas:

- Components of interest to consider for the MVI (Domains - Sections 2.1.1 and Factors – Section 2.1.2)
- Data Sources (Section 2.1.3)
- Index development methods (Section 2.1.4)
- Outputs (Section 2.1.5)
- Design (Section 2.1.6)

2.1.1 Domains

ERG reviewed the existing tools to identify components applicable to the MVI and the unique needs of its end users in Vermont. The evaluation framework captured information on seven key topic areas[4] that were identified as priorities by the State of Vermont for this project or suggested by ERG based on prior

[4] Key topic areas include social/community, governance, just transitions, economic, built environment, natural environment, and hazards.

work developing and reviewing similar indices. These topic areas have been categorized into five "domains". The five domains are listed below in bold, followed by the types of information included within the domain:

- **Built/physical environment.** Information on transportation assets, buildings, infrastructure, and the electric grid.
- **Economic/jobs.** Information on unemployment, per capita income, and industry types.
- **Hazards.** Information on natural hazards such as flooding, extreme temperatures, or landslides.
- **Natural environment.** Information on forest cover, wetland extent, fish and wildlife habitats, and ecosystem services.
- **Social/community.** Information on governance, sociodemographic factors, housing, access to emergency services, and active community organizations. This domain considers equity and just transitions, including challenges faced by rural communities across the state/region.

Table 2 below indicates whether each tool reviewed addresses the domains. As the table shows, the majority of the 21 tools reviewed inform the key areas of built environment (19), hazards (14), natural environment (13), and social/community (14). Ten tools included economic information. The next section describes the data underlying each domain.

Table 2. Summary of tools reviewed by domain.

Tool	Built Environment	Economic	Hazards	Natural Environment	Social/ Community
BioFinder	✓			✓	✓
Department of Housing and Community Development Planning Atlas	✓	✓	✓	✓	✓
Flood Ready Atlas	✓		✓	✓	✓
Green Mountain Power 2021 Integrated Resource Plan	✓		✓	✓	✓
Green Mountain Power Maps	✓				
Historic Preservation Online Resource Center	✓				
Landslide Hazard Mapping	✓		✓	✓	
Mobile Home Park Registry	✓	✓	✓		
Natural Resources Atlas	✓			✓	✓
Vermont Commercial/Industrial Site Locator	✓	✓	✓	✓	✓
Statewide Highway Flood Vulnerability and Risk Map	✓		✓		
Vermont Social Vulnerability Index		✓			✓
Vermont Transportation Flood Resilience Planning Tool	✓		✓	✓	
California Climate Change & Health Vulnerability Index	✓	✓	✓	✓	✓
Climate Vulnerability in Greater Boston	✓	✓	✓	✓	✓
Maine Coastal Risk Explorer	✓	✓	✓	✓	✓
Rural Capacity Index	✓	✓	✓		✓
Cooling Site Map	✓			✓	
Reducing Repeat Damage Tool	✓		✓		✓
Vermont Communities Index		✓			✓
Vermont Heat Vulnerability Index	✓	✓	✓	✓	✓
Total Number of Tools in Area	**19**	**10**	**14**	**13**	**14**

2.1.2 Factors

A range of factors, or indicators, inform vulnerability within each domain. Figure 4 provides a template for how domains and factors relate to one another. For clarity, we define each of the terms in Figure 4 below:

- The **domain** is the category that includes the factors we're considering. For example, social factors may be grouped into one domain, while factors related to the built environment are considered as a separate domain with its own factors.
- The **factors** are the assets and issues that inform vulnerability.
- The **metric** is the way we will measure each factor. The metric chosen for each factor may be based on data availability.

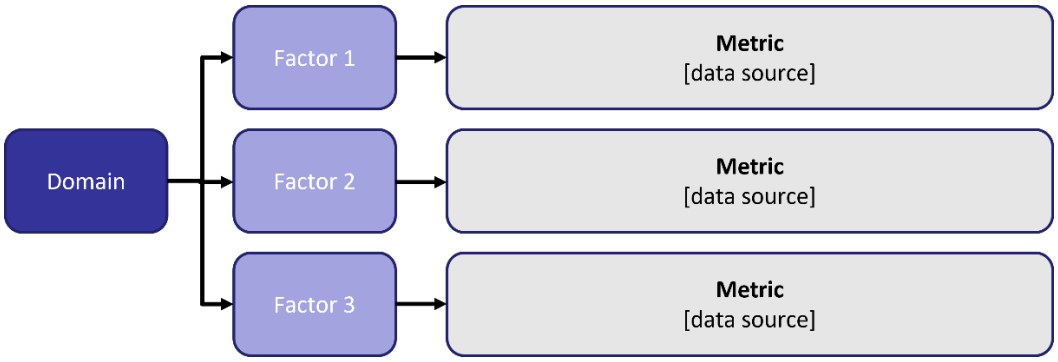


Figure 4. Relationship between domain, factors, and metrics.

For example, under the Social/Community domain, factors that inform vulnerability may include characteristics of the population, such as whether people are elderly, have a disability, or own a vehicle (see Figure 5). These factors are then measured using available data, such as that from the U.S. Census Bureau in the example provided in Figure 5.

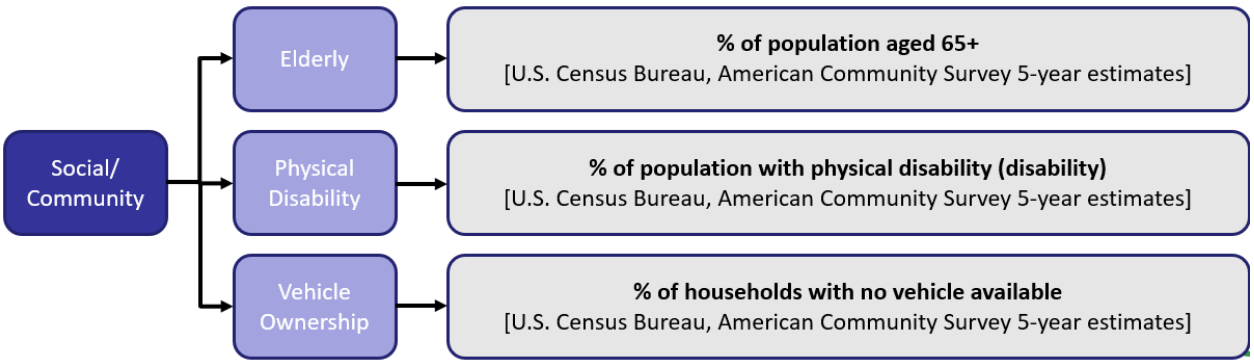


Figure 5. Example of social/community domain factors and metrics.

Table 3, below, shows the preliminary set of factors that ERG identified during the review of existing tools for each domain identified in Section 2.1.1. These factors serve as a starting point for discussion with the VT state team, MVI task group, and others about the key factors to include in the MVI as ERG moves through the stakeholder engagement process and begins developing the tool framework.

Table 3. Factors identified through the tool review and outside sources, organized by domain.

Social/Community	
• Education level • Vulnerable ages (i.e., children, elderly) • Varying disabilities • Housing unit overcrowding • Racially minoritized populations • Non-English speaking abilities • Vehicle ownership • Single-parent families • Pre-existing health conditions • Access to internet	• Cultural resources • Outdoor workers • Municipal financial capacity • Municipal staff capacity • Active public and civic organizations* • Distance from emergency services and shelters* • Tribal cultural resources** • Mitigation measures (as measured by the VT Emergency Relief and Assistance Fund)**
Economic/Jobs	
• Income • Poverty rate • Unemployment • Labor force participation • Key sectors in municipality** • Job centers in municipality** • Agricultural land**	• Ports, airports, and goods movement** • Timber and fisheries** • Repetitive loss properties and past damages** • Job training and opportunity to participate in climate economy** • Tourism**
Built/Physical Environment	
• Housing density • Large apartment buildings • Mobile homes • Lack of air conditioning • Impervious surfaces • Transportation and transit • Utilities • Cultural resources	• Community services (e.g., schools, libraries, grocery stores)** • Age and condition** • Construction methods** • At-grade or underground assets** • Public safety (e.g., hospitals, police stations, fire stations)**
Natural Environment	
• Tree canopy • Biodiversity • Critical habitat • Water quality and quantity • Air quality • Equitable access to healthy and safe open spaces and parks** • River and stream protection**	• Green infrastructure** • Parks and open space** • Tribal cultural resources and lands** • Adaptability to future conditions** • Connectivity and corridors** • Conserved Land**
Hazards [a]	
• Cold • Drought • Earthquake • Fluvial Erosion • Hail • Heat • Ice	• Inundation Flooding • Invasive Species • Landslides • Snow • Wildfire • Wind

* Identified by the RFP. ** Identified by outside sources (MVI task group member or ERG)

[a] List of hazards taken from the Vermont State Hazard Mitigation Plan: https://vem.vermont.gov/plans/SHMP

2.1.3 Data Sources

The tools reviewed for the MVI incorporate many data sets that could be useful to include in the MVI. These datasets can be used to measure factors (as listed in Table 3 above) at the municipal level in Vermont and incorporated into the MVI using the methods described in Section 2.1.4. This list of data sources will be a starting point for identifying data needed for the MVI. Where there are gaps in the data needed to for each of the desired factors, or where data sources are not available at the municipal level, these gaps will be identified in this process and attempts will be made to close each gap. Table 7 in Appendix A shows the 68 unique data sources ERG was able to identify, as well as the variables associated with each data source. For each data source, the table indicates the variables captured, geographic scale, and associated tool.

As shown in Table 7 in Appendix A, these data sources are at the census tract, municipal, county, state, and custom geographic levels. Given that the MVI is focused on the municipal level, the focus will be on finer grained data, such as census tract data, municipal data, or data from custom geographic levels will be preferable for tool development. Data sources with custom geographic levels include both individual locations or point data (e.g., mobile home parks, historic sites) or geographic layers or polygon data (e.g., flood zones, ecosystem regions). Additional processing will be required to merge these data into municipal-level observations. Generally, these data sources include:

- Natural environment data, such as forested areas or river locations.
- Transportation infrastructure, including locations of roads, bridges, and culverts.
- Natural hazard data, such as locations of landslides or regions with elevated flood risk.

Other key takeaways from the review of data sources include:

- Several tools identified were developed for other geographic regions, and their data sources do not include any observations in Vermont. We include these data because they may still help identify data needs within Vermont, as well as useful inputs and outputs, user interface, design, and other features of the MVI tool.
- Not all tools listed data sources. The following tools did not provide sources for a significant portion of the information provided by the tool:
  - Department of Housing and Community Development Planning Atlas
  - Flood Ready Atlas
  - Vermont Natural Resource Atlas
  - Climate Vulnerability in Greater Boston (for socioeconomic factors)
- Some tools conducted complex calculations to process data sources into a risk index. When these processed data products are available, the MVI may use the tool outputs or link to these tools rather than the original data sources to avoid duplicating work from other applications. These tools include:
  - Transportation Flood Resilience Planning Tool (can download maps with calculated flood risk)
  - VT BioFinder (can download maps with expert labeling of ecological zones and wildlife connection)
- Data underlying the tools is largely from publicly available data sources (e.g., state and federal data sets).

Data Gaps and Limitations

The review of existing tools identified data and information related to most of the domains of interest (see 2.1.1 for information on domains). Table 8 in Appendix B shows examples of factors for each domain for several of the most relevant tools identified.

Figure 6 shows the number of variables identified by each tool and how many of these variables are associated with each domain. This figure only includes variables for which a data source was identified. Several tools only had one variable with an identified data source. These tools are grouped under the "Other" category.

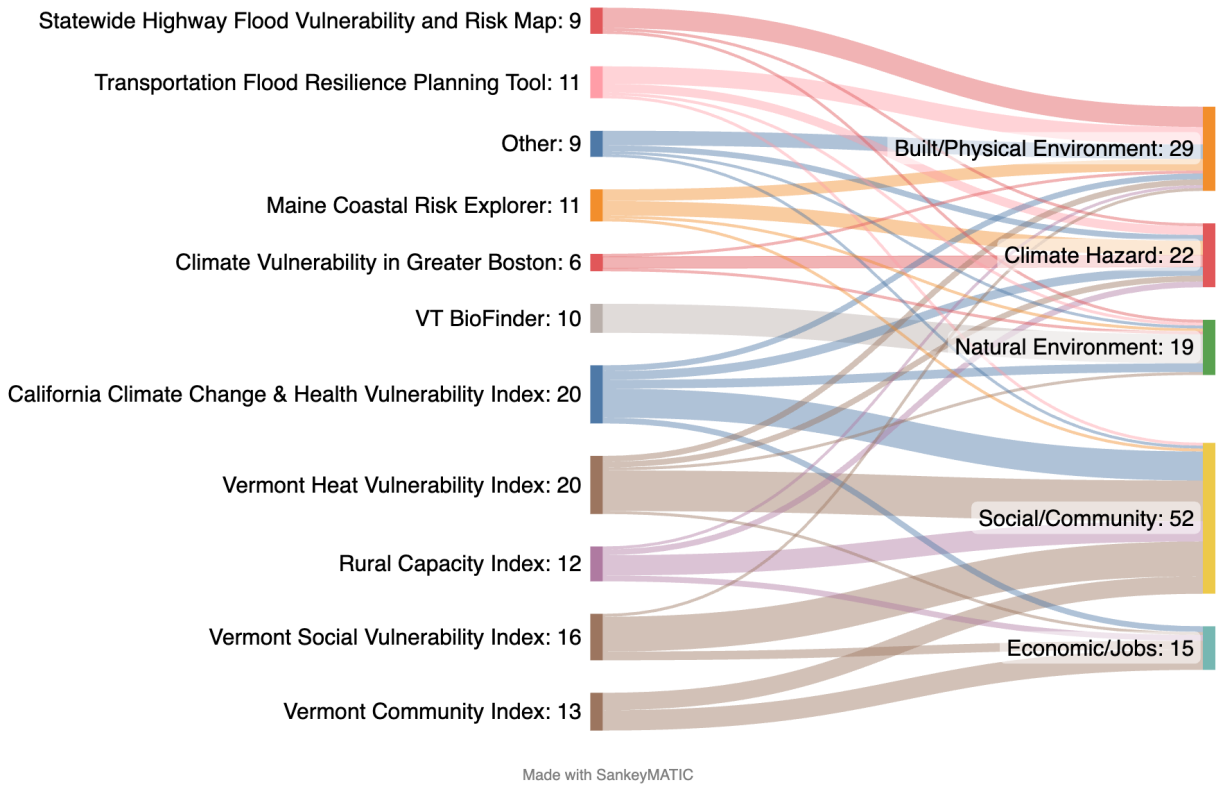


Figure 6. Flow of variables from reviewed tools to domains.

As illustrated above, not all tools provide information related to each domain. As to be expected with a tool such as the MVI, its design and development will include multiple data sources. Based on this initial review, the following data gaps and limitations of existing tools were identified in the evaluation.

General (limitation)

- Data may not be at the geospatial scale needed for all factors that are incorporated into the MVI.
- Data quality for socioeconomic indicators can be worse for rural communities (Headwaters Economics, 2022).

Built/Physical Environment (data gap)

- Vermont-specific data that maps energy distribution networks for the state.[5]
- Locations of vulnerable critical infrastructure (including energy infrastructure, drinking and wastewater infrastructure, stormwater infrastructure,[6] communications infrastructure, emergency services, and housing[7]).
- Tools or data that map or provide information on impervious surfaces.

Economic (data gap)

- Data on natural resource jobs and small businesses.[8]
- Costs associated with repetitive loss.

Hazards (data gap and limitation)

- Vermont specific data on natural hazards beyond flooding and landslides.
- Data on climate projections and rising temperatures.

Social/Community (data gap and limitation)

- Location of emergency service facilities.
- Data on providing emergency service to help understand how quickly a community can respond to an event.
- Only communities with active or expired emergency response plans were identified.

2.1.4 Index Development Methods

Climate vulnerability indices are often developed by weighting and/or scoring the factors that contribute to climate vulnerability. This section provides an overview of the methods used to develop indices in the tools reviewed. By better understanding the methods used in tools relevant to the MVI, we can begin to establish the range of considerations for the framework development, including using weighting to prioritize certain issues such as equity and just transition and how the MVI tool could be designed to be compatible with other Vermont tools.

Five of the 21 tools reviewed provided transparent and detailed information about the methods used to score and/or weight their vulnerability indicators. These tools include:

- Vermont Social Vulnerability Index
- California Climate Change & Health Vulnerability Index
- Climate Vulnerability in Greater Boston

[5] This information may be available from the Vermont Electric Power Company (VELCO). We will request mapping data from VELCO.

[6] Based on the Vermont Department of Environmental Conservation, the majority (but not all) of Vermont census tracts have stormwater infrastructure mapped (see Clean Water Initiative Program Stormwater Infrastructure Map).

[7] Affordable housing and mobile homes may be particularly important when considering people who might be most vulnerable to climate change impacts. Census data can provide information at the tract level on the number of mobile homes in an area. The Vermont Housing Finance Agency provides a database on affordable rental housing properties in Vermont.

[8] Small businesses may be particularly vulnerable to impacts from climate change if they are less able to bounce back after an unexpected closure (e.g., a closure due to flooding).

- Maine Coastal Risk Explorer
- Rural Capacity Index

The methods used by these tools are described below.

Vermont Social Vulnerability Index

The Vermont Social Vulnerability Index (SVI) is an equity tool based on the top measures of social vulnerability for each census tract. More specifically, as described in tool's user guide,[9] the index:

- Uses 16 measures of social vulnerability from the U.S. Census American Community Survey five-year estimates for Vermont census tracts that span topics including poverty, unemployment, health insurance, demographics (e.g., minority and elderly populations), disability, English proficiency, housing, and transportation. See Appendix C for a full list of measures included in the index.
- Ranks each measure and flags the 10 percent of census tracts that are most socially vulnerable for each measure. The SVI is based on the count of the flagged measures in each census tract.
- Each SVI measure map is displayed with six classes of data. These six classes are broken into quantiles, meaning each class has the same number of census tracts. In this way, the three lower classes of data are below the state median and the three higher classes of data are above the state median.
- The SVI theme composite maps are broken into five or six categories corresponding to their maximum possible number of flags, and each class is defined by a single number.
  The final SVI index is broken in to six classes by quantile. However, since there are only 11 possible values between zero and 10, some classes have more tracts than others.

Key Takeaways and Considerations

Key takeaways and considerations after reviewing methods used to develop the SVI include:

- The tool is highly relevant to the MVI, and it could be advantageous to adopt a similar index that scores and weighs methods to easily integrate the information between the SVI and MVI.
- We will need to consider all factors used to determine climate vulnerability in the MVI and determine whether the methods used to develop the SVI allow for the array of data types that we will need to incorporate.

California Climate Change & Health Vulnerability Index

The California Climate Change & Health Vulnerability Index (CCHVIz) assesses climate and health vulnerability by looking at the intersection of selected exposure (e.g., projected number of extreme heats days) and sensitivity indicators (e.g., percent of population under the age of five).[10] For a given county, the tool pulls in values for the selected exposure and sensitivity indicator and then considers the combination of those two values to determine the county's climate and health vulnerability relative to other counties for that same exposure–sensitivity combination. For example, a county with a high

[9] https://www.healthvermont.gov/sites/default/files/documents/2016/12/ENV_EPHT_SocialVulnerabilityIndex.pdf

[10] https://skylab.cdph.ca.gov/CCHVIz/

number of extreme heat days and a high number of children under the age of five has a higher combined vulnerability than a county with a low number of extreme heats days and a high number of children under the age of five. Based on the combined exposure–sensitivity, counties are assigned to the bottom (least), middle, or top (most) third for both exposure and sensitivity (California Department of Public Health, 2023).

Key Takeaways and Considerations

Key takeaways and considerations after reviewing methods used to develop the CCHVIz include:

- The CCHVIz determines and presents climate and health vulnerability using one exposure–sensitivity combination at a time. This approach can be discussed within a broader conversation about the MVI framework and methods that considers how the tool will both be multi-hazard and provide a way to understand the cumulative risk of all hazards across social, health, economic, and environmental domains.
- The CCHVIz is a county-based tool. Developing this type of exposure–sensitivity tool at the town or census tract level may present other data considerations or limitations, such as how useful this type of output would be for MVI users and how the outputs might be displayed in a manner that is meaningful and useable for tool users.

Climate Vulnerability in Greater Boston

The climate vulnerability index for the Climate Vulnerability in Greater Boston is derived from an average of three separate indices measuring sensitivity, exposure, and adaptive capacity. Each of these indices uses quantitative, demographic data to determine which communities are at higher risk based on housing style and age, socioeconomic status, impervious surfaces, and demographic data such as age and disability. At a more granular level, the index underlying the tool was developed using the following steps outlined in the tool's technical documentation:[11]

- "The index categorizes variables as exposure, sensitivity, or adaptive capacity indicators, which are further subcategorized by hazard, such as extreme heat and flood (both current and future surge).
- Hazard- and climate-specific vulnerability indices were constructed using relevant indicators.
- All variables were then rescaled using min-max scaling across all Metropolitan Area Planning Council census tracts, such that the highest value for a given variable is rescaled to 1, the lowest value rescaled to 0, and all other values rescaled within that range.
- For indicators that have an inverse association with vulnerability (e.g., higher household income makes a household less sensitive to climate events), the values were inverted in order to keep the interpretation of vulnerability scores consistent.
- After min-max rescaling of the individual variables, the arithmetic mean of a given index (e.g., sensitivity) was calculated for each census tract by summing the rescaled values for all indicators in the index and dividing by the total number of variables for that index."

[11] https://climate-vulnerability.mapc.org/assets/data/MAPC_ClimateVulnerability_Technical-Documentation_2019-12-10.pdf

The final extreme heat and current flood vulnerability index values for each census tract was developed by summing the exposure, sensitivity, and adaptive capacity index values for a given census tract and dividing by three (for each of the indices developed), followed by a final round of min-max scaling (as described above).[11]

Key Takeaways and Considerations

Key takeaways and considerations after reviewing methods used to develop the Climate Vulnerability in Greater Boston index include:

- The three indices incorporated into this tool—sensitivity, exposure, and adaptive capacity—could provide a helpful way to think about the dimensions of the MVI tool.
- This tool provides an example of how to integrate multiple indices into a single platform, which is needed to develop the MVI. However, each of the three indices included in the Greater Boston tool were all developed using a similar scale; therefore, we would need to consider the index scales of the data that will be included in the MVI. An approach that allows for integration of data across different scales will likely be needed for the MVI.

Maine Coastal Risk Explorer

The Maine Coastal Risk Explorer uses a percentile ranking of vulnerability based on 17 socioeconomic and demographic factors to develop its social vulnerability index.[12] It compares census block groups and in certain cases county subunits along Maine's coast (Johnson et al., 2018). The index is modified from the Center for Disease Control and Prevention's Social Vulnerability Index developed by Flanagan et al. (2011). Flanagan et al. (2011) construct their index using two approaches: percentile ranking and counts of variables with percentile ranks of 90 or higher, as described below.

Percentile Ranking

- Each census variable was ranked from highest to lowest across all census tracts, except per capita income, as a higher value indicates less vulnerability.
- A percentile rank[13] was then calculated for all variables, each domain (i.e., socioeconomic status, household composition and disability, minority status and language, and housing and transportation), and the overall social vulnerability index using the formula

  Percentile Rank = (Rank-1) / (N-1)

  where N = the total number of data points, and all sequences of ties are assigned the smallest of the corresponding ranks (Flanagan *et al.*, 2011, p. 9).
- The tract-level percentile rank was based on an across-the-board sum of the percentile ranks of the variables comprising that domain, and the overall percentile rank for each tract was calculated as the sum of the domain percentile rankings (Flanagan et al., 2011, p. 9).

[12] https://storymaps.arcgis.com/stories/7dac7a0b55bd4ca0b6087e48bd4f5ebd

[13] A percentile rank is defined as the proportion of scores in a distribution that a specific score is greater than or equal to (Flanagan *et al.*, 2011, p. 9).

Counts of Variables with Percentile Ranks of 90 or Higher

The number of individual variables with percentile ranks of 90 or higher for each of the domains (socioeconomic status, household composition and disability, minority status and language, and housing and transportation) and for the tract overall were "flagged." The flagging approach "highlights instances where a census tract may have a high SVI but few flags, indicating that the vulnerable population is due to a high percentile in at least one demographic variable, yet their overall social vulnerability scores are masked because of averaging with low percentiles in other demographic variables" (Flanagan *et al.*, 2011, p. 9).

Key Takeaways and Considerations

Key takeaways and considerations after reviewing methods used to develop the Maine Coastal Explorer and corresponding vulnerability index include:

- The tool uses similar methods to those used in the Vermont SVI, and there may be opportunities to leverage the type of data and index developed for Maine and integrate them with the SVI for use in the MVI. Integrating hazard exposure with social vulnerability, for example, will be needed to assess climate vulnerability and will require the integration of data on hazard, climate, and social vulnerabilities.
- The Maine tool uses data at the census block level rather than those at the census tract level used in the Vermont SVI. When considering the data available for the MVI, and the level of data granularity available, the Maine tool and methods provide perspective on using census block data in index development.

Rural Capacity Index

The Rural Capacity Index incorporates a set of 10 indicators aimed at estimating community capacity by incorporating factors based on metrics related to local government staffing, community education and engagement, and socioeconomic trends. Seven indicators are normalized on a scale of 0–100, and three binary indicators are assigned either 0 or 100. The final index is calculated as the sum of all indicators. The index is then mapped and overlaid with maps of wildfire risk and flooding to highlight areas with low capacity and high risk of flooding or wildfires.[14]

In reviewing the methods factsheet, there were several limitations stated that are worth noting (pg. 2, Headwaters Economics, 2022):

- It is difficult to measure some indicators of capacity, such as strength of relationships within a community.
- Data are missing for some communities.
- Data quality for socioeconomic indicators can be worse for rural communities.

Key Takeaways and Considerations

Key takeaways and considerations after reviewing methods used to develop the Rural Capacity Index include:

[14] https://headwaterseconomics.org/wp-content/uploads/2022HE-RuralCapacityIndexBrief.pdf

- In considering the types of factors for inclusion in the MVI, it is important to consider how each factor will be measured and whether sufficient data for that measurement occur at the scale needed to inform a municipal-level index.
- The way that the tool overlays the rural vulnerability index with other natural hazard map layers provides one option for presenting such information in the MVI.

2.1.5 Outputs

The tools reviewed provide a variety of outputs. Some tools consist of a database of information with no mapping ability (e.g., Historic Preservation Online Resource Center, Mobile Home Park Registry), while others include a database with a mapping component (e.g., Landslide Hazard Mapping, Natural Resources Atlas, Vermont Commercial/Industrial Site Locator). The list below identifies which tools may have useful outputs to consider incorporating into the MVI framework. The list is subdivided into the three key domains that are often used in a range of social and climate vulnerability indices:

Hazard and Asset Exposure and Risk

- Flood Ready Atlas, which determines flood risk of a community.
- Landslide Hazard Mapping, which identifies locations at high risk of landslides.
- Vermont Transportation Flood Resilience Planning Tool, which provides data on the transportation infrastructure that is critical, vulnerable, and at-risk of damages from flood inundation, erosion, or deposition hazards.

Vulnerability

- Vermont SVI, which identified vulnerability of a community, equity and social justice considerations, and disproportionate impacts.

Resilience

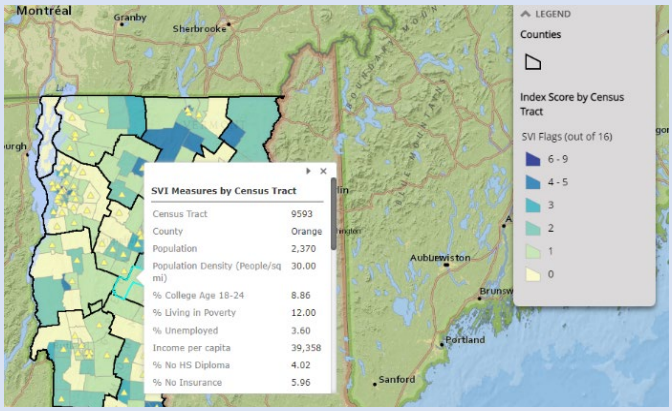
- Rural Capacity Index, which identified adaptive capacity of a community, equity and social justice considerations, and disproportionate impacts.

The review of existing indices and tools provides information on the range of possible outputs for the MVI. Issues to consider when determining the outputs for the MVI include audiences, use cases, and outputs from similar tools in Vermont and alignment and support amongst the tools and data. The audience, uses and tool alignment will inform both the output and the design and presentation of the outputs to ensure value for users. The remainder of this section focuses on the types of outputs of geospatial mapping tools that were reviewed and how this review informs the MVI. The types of outputs to include in the MVI will be based on existing tool review and engagement with key partners to determine the needs and objectives of future MVI tool users including municipal, regional, state, and NGOs and community organizations. The following tools were reviewed and evaluated for how their outputs inform MVI design and development.

- Vermont Social Vulnerability Index
- BioFinder
- Transportation Resilience Planning Tool
- California Climate Change & Health Vulnerability Index
- Climate Vulnerability in Greater Boston
- Rural Capacity Index

All the above tools have an output that includes a geospatial mapping of vulnerability. Some of these tools include color-coded mapping outputs of an index for geographic regions (e.g., Vermont SVI), while others provide a high/medium/low ranking for vulnerabilities related to specific locations (e.g., Transportation Resilience Planning Tool). Some tools provide a percentile ranking comparison (e.g., Rural Capacity Index), which gives a description of what percentile the region is compared to all other regions (e.g., 67 percent of locations have higher capacity). The outputs of each of these tools are reviewed in more detail in Table 4 below.

Table 4. Outputs of example tools reviewed.

Vermont Social Vulnerability Index
Output type: A count (0–16) of the number of vulnerability measures above the 90th percentile. **Does it incorporate outputs of other tools reviewed?** No, the SVI does not include outputs from any of the tools reviewed. **Does it have graphs/charts to support data interpretation?** The SVI provides information at the census tract level on the 16 vulnerability measures it considers. It also provides a chart that shows the vulnerability percentiles of each of the 16 vulnerabilities. **Does it provide an explanation of how to interpret the output?** The tool includes a brief explanation of how the SVI was calculated. Links are provided for users interested in reading more about how the SVI components were calculated. **How are the outputs used (for what purpose)?** The SVI is intended as a planning tool to help understand areas of Vermont at greatest risk. It can be used in the event of an emergency (natural or human-caused) to identify populations that may need additional help.    **Figure 7. The SVI provides a count of the vulnerability measures (1–16) and provides a chart that shows the vulnerability percentiles of each of the 16 vulnerabilities for the census tract selected.**
BioFinder
Output type: Geospatial map output of priority areas for conservation, including what type of ecological features are the highest priority. **Does it incorporate outputs of other tools reviewed?** Yes, BioFinder includes the Vermont SVI as a geospatial data layer that can be overlayed with the other layers in the tool. **Does it have graphs/charts to support data interpretation?** No, BioFinder does not provide additional outputs beyond a geospatial map. It does, however, allow different map layers to be overlayed on each other. For example, a user can view conservation priority areas and the SVI of Vermont census tracts at the same time. **Does it provide an explanation of how to interpret the output?** Though there is not a thorough explanation of how to interpret the results within the tool itself, there is a detailed explanation of how to interpret the results of BioFinder on a separate webpage.

How are the outputs used (for what purpose)? BioFinder can help municipal and regional planners identify areas that are most critical to conserve. The tool helps developers, scientists, planners, educators, and others understand the richness and distribution of biological diversity throughout Vermont. It can help identify ecologically important locations and can also be used in climate work to determine the biological areas at greater risk or disproportionate risk. It can be used to support landscape-scale decisions regarding conservation, restoration, and management of lands for mitigation and adaptation purposes, including identifying possible transition zones, buffers, and corridors for climate migration of plant and animal species. The tool can also be used to identify possible risk reduction and community benefit opportunities to address heat islands, flooding, and wildfires. When used in conjunction with socioeconomic data, such as from the SVI, assessments can be conducted to identify opportunities and challenges with conservation decisions, including specific considerations for their impact on disadvantaged communities.

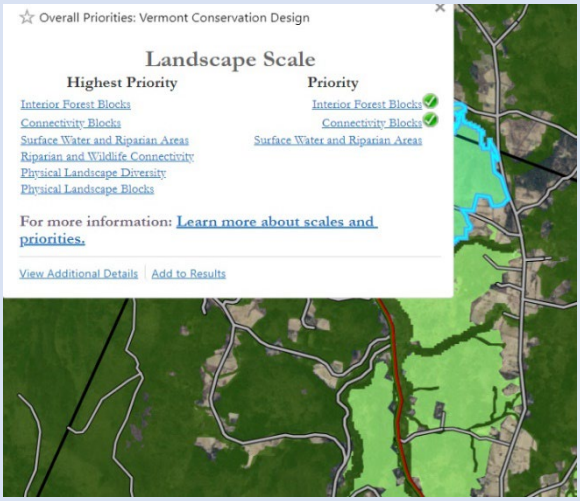


Figure 8. BioFinder allows users to overlay conservation priority areas with the Vermont SVI. An explanation of how to interpret the data is provided on a separate webpage.

Vermont Transportation Flood Resilience Planning Tool (TRPT)

Output type: High/medium/low ranking.

Does the tool import or link to other tools? No, the TRPT does not import or link to any of the tools reviewed.

Does it have graphs/charts to support data interpretation? Yes, the TRPT allows the user to view the risk, criticality, and vulnerability of the infrastructure graphically or in a tabular format.

Does it provide an explanation of how to interpret the output? Though there is not a thorough explanation of how to interpret the results within the tool itself, there is a TRPT User Guide that provides information on how vulnerability, criticality, and risk are determined.

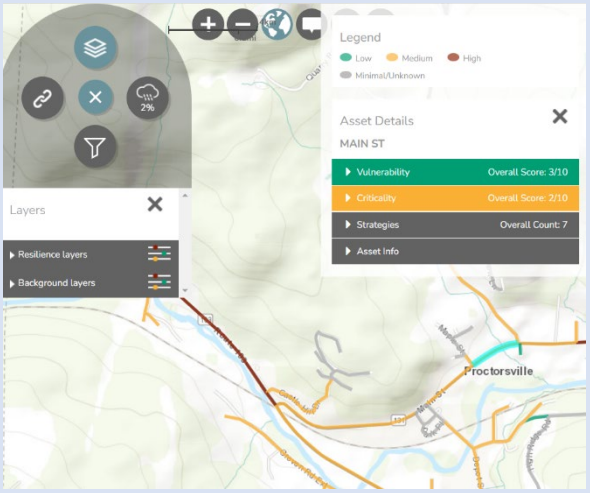


Figure 9. The TRPT provides a high/medium/low ranking of the asset's risk.

How are the outputs used (for what purpose)? The TRPT can be used to inform project scoping, capital programming, and hazard mitigation and climate adaptation planning for state and local highways, including project prioritization, budgeting, resource allocation, and asset management. Its purpose is to identify roadway vulnerabilities to avoid or mitigate against the impacts of current and future risks in order to reduce damage and disruption (specifically from flood inundation, erosion, or deposition hazards) in the most critical, high-risk locations. The tool is intended for planning purposes only—findings must be confirmed in the field prior to selecting a preferred alternative, initiating design, or seeking project funding. The primary user groups of the TRPT are VTrans, the Vermont Department of Environmental Conservation, regional planning commissions, and Vermont Emergency Management (including their hazard mitigation grant program project coordinator).

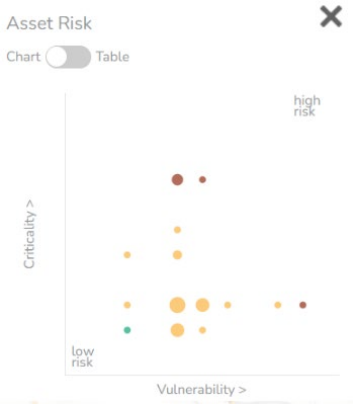


Figure 10. The TRPT provides the option to view asset risk through a graphical (shown here) and tabular format.

California Climate Change & Health Vulnerability Index (CCHVIz)

Output type: Geospatial output of the percentile ranking for selected vulnerability factors.

Does the tool import or link to other reviewed? No, the CCHVIz does not import or link to any of the tools reviewed.

Does it have graphs/charts to support data interpretation? Yes, the CCHVIz provides charts to compare the vulnerability indicator for a county compared to the state average. Charts also help users understand the differences by race for the selected indicator. These charts can be used to identify which indicators may be of greatest concern in the county. Charts also show the vulnerability of a county based on the exposure and sensitivity of a demographic to a specific hazard.

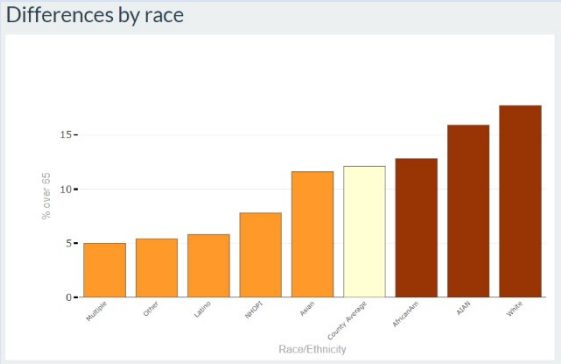


Figure 11. The CCHVIz allows users to explore vulnerability indicators by race to identify if there are particularly vulnerable populations.

Does it provide an explanation of how to interpret the output? Yes, explanations are provided within the tool to help the user understand how to interpret the maps and charts displayed.

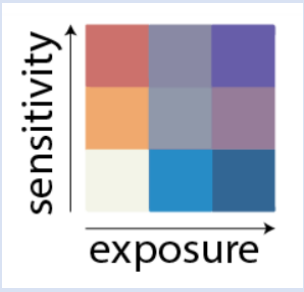


Figure 12. The CCHVIz includes graphics to help users understand the vulnerability of a county based on its exposure to a hazard and the percent of the population that may be particularly vulnerable to that hazard.

How are the outputs used (for what purpose)? The tool is intended to help users identify the people and places that are most vulnerable and susceptible to negative health impacts associated with climate change. Local and state programs within California are using the indicators to assess vulnerability, identify resources and actions to reduce risks, and increase the resilience of communities most at risk from current and future hazards of climate change. The tool can be used to identify disproportionate impacts and highlight potential equity and justice issues. This information can help direct resources and prioritize project implementation to reduce risks to those who are most vulnerable.

Climate Vulnerability in Greater Boston

Output type: Scale of 1–5 (extremely low vulnerability to extremely high vulnerability).

Does the tool import or link to other tools reviewed? No, it does not import or link to any of the tools reviewed.

Does it have graphs/charts to support data interpretation? Yes, this tool provides a chart showing the value of each factor included in calculating the index (exposure, sensitivity, and adaptive capacity). The user can also view the percentile rank of each of the indicators included in the index calculation.

Does it provide an explanation of how to interpret the output? The tool is accessible as part of a larger webpage. The webpage that houses the tool does provide context for how to interpret results.

How are the outputs used (for what purpose)? The tool is intended to help users identify populations that should be centered in climate preparedness and resilience work due to their increased vulnerability.

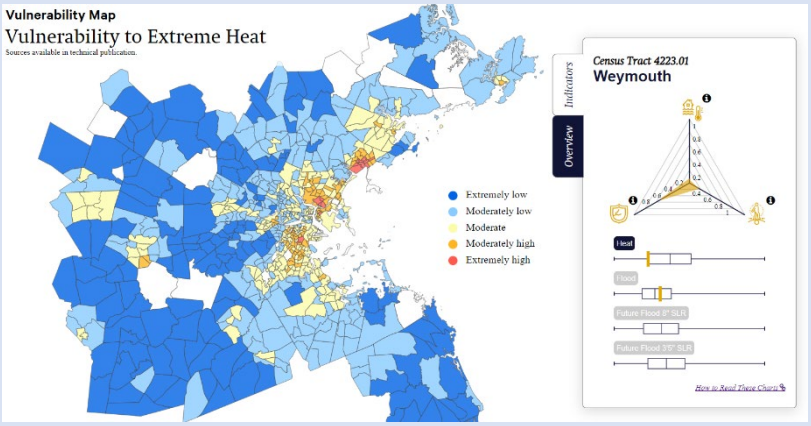


Figure 13. The Climate Vulnerability in Great Boston tool provides a vulnerability measure of extremely low to extremely high for each census tract. Charts are provided to support data interpretation.

Rural Capacity Index

Output type: Rural capacity index score (0–100) and percentile ranking of the rural capacity index score.

Does the tool import or link to other tools reviewed? No, it does not import or link to any of the tools reviewed.

Does it have graphs/charts to support data interpretation? This tool does not provide graphs or charts to support data interpretation, but it does clearly and transparently provide the value of each variable considered in the index.

Does it provide an explanation of how to interpret the output? The tool is accessible as part of a larger webpage. The webpage that houses the tool does provide context for how to use the Rural Capacity Index.

How are the outputs used (for what purpose)? The Rural Capacity Index is intended to be used by federal and state agencies to invest in communities that lack capacity to address issues such as climate change, hazard mitigation, equity, and economic disadvantage without targeted resource investment. Communities can also use the tool to advocate for resources.

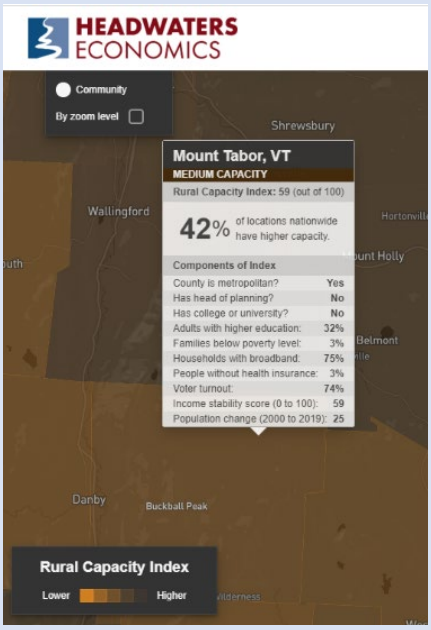


Figure 14. The Rural Capacity Index provides an index score on a 0-100 scale, and a percentile ranking of the index score for the selected location.

Based on the outputs of the relevant tools described in Table 4 above, we developed considerations for the development of the MVI as presented below.

Key Takeaways and Considerations

Consideration based on the review of existing tool outputs include:

- The outputs of reviewed tools provide a range of options in terms of vulnerability ranking, score, or identification (e.g., high/medium/low rankings, percentile ranks, index score of 0–100). The relevant outputs for the MVI tool will be identified based on considering the main objective and purpose of the tool, what is most useful for end users, data availability, and alignment with other Vermont tools. Input received during the engagement process will be key to inform audiences and desired outputs.
- The simplicity and clarity of tool outputs must be considered, including how maps, charts and figures, and narrative explanations can support understanding and communication of the analysis being conducted by the tool and the findings resulting from the analysis.
- Some of the tools reviewed include a relative ranking of geographic areas for issues such as social, climate, and other types of vulnerabilities to risks. Whether Vermont wants to rank areas within the state as more or less vulnerable based on ranking them with other areas of Vermont is worth considering. Other approaches include providing tool outputs that describe the climate vulnerabilities to each area and the underlying causes, independent of the other areas of the state.

2.1.6 Design

Another important consideration in the development of the MVI is the look and feel and overall design of the tool. Design can invite and encourage broad use or discourage potential users from engagement with the tool. This section describes findings on the design of the tools reviewed, including tool appearance, function, and ease of use. Each of these design aspects is described further below.

Design and Appearance

When reviewing the existing tools and data sets, issues that were considered included design, layout, readability, flow between screens, and other features of each tool and questions such as: Is the tool straightforward and intuitive to use? Is the interface visually pleasing and informative? What influences a database or tool's visual appeal? To ensure the MVI is useful to and used by a broad audience, these issues are important factors to consider when designing the Vermont MVI tool.

Examples of tools that scored high on design, layout, ease of use, and other features are described in more detail below.

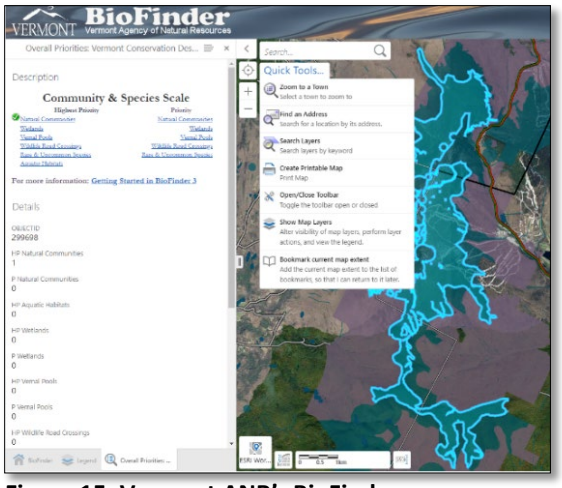


Figure 15. Vermont ANR's BioFinder.

BioFinder

- Map provides the ability to show layers or a legend when exploring the data.
- Map provides a bird's eye view of the layers a user has chosen and then provides additional layers or outlines on a finer scale if the user seeks additional information.
- Layers are clearly defined with contrasting colors to clearly communicate the data.
- When data is selected, there is always an option to "View Additional Details" providing background information on the geospatial layers, selected area, and other data.

Maine Coastal Risk Explorer

- Tool presents conservation opportunities in three areas:
  - Future Habitat Explorer, which predicts tidal marsh expansion with rising seas, informing coastal protection decisions.
  - Aquatic Barrier Prioritization tool, which helps identify fish passage restoration projects in Maine.
  - Coastal Risk Explorer, which helps communities plan for sea level rise by identifying roads that may be flooded and inaccessible in an emergency.

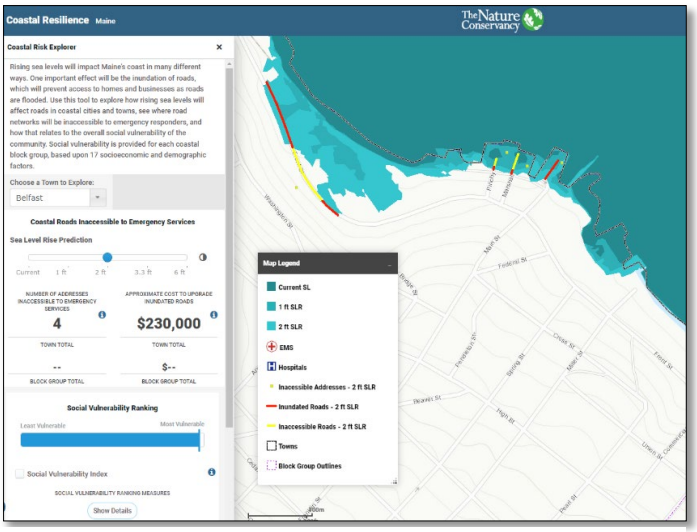


Figure 16. The Nature Conservancy's Maine Coastal Risk Explorer.

- Map is visually pleasing and easy to understand, without needing to click through multiple sections to understand the legend.
- Provides multiple sea level rise scenarios (up to 6 feet of sea level rise) in one map without overcrowding the image.

- By splitting three different maps (future habitat, aquatic barrier prioritization, and coastal risk) into separate tabs, each map remains simple and easy to use without the user being overwhelmed by data. However, there are options to incorporate the maps as multiple layers if a user desires.

Vermont Transportation Flood Resilience Planning Tool

- Home page provides a user guide, background on the content of the tool, and intended use and audience for the tool.
- Upon entering the tool, users can choose a river basin to automatically zoom to.
- Flood risk is illustrated with highly contrasted colors and an easy-to-understand legend.

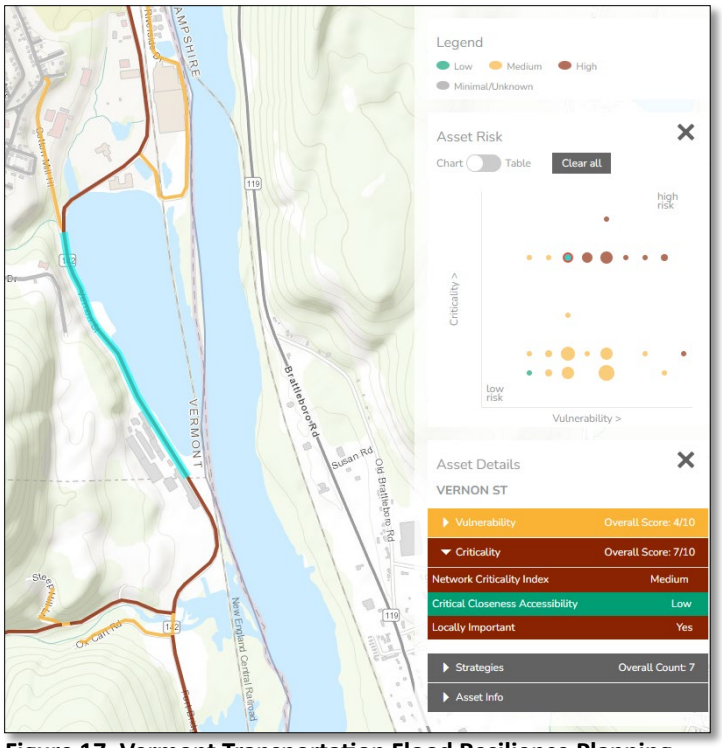


Figure 17. Vermont Transportation Flood Resilience Planning Tool.

- Legend provides the option to understand asset risk via a color-coded graph or a table.
- Users can click anywhere on the map and automatically get a reading of vulnerability, criticality, and strategies to reduce flood risk for the chosen area.

Key Functions

The tools reviewed provide a range of key functions to help users collect, analyze, understand, and explore data. Fourteen of the 16 tools provide geospatial information in map form, with keys and descriptions to provide both qualitative and quantitative information on the data presented in the maps. Additional key functions of the tools reviewed include:

- Option to download maps or data as Shapefiles, KML, CSV, or GeoJSON files.
- Ability to hover over or click on data regions (e.g., counties) to see relevant information.
- Capability to select or query specific geographic units (e.g., county, state), hazards, or types of vulnerabilities.
- Ability to easily stack multiple data layers on the map to assess multiple factors at once.
- Ability to zoom in and out of content.
- Inclusion of climate projections or scenarios.
- Availability of graphs or tables in the key to help users understand vulnerability or risk.
- Ability for users to manipulate or select map layers.
- Options to select different base maps.
- Public user interfaces.
- Use of color coding in addition to map and data outputs to indicate vulnerability.

- User guides.

Ease of Use

A tool that is well designed and has an easy-to-understand interface is important not only so users can quickly find information, but also so that information is efficiently and effectively communicated to the intended audience. No matter the intention of the tool and how useful its data and information, if the tool is difficult use or hard to understand or explain, its outputs will likely not be used in assessments planning and plan development, engagement with others on the issues included in the tool, to inform decision-making, or to advance the understanding of, and progress on, the issues.

Some key features that facilitate a successful user experience of geospatial tools include:

- Keys to provide context and clarification of illustrations, maps, and use of different colors or symbols.
- User guide that is presented on the home page or is otherwise easy to find on the map or data page. A very useful feature is a recorded training that walks potential users through the tool to explain the features and functions. Recordings can make it more likely that users are able to take full advantage of the features a tool includes.
- Ability to manipulate data layers to support multiple uses (e.g., climate risk and vulnerability assessments, grantmaking, land use and infrastructure planning, equity and environmental justice (EJ) assessments, identification of patterns of risk or opportunity at broader scales such as watershed planning or natural and working lands planning).
- Fast loading times to help users quickly access results.
- Regular updating and maintenance of data, maps, and other features of the tool.
- A help desk or support number to call or email if users have difficulty with the tool, find an error, or otherwise need assistance or would like to provide information relevant to the tool.
- Clearly noted data sources that support tool outputs so users have a comprehensive understanding of the outputs and can cite them when using them in reports, presentations, assessments, findings, and decision-making.

Examples of easy-to-use tools, based on ERG's review of 22 tools, include:

- **BioFinder.** Users can open the "Quick Tools" tab to save the current map extent, search layers or addresses, create printable maps, and more. Having this feature easily accessible in the tool makes it fast and simple for users to zoom to the area they're looking for and save or print their map of interest. The BioFinder home page also provides the following guides to enhance users experience:
  - Using BioFinder, which suggests a process for how to use the tool.
  - Interpreting Results, which provides guidance for getting the most out of BioFinder research.
  - Creating BioFinder and Vermont Conservation Design, which explains the science and methods behind the data presented in BioFinder.

  - Mapping Vermont's Natural Heritage, a guidebook that describes the data sets in BioFinder, interprets them, and reviews different strategies for conserving important ecological features.
  - Webinars & Trainings, which introduces users to BioFinder and other topics in conservation science and land use planning.
  - Resources, which provides archived webinars, download handouts, and access other BioFinder materials.

- **Maine Coastal Risk Explorer.** This tool helps identify conservation opportunities in three different areas: future habitat, aquatic barriers, and coastal risk. These three areas are mapped separately (e.g., on different pages). However, users can also merge all three elements to gain a more comprehensive understanding of sea level rise and associated changes, vulnerabilities, and risks. The Coastal Risk Explorer also has a "tour" feature, which walks users through the mapping page and its different features by pointing out different elements of the tool and providing a description of its capabilities and how to manipulate them.

2.2 Next Steps

Based on the findings from reviewing and assessing existing tools, ERG anticipates the following next steps:

- Identify and review datasets (including those suggested by the MVI task group[15]) needed to support the tool's development to:
  - Determine data availability and limitations.
  - Highlight any gaps between desired factors and data availability.
  - Understand the role of scale.
- Refine and revise draft purpose of the MVI tool through engagement and further discussion with the MVI task group and the project management team, and confirm required factors and datasets based on the finalization of the MVI tool purpose.
- Refine and revise the audiences of the tool through engagement and further discussion with the MVI task group and project management team.
- Engage with key MVI tool partners to inform the design, outputs, functions, and other features of the tool.

The next section of the report (Section 3) describes the MVI tool engagement process that ERG conducted to build upon the evaluation of existing tools and further inform the development of the MVI tool and methods.

[15] Additional datasets suggested by the task group include the Emergency Relief Assistance Fund (dataset) and Vermont Communities Index (dataset). Additional tools suggested by the task group were reviewed and integrated into this final report.

3 Municipal Vulnerability Index Tool Engagement

Building upon the findings from the evaluation of existing tools (Section 2), ERG conducted engagement efforts to further inform the development of the MVI framework and methods. The aim of the engagement efforts was to give participants the opportunity provide input on the approach for defining the vulnerability tool, ensure tool outputs meet the needs of tool users, confirm or modify the findings from the evaluation of existing tools, and identify the types of data and information that would be most useful for them. This report section is organized as follows:

- Section 3.1 describes the identification and selection of participants, including the key groups and their representatives.
- Section 3.3 provides an overview of the engagement methods used.
- Section 3.4 provides the key themes and takeaways resulting from engagement efforts.
- Section 3.5 includes considerations and recommendations for how the engagement findings should translate into further MVI method and tool development.

3.1 Participant Identification

ERG worked with the VT state team and MVI task group to determine the key groups for engagement prior to developing the tool's framework and methods. Through a series of conversations with the VT state team and input from the MVI task group, we identified the following groups:

- **MVI tool users.** Primary end users of the MVI tool, including municipalities, regional planning commissions (RPCs), and utilities.
- **Affected populations.** Populations that may experience disproportionate impacts from climate change based on characteristics such as race, ethnicity, age, income, education, and geographic location. Engagement included representatives of organizations serving or working with these populations.
- **MVI tool partners.** Entities whose work is parallel to, or overlaps with, the MVI tool where there is a need to align efforts.
- **Vermont State staff responsible for MVI tool design and maintenance.** Individuals working with the State of Vermont to assist in the tool's development and who are responsible for updating and maintaining the tool over time.

The scope of the engagement efforts across participant groups for this project included seven to 10 interviews and two larger online meetings. Due to the needs of the project and the importance of capturing participant needs, capacity, and perspectives on climate vulnerability, ERG and the VT state team decided to focus the engagement efforts on tool users and affected populations. Meetings with MVI tool partners and Vermont State staff are occurring throughout the project to discuss data availability, state capacities and needs, existing tool design and approach, and other key issues that require collaboration but are outside of the formal engagement process. Table 5 below shows the allocation of interview slots and online meetings across tool users and affected populations.

Table 5. Stakeholder interview and meeting slots by stakeholder group.

Engagement Slot	Stakeholder Group	Representative(s)
Interviews (9)		
1	Tool User	Brattleboro
2	Tool User	Bristol
3	Tool User	Newark
4	Tool User	Newfane
5	Tool User	South Burlington
6	Tool User	Vermont Departments of Public Service and Electric Utilities (GMP, WEC, VEC)
7	Affected Population	Champlain Valley Office of Economic Opportunity and Capstone Community Action
8	Affected Population	Natural Resource Conservation Districts
9	Affected Population	Community Resilience Organizations
Online Meetings (2)		
1	Tool Users	Municipalities
2	Tool Users	RPCs

3.1.1 Identification of Participant Group Representatives

Participant group representatives were identified through input and recommendations from the MVI task group as well as through outreach efforts conducted by the VT state team. The resulting group representatives are described below.

Affected Populations

A set of interviewees that represent or work with affected populations was developed through a review of engagement summaries from prior State efforts, input from the MVI task group and VT state team, and recommendations from organizations contacted during the outreach process. Three interviews emerged from this process and included representatives from:

- Champlain Valley Office of Economic Opportunity and Capstone Community Action
- Natural Resource Conservation Districts (NRCDs)[16]
- Community Resilience Organizations

Tool Users

Prior to conducting engagement efforts, the VT state team specified that the MVI is intended to be a municipal-level tool, with the primary user groups considered to be municipal staff and/or volunteers involved in planning, hazard mitigation, or climate efforts, as well as RPCs. RPCs are "political subdivisions of the State created by their member municipalities"[17] that act as a link between municipal affairs and state government and provide a range of technical assistance to municipalities around topics such as environmental quality, economic development, land use, transportation, and housing.[18] The MVI task group also recommended that the Vermont Department of Public Service and representatives from

[16] Participating NRCDs included: Caledonia County, Essex County, Lamoille County, and White River.

[17] 24 VSA § 4341

[18] https://www.vapda.org/

electric utilities be included in the engagement process, as utility agencies are considered to be an important end user of the tool as well as contributors of data and information.

Municipalities

Through outreach efforts and coordination with partners and MVI task group members, the VT state team suggested nine municipalities to reach out to for engagement and developed a spreadsheet to capture the following about each municipality:

- Municipality name
- Municipal characteristics, including:
  - Population
  - Whether they have paid planning staff
  - Whether it is rural or urban
  - County
  - Affiliated Regional Planning Commission
- Notes from the person recommending the municipality, such as vulnerabilities faced by the municipality (e.g., recent experience with flooding or other disasters, lack of access to clean water), perspectives that an associated staff person or volunteer might offer, and recent planning initiatives undertaken by the municipality, such as developing a local hazard mitigation plan or applying for FEMA funding.

The above information was used to develop the set of municipalities to include in the engagement process. Selections represent a distribution of municipalities across key characteristics and locations. Factors considered included municipal climate and social vulnerabilities or whether the municipality had engaged in hazard mitigation planning efforts. The resulting list of municipalities is presented in Table 6 below.

Table 6. Suggested municipalities for engagement.

Municipality	Population	Paid Staff? (Y/N)	Urban/Rural	County	RPC
South Burlington	20,282	Y	Urban	Chittenden	CCRPC
Brattleboro	12,046	Y	Urban	Windham	WRC
Bristol	3,782	Y	Rural	Addison	ACRPC
Newark	591	N	Rural	Caledonia	NVDA
Newfane	131	N	Rural	Windham	WRC

Regional Planning Commissions

The VT state team worked with The Vermont Association of Planning and Development Agencies to conduct outreach to the 11 RPCs in Vermont and request their participation in a municipal online meeting.

VT Department of Public Service and Utilities

The VT state team worked with a representative from the Vermont Department of Public Service (PSD) who also participates in the MVI task group to coordinate a group of up to five utilities representatives to participate in a group interview. Three utility companies were identified by PSD for inclusion in the conversation given their variation in size and the populations that they serve: Green Mountain Power, Vermont Electric Cooperative, Washington Electric Co-op.

3.2 Engagement Methods

ERG conducted nine interviews and two online meetings to engage municipalities, RPCs, and affected populations about the MVI tool. The sections that follow describe the methods for engaging these entities.

Figure 19 below shows the engagement by participant type presented in Table 5 and the MVI task group. As the figure shows, the majority of engagement occurs prior to the tool's framework development in order to inform data, information, user needs, alignment with other tools, social and climate vulnerability perceptions and experiences, and other issues needed prior to finalizing the tool framework and approach. Once the draft factors and framework have been established, an additional online meeting will be held with the MVI task group and individuals who participated in the MVI tool engagement process to provide an overview of the draft tool framework and discuss how the information learned through engagement efforts was applied to its development. Outside of the formal engagement process, state staff and tool partners are participating throughout the process in one-on-one meetings to discuss alignment with existing tools and processes, data availability, and state needs and interests in the MVI tool.

After the draft tool is developed, beta testing will be conducted with state staff involved in tool development and maintenance, as well as four to five tool users.

3.2.1 Tool Users

Three engagement efforts were conducted for tool users:

- A large online meeting with RPC representatives.
- Interviews with municipalities (5), PSD, and electric utilities.
- A large online meeting with a range of representatives of Vermont's municipalities.

Additional detail on each of these components is provided below.

Online Meeting with RPCs

ERG facilitated an online meeting with representatives of Vermont's 11 RPCs to gather input on the content, data, information, use, functions, and outputs of tool, as well any potential barriers to tool use. The online meeting was conducted via Zoom and lasted two hours. The meeting included a presentation that provided a brief overview of the project and the draft purpose of the MVI tool, followed by break-out group discussions facilitated by ERG staff.

Discussion topics included:

- Key components of climate and social vulnerability in Vermont.
- Data availability.
- Tool use cases (e.g., how might the tool be used).
- Tool information and data to be used in the tool.
- Tool functions, features, and outputs that would be helpful to RPCs.
- Challenges and barriers to tool use, including RPC staff and resources as well as municipal capacity.

The specific discussion questions can be found in Appendix E.

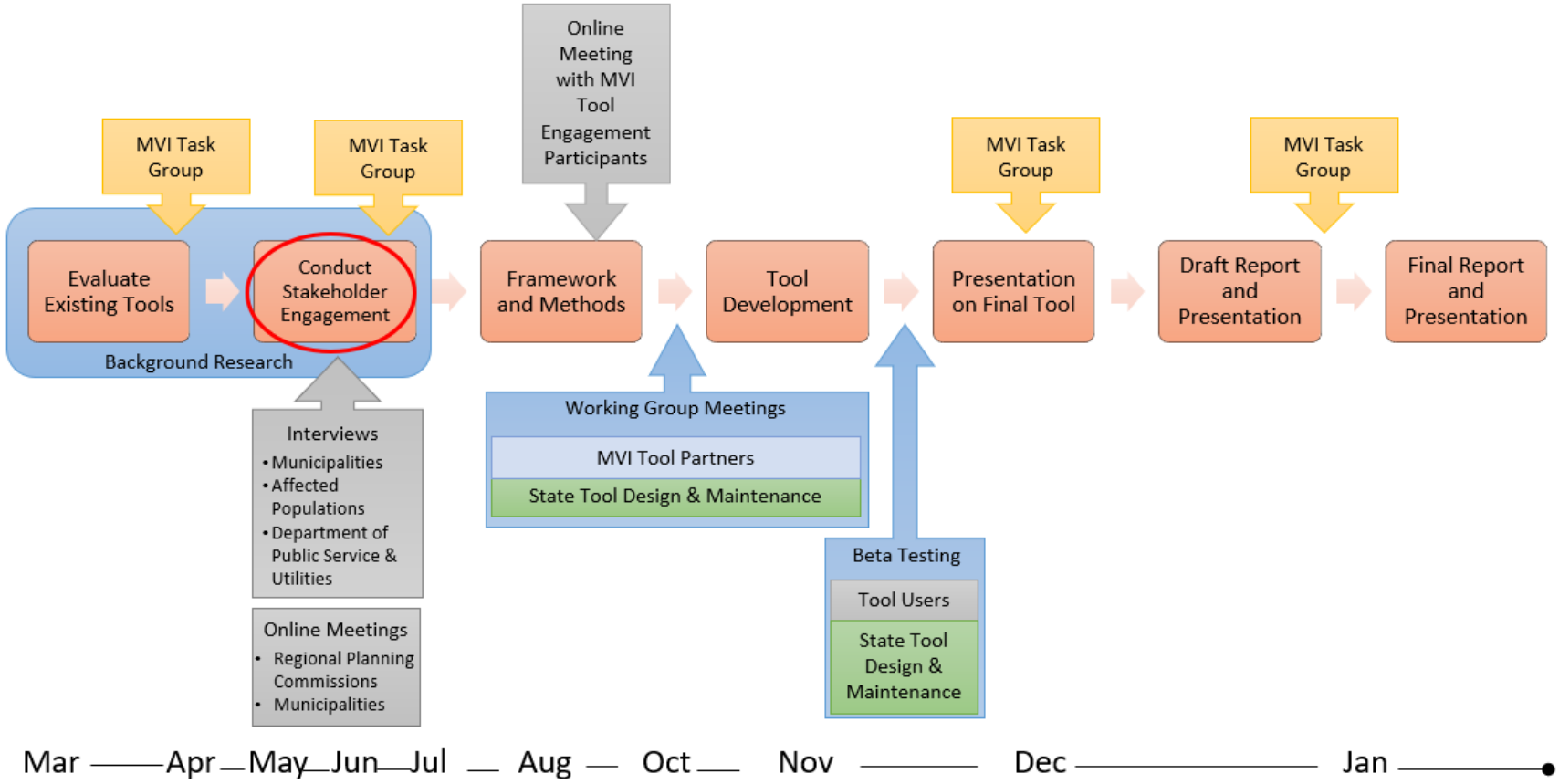


Figure 18. Key junctures for stakeholder engagement.

Interviews

Similar to the discussion with RPCs, the aim of interviews was to collect information from municipalities to inform the content, data, information, use, functions, and outputs of the tool. To this end, the interviews focused on the following topics:

- Key factors that inform climate vulnerability in Vermont's towns.
- Available data.
- Tool use cases (e.g., how might the tool be used).
- Tool information and data to be used in the tool.
- Outputs that would be helpful to municipalities.
- Priority functions and features.
- Challenges and barriers to tool use, including staff or volunteer capacity.

The interview guide used for the municipal interviews is included in Appendix D.1, and the interview guide tailored more specifically to the conversation with PSD and electric utilities is included in Appendix D.2.

Online Meeting with Municipalities

Following the interviews with municipalities, a broader meeting of municipal representatives was held to ensure input was collected from as many municipalities as possible to inform the MVI. The aim of this meeting was to present and confirm our findings to date, fill any information gaps identified after reviewing and summarizing the findings from the previous interviews and meetings, and broaden input on key topics addressed in the municipal interviews.

Forty-eight municipal representatives attended the two-hour online meeting conducted via Zoom. The meeting included a presentation that provided an overview of the project and the tool's draft purpose, followed by breakout group discussions facilitated by ERG staff. The discussion questions are included in Appendix F.

3.2.2 Affected Populations

Three small group interviews (two to four participants) were held with representatives from organizations that work closely with affected populations. The focus of these interviews was to gather input on:

- Key factors and population characteristics that inform climate and social vulnerability.
- Underlying conditions that affect the way that climate exposure is experienced.
- Sources of community support and assistance to prepare, respond to, and recover from hazards, climate change, and other shocks and stressors.
- Potential uses of the climate vulnerability information that will be generated by the MVI.
- Concerns or considerations when making decisions using the tool's outputs.

The interview guide is provided in Appendix D.3.

Participants were offered a $50 gift card for their participation.

3.3 Key Findings

The engagement methods described in Section 3.2 yielded a variety of key themes related to factors that influence a municipality's vulnerability to climate change; ways that the MVI tool can assist with municipal, regional, or state planning efforts; and desired features and information to include in the tool. Given the differences in the capacity and capabilities of the municipalities and RPCs, some participants were unsure how they might use the tool, while others were enthusiastic about the prospect of using the MVI tool to better understand climate and social vulnerabilities.

The sections that follow delve deeper into the key findings that emerged from engagement efforts, including key findings by participant type (e.g., municipality, utility, RPC, affected population representative) and a discussion of findings on the ways the MVI tool can fill existing information gaps.

3.3.1 Findings by Participant Type

Municipal Representative Participants

Representatives of five municipalities of different sizes, densities, geographic locations, and staff capacity were interviewed to gather the input to further inform the development of the MVI. Key findings from these interviews are presented below by discussion topic.

Factors Influencing Climate Vulnerability

Municipal representatives who participated in the interviews were asked to share their perspectives on what makes their towns vulnerable to climate change. As part of this question, representatives were also asked to identify specific factors or indicators related to climate exposure and vulnerability, such as natural hazards (e.g., flooding, extreme temperatures), the built environment (e.g., infrastructure, the electric grid), demographic factors (e.g., race, age), and others. According to municipal representative interview participants, key themes around climate vulnerability, indicators of concern and elements that contribute to vulnerability in Vermont municipalities include the topics presented below.

Indicators of Climate Vulnerability

- **Impacts from natural hazards** that result in biodiversity and habitat loss, increased distribution of invasive species, and corresponding loss of native species have already begun to impact Vermont and will continue to do so according to current climate projections. There has been an increasing number of severe weather events, with snow, extreme precipitation, and corresponding flood events specifically mentioned. Seasonal droughts and loss of food and water security have also affected some municipalities. The issue of increased forest fire risk and air quality effects related to fires inside and outside of Vermont was raised as a concern. Wildfire risk was brought forward within the context of the severe wildfires in Canada that began in March 2023, and participants shared that they were increasingly concerned about wildfire risk across Vermont, particularly in southeastern Vermont and in heavily wooded areas.
- **Built environment** concerns included physical assets such as bridges and roads as well as energy and water infrastructure. Bridges are critical infrastructure in small and rural communities. In some areas, bridges connect two parts of a town, and if the bridge goes out, part of the community would be cut off from critical services. Additionally, some small, rural communities may lack town water systems, therefore making individuals who rely on their own wells more

vulnerable during periods of seasonal drought or power outages when they're unable to pump water.

- **Demographic factors** and indicators of social vulnerability mentioned by participants included low-income populations, households without sufficient heating and cooling systems, populations that experience high energy cost burden, unhoused populations, individuals above the age of 65, and individuals without cars or accessible transportation options.

Community Characteristics Contributing to Municipal Vulnerability

- **Built environment and infrastructure,** such as a lack of town sewer and water treatment systems and corresponding reliance on wells, lack of broadband connectivity, and aging transportation and energy infrastructure.
- **Demographic factors,** such as an aging population and unhoused populations. Low population density across the majority of the state can make it difficult to reach individuals during severe storms or power outages. Aging housing stock, lack of affordable housing, and a high percentage of renters can also contribute to community vulnerability.
- **Additional factors** mentioned included the reliance on volunteer emergency service providers (e.g., firefighters) and the scale of agriculture (e.g., loss of small farms in favor of wholesale distributors and subsequent loss of food security).

Data, Information, and Tool Use

Municipal interview participants were asked to share whether their towns currently use demographic or climate information or tools for planning purposes in their towns, what types of information and outputs would be helpful to municipalities in their planning purposes, and if they were aware of any data or information that should be included in the tool. In response, participants indicated the following:

- **Current uses of demographic or climate information or tools for municipal planning.** Most of the participants shared that they were not using demographic information or tools to inform their climate planning, and a few representatives shared that their towns were not engaged in much climate planning at all. One participant, for example, noted that their town plan includes some census data to inform future development decisions in terms of where future town development may occur, but this was the extent of their use of demographic information in planning. Participants who represented smaller towns explained that they lacked professional planners and often rely on assistance from their RPCs for town planning efforts. Some of these representatives noted that they were familiar with ANR's tool, BioFinder, but that it was not a tool they used regularly. Representatives from a large Vermont municipality explained that their planning department uses national weather service data to understand precipitation trends to inform planning, and also uses census data and Green Mountain Transit ridership data to inform planning for the creation of bike lanes and associated bike infrastructure.
- **Desired information and outputs from the tool.** Multiple representatives thought it would be helpful to include information on past and future weather-related events, such as rain and ice storms, flooding, extreme temperatures (hot and cold), and previous occurrences of natural disasters like flooding or landslides. Similarly, one participant suggested including information about the ways river and stream corridors are changing or could change in the future. Several

participants noted that it would be helpful to include information on why areas are vulnerable to specific climate effects and explained that having this information would help to educate the general public and contribute to informed voting and decision-making. Regarding the scale of data to be included in the tool, participants noted that it would be helpful to have data at town, regional, and watershed scales. Some municipal participants also explained that it would be helpful to have data that is more granular than the town level to help identify where previous vulnerabilities have occurred in the past (e.g., specific bridge or road failures, flooding) and inform where they might occur in the future. They went on to say if they are unable to get a downscaled and accurate picture of vulnerabilities in their town, the tool might not be of great use to them. Participants also reinforced that having a regional understanding of vulnerabilities that extend beyond state lines is crucial, as natural hazards span across town and state boundaries.

- **Additional data sources.** Participants suggested several sources of data and information to include in the tool, such as:
  - Data from ANR's BioFinder tool.
  - Information from town planning documents to provide an overview of community and zoning characteristics.
  - Data on vegetation migration and information on how climate change is shifting species distribution.
  - Natural disaster locations, such as those made available by FEMA.
  - Information on transit corridors and transportation data.

Capacity and Potential Barriers to Use

In order to understand potential barriers to the use of the MVI tool and to potentially overcome these barriers or challenges, ERG asked participants to consider town capacity and capability to use the tool, anticipated barriers or challenges to tool use, and potential ways these barriers or challenges could be overcome. Key findings emerging from these discussion topics include:

- **Capacity and capability to use the tool.** There was mixed feedback among participants surrounding their capacity for using the MVI. Some participants indicated that their town, or an agency within their town government, has the staff capacity and capabilities to use the MVI. These participants noted that they would likely work with their planning and zoning offices to use the tool to inform planning decisions and decisions about where to prioritize capital improvement projects, or that their fire departments might use the tool to understand potential fire risk. The majority of municipal representatives indicated that their town does not have the staff capacity and/or capabilities to use the tool. They were often from smaller, rural towns that may or may not have paid staff, let alone full-time planning staff. These participants shared that they are already overwhelmed with other efforts and likely would not have the time or capacity to learn how to use the MVI tool and take on planning efforts using the tool. While these participants noted that their RPCs would likely be able to support them in using the tool, they also shared that they would prefer to have the RPCs be the primary tool users.
- **Anticipated barriers or challenges to use.** Participants mentioned a lack of staff capacity, a community's reluctance to acknowledge climate change, difficulties communicating climate change effects to residents, and a general lack of geographic information system (GIS)

experience in planning or town offices. To overcome these barriers, participants suggested that tool outputs should be directly tied to planning requirements and that the level of detail in the data provided is consistent across towns both large and small. Multiple participants emphasized that it will be challenging to effectively communicate climate risk and vulnerability to a wide audience, but this barrier could be lessened if the tool presents information in a way that is straight forward and easy to understand.

Representatives of Vermont Utilities and the Vermont PSD

A group discussion was held with representatives from PSD, Green Mountain Power, Vermont Electric Cooperative, and Washington Electric Co-op to better understand how both large and small utility providers in the state are thinking about climate vulnerability, how they're planning for climate change, challenges or issues they face in taking climate planning steps, suggested information or data to include in the tool, and how the MVI tool might assist them in understanding, planning for, or prioritizing actions to address climate change. Key takeaways from this conversation are presented below.

Factors Influencing Climate Vulnerability

Utility representatives shared that the greatest indicators of climate and social vulnerability of the energy grid are the remoteness and rural nature of the coverage area, type of vegetation cover, and proximity to floodplains. The greatest factor influencing power grid or energy transmission vulnerability was perceived to be the age of the infrastructure and type of power line (e.g., three-phase or single-phase lines).

- **Rural nature of coverage areas.** Representatives explained that the more rural an area is, the more vulnerable the energy infrastructure will likely be, and it will require more effort to maintain service per customer. With regard to vegetation cover and proximity to floodplains, the participants explained that after Hurricane Irene, it became apparent that energy customers living in mobile home parks near floodplains were especially vulnerable. Additionally, energy providers found that rural customers were more likely to live in areas with high vegetation cover, so in the event of a rainstorm or high winds, the energy infrastructure is more exposed to wind and downed trees. These customers are also harder to reach based on distance, single points of access, and hazard disruptions to this access (e.g., flooding, snow, downed trees or utility poles, landslides). In addition to low population density as a factor influencing vulnerability, respondents noted that rural customers who are older, have lower incomes, and who may not have neighbors or family nearby to assist them during a power outage are particularly vulnerable during outages.
- **Age and type of power line.** Some participants shared that most of the power lines under their jurisdiction were installed in the 1930s, making the lines over 90 years old. While relocating or undergrounding the lines is a priority for utilities, it is extremely difficult and expensive and is therefore not something that is taking place across the state at this time. Additionally, the participants shared that the type of wire in a power line is indicative of its age and that the older, single-phase lines experience the worst outages. These single-phase power lines are the primary type of lines in rural areas.

Ways Electrical Utilities are Planning for Climate Change

One of the primary ways electrical utilities are planning for climate change is thinking about the resilience of their systems and how quickly the systems can recover after a disaster or disruption that

results in a power outage. While energy utilities in the state are trying to improve the grid's resilience, it has been difficult for energy providers to keep up with newer technologies. Participants observed that in rural areas of Vermont, the gap is widening in terms of infrastructure preparation and resilience compared to non-rural areas. They also noted that low-income, rural communities experience a significant energy burden in the state, where energy costs can comprise a large percentage of a household's income.

Suggested Data or Information to Include in the Tool

Suggestions for data or information to be integrated into the tool included:

- **Outage data** to help visualize areas which repeatedly experience outages. Communities that frequently experience power outages are likely to be more vulnerable during climate-related weather events and natural disasters, as basic needs and services dependent upon electricity are diminished or eliminated (e.g., daily household or business operations, internet-based communication systems).
- **Zoning information** to know if a town falls under the Act 250 zoning laws,[19] which require permits for commercial projects on more than 10 acres if the town has permanent zoning and subdivision regulations, or on more than 1 acre if the town does not, or on the subdivision of 10 lots or more in a five-year period.
- **Data on EJ communities** would help utilities support decision-making and promote equity in the Tier 3 energy programs that aim to help their customers reduce fossil fuel consumption by adopting new, affordable, and clean energy electrification technologies, thereby cutting energy costs.

Desired Tool Outputs

Suggestions for MVI tool outputs included:

- **Data layers on broadband network, cellular reliability, and electric infrastructure.**
- **Data layers illustrating locations of previous power outages.**
- **Locations of emergency backup systems and critical facilities** such as hospitals, emergency shelters, fire stations, and electric vehicle charging stations.
- **Locations of EJ communities.**
- **Locations of people who rely on electricity for health provision.** Participants acknowledged that there may be challenges obtaining and publicizing this information due to privacy concerns but noted that it could be critical information.

RPC Participants

An online meeting was held with representatives from RPCs across the state to discuss climate vulnerability factors, MVI tool use and information, and capacity and barriers to using the MVI. Key findings from this discussion are presented below.

Factors and Vulnerability

[19] Act 250 Rules: https://nrb.vermont.gov/sites/nrb/files/documents/2015%20Adopted%20Rules.pdf

In discussing factors and vulnerabilities, meeting participants were asked to consider what populations in the communities they work with are most vulnerable. The populations that are considered most vulnerable by participants included:

- Aging populations.
- People living in floodplains.
- People who are dependent on electric medical devices.
- People who are energy burdened.
- People who are unable to reach or access heating or cooling centers during extreme temperatures.
- Unhoused populations.
- Migrant workers.
- New Vermont residents.
- People with limited English language proficiency.
- Black, Indigenous, and people of color (BIPOC) populations.

Tool Use and Information

Meeting participants discussed specific data or information related to climate and social vulnerability that they would like to see included in the tool as well as the type of preferred outputs generated by the MVI.

Specific data or information that RPC meeting participants would like to see embedded in the tool include:

- Income data.
- Flooding data, including the new FEMA flood plans and also flood maps that consider future precipitation.
- Heat data and projected heat increases for the state.
- Utility data, including grid capacity, vegetation data overlaid with transmission lines, location of broadband networks, and wastewater, drinking water, and stormwater capacity for towns.
- Location of emergency services.

Outputs and information that participants would like to see generated by the MVI tool include:

- Vulnerability by hazard in map form.
- Housing needs and where development is most suitable based on hazards in different locations.
- Municipal capacity for fire suppression (e.g., wet and dry hydrants).
- Forest fire risk and data on red flag warnings.
- Hazard mitigation strategies by census block group and region.
- Sample policy recommendations or sample language to include in policy recommendations.

Capacity and Barriers

Meeting participants raised capacity concerns at both the RPC and municipal levels. In general, participants shared that a general lack of familiarity with GIS mapping and technology could present a barrier to tool use. At the municipal level, RPCs often provide technological support to community members and staff, and participants were unsure if municipal staff would be able to use the MVI tool without their support. Participants suggested including tutorials and “how-to” resources to help people

who may not be as familiar with the technology to use the tool. Other participants noted that it was unclear to them how they might use a "big-picture" tool like the MVI and that it would be helpful for RPCs and municipalities to receive some education on how to use the tool and for what purposes. Participants also commented that in order to support the municipal use of the tool, RPCs would need additional resources that include not only additional funding, but also take into account the potential need to hire additional staff, which can be a complex issue given the additional resources needed, turnaround time for hiring, and difficulty attracting new hires in some areas due to a range of contextual factors, such as lack of housing.

When discussing capacity from a community-resilience perspective, participants shared that during events that significantly impact their communities (e.g., COVID, significant flood), they have observed that sources of community support tend to be organic, with communities and/or their members coming together in times of need.

Findings from Representatives of Affected Populations

During interviews with representatives from three organizations that work with or serve vulnerable populations, participants shared information regarding factors or indicators of climate vulnerability that are prevalent in the communities in which they work, the characteristics contributing to these vulnerabilities, the groups that people turn to during a climate-related event (e.g., flooding, snowstorm), how the MVI tool might assist municipalities and community organizations, and types of outputs or information from the tool that they would find most helpful. The findings from these discussions are presented below by discussion topic.

Factors Influencing Climate Vulnerability

Factors or indicators of climate exposure and vulnerability that are prevalent in the communities in which participants work or communities that they work with included:

- **Demographic factors** such as populations with limited or no English language proficiency, transgender people, chronically ill populations, people with low literacy levels, low-income populations, and other traditionally marginalized communities, as well as individuals with pre-existing medical conditions or individuals who may not even know they are vulnerable to particular natural hazards or pre-existing hazards such as toxic waste.
- **Industry and job sector.** Multiple participants highlighted farmers and the agricultural sector as being especially vulnerable to climate impacts, as farmers tend to have low incomes and/or limited resources and often lack capacity to apply for state or federal assistance programs.
- **Natural hazards** such as extreme weather, drought, and flooding.

Participants indicated that some characteristics of these communities that make them more vulnerable to climate impacts include demographic factors such as race, new Vermont residents, income, English proficiency, literacy, pre-existing medical conditions, energy burden, lack of access to weatherization services for renters, high population density within households and neighborhoods, high concentration of low-income residents, low population density, lack of access to transportation, lack of access to medical and health care, lack of secure and affordable housing, lack of food security, and lack of access to land.

Sources of Support for Communities During a Disaster

Participants shared a number of ways communities find support during or after a significant event, such as COVID-19 or a natural disaster. Multiple participants spoke about person-to-person connections, neighborhood support, and the strong community ties that people rely on during a significant event. Similarly, other participants spoke to the strength of grassroots mutual aid organizations throughout the state and the role those organizations played in providing direct support to people during the COVID-19 pandemic. Other participants noted that conservation districts provide support during disasters but also acknowledged that the districts are often underfunded and unable to provide all the support that people may need. The Vermont Farm Bureau and farming alliances[20] provide support to the farming community.

Ways the MVI Could Assist Municipalities and Desired Outputs

Community organization representatives shared that the MVI could assist municipalities in understanding the issues that community members face related to climate change; inform planning both for the purposes of development as well as disaster; and help prioritize improvement projects for underserved and vulnerable communities. Participants noted that it would be helpful if the tool could provide demographic information about land and home ownership, data illustrating food security and people's ability to access to healthy foods, data layers on social and ecological vulnerability, information on locations of mutual aid networks in different communities, and locations of emergency routes. Having this information in a centralized tool would help staff at municipal, regional, and state levels gain a better understanding of the interplay between climate and social vulnerability and how to prioritize assistance to the most vulnerable communities.

3.3.2 Findings Related to Needs, Gaps, and Opportunities for the MVI Tool to Fill

The MVI tool is intended to indicate municipal-level vulnerability to climate change based on a range of social, economic, and biophysical factors. The State of Vermont anticipates that information generated by the tool may be used to develop local hazard mitigation plans, local and regional energy plans, or other climate-related plans; inform decisions on how to prioritize climate-related projects and funding within communities and possibly across the state; and help emergency managers and members of the public prepare for and respond to likely hazards. In gathering input from municipal, utility, RPC, and affected population representatives, participants thought the MVI tool could fill the following needs and gaps currently facing these groups:

- Lack of comprehensive understanding of climate vulnerabilities.
- Need to prioritize allocation of resources.
- Lack of comprehensive understanding or definition of equity.
- Lack of actionable income data for energy utility customers.
- Lack of centralized information and data on EJ populations.
- Lack of maps illustrating critical facilities, including emergency shelters, hospitals, and microgrids.
- Lack of information on whether a municipality has paid staff.

By providing comprehensive data on climate hazards and social and climate vulnerability for municipalities in Vermont in a centralized tool, the MVI could fill the gaps mentioned above and assist municipalities, RPCs, and state agencies in better understanding the different social and climate

[20] The Connecticut River Watershed Farmers Alliance, the Champlain Valley Farmers Coalition, and the Franklin County Farmers Alliance were specifically named.

vulnerabilities that Vermont communities face. The MVI could also help communities prepare to address those vulnerabilities in a way that reduces the most urgent vulnerabilities.

Desired Functions or Outputs of the MVI Tool

In both interviews and larger group meetings, participants were asked which functions and outputs would be most helpful from the MVI tool. The primary desired functions or outputs included:

- Map layers of the locations of past and future weather-related events, natural disasters, and power outages.
- Map layers of projected changes in locations of streams or river corridors and changes in water flow.
- Forest fire risk and historical data on red flag warnings.
- Map layers of broadband networks, cellular reliability, and electric infrastructure.
- Locations of emergency backup systems and critical facilities such as hospitals, emergency shelters, hospitals, fire stations, and electric vehicle charging stations.
- Map layers that provide information on municipal vulnerability to specific hazards.
- Map illustrating municipal capacity for fire suppression (e.g., locations of wet and dry hydrants).
- Map layers of EJ communities.
- Map layers illustrating housing needs for an area and where development is most suitable based on current and future hazards.
- Locations of people who rely on electricity for health provision.
- Data on current risks and projections, including details of scenarios used for projections.

Concerns Regarding Resources, Value, or Role of the MVI Tool

While some participants were enthusiastic about the data and information that the MVI tool will provide, other participants had some reservations regarding the need for and utility of the tool. One of the primary concerns from participants representing smaller towns was that the tool would result in greater burdens rather than benefits, and they noted that they would prefer if state agencies were the primary user of the tool, rather than municipalities without the necessary capabilities and capacities. Some participants also shared concerns regarding how the tool will communicate climate risk and noted that in some areas of Vermont, it is very difficult to talk about climate change and some residents are resistant to learning about or preparing for climate change. Similarly, a few participants mentioned that they hope the MVI tool does not overwhelm municipalities with too much information and data; while detailed data are important for professional planners and GIS experts, participants also thought it would be helpful to have fact sheets or summaries included so that vulnerability information could be easily communicated to towns, municipalities, and their residents. Another participant also raised the concern that even if towns or state planners are able to access information on vulnerable populations and climate vulnerabilities through this tool, vulnerable communities will continue to be left out of decision-making. Participants emphasized the need to involve vulnerable communities in the development of the tool and to educate them and the organizations representing vulnerable communities about the information included in the tool and how it will be used.

3.4 Other Findings Beyond Project Scope

In conducting MVI tool engagement, participants made suggestions for tool features, information, and outputs, as well as additional engagement efforts. While these features will likely not be included in the MVI tool as they are outside of the agreed-upon scope of work, ERG captured these suggestions below so that the VT state team can refer to them for future work and/or future iterations of the MVI.

Suggestions for MVI features or information that are outside of the current project scope are to:

- Include information in the tool that helps users address the climate vulnerabilities and impacts that the tool identifies. This information could include actions and strategies for addressing climate vulnerabilities and increasing resilience to future disasters, such as hazard mitigation strategies by census block group and region, as well as draft policy language and best practices.
- Expand the geographic scope of the tool to include areas in other states bordering Vermont.
- Develop information on the return on investment of adaptation projects at the municipal and state level.
- Include information on climate action activities being taken at the state and federal level.
- Assist municipalities, RPCs, and other groups in anticipating needs (e.g., "there's a forest fire—what should we do?") and provide a way to quickly disseminate that information across the state in multiple languages.
- Conduct additional engagement with other municipal and regional groups and direct outreach to vulnerable populations.

3.5 Considerations and Recommendations

The following considerations and recommendations for developing and using the MVI tool are based on the information gathered during interviews as well as large and small group meetings during engagement efforts.

Expansion of Initial Tool Users

Prior to conducting engagement efforts, the legislation that describes the need to develop the MVI and the VT state team defined primary users of the MVI as (1) municipal-level staff or volunteers fulfilling municipal-level duties and (2) RPCs. Throughout engagement efforts, we heard from many municipalities that they are not likely to use the MVI, citing reasons such as a lack of staff or volunteer capacity, concern that the data won't be granular enough to provide the necessary detail, and a lack of clarity around how the information would be directly applicable to their current work or work products.

After hearing this input from the municipal interviews and online meeting, ERG and the VT state team discussed the possibility of the State also being one of the initial users of the tool. ERG noted that in other states (e.g., California, Massachusetts, New York), state and regional agencies are normally the initial users of these types of tools. Through this initial use, state and regional agencies are able to demonstrate how the tool can be used, thereby generating greater use by municipalities.

Recommendation: Based on the participant input gathered during engagement and subsequent discussions held with the VT State team, we recommend that the State be considered a primary user of the MVI.

Resources Needed to Support Tool Implementation

Given the lack of capacity among many municipalities to use the MVI, additional resources will need to be provided to support municipalities through training and use of the tool. These resources might include tutorials or training on the use of the tool that go beyond the MVI user guide being developed and ongoing technical support. Given their current relationship supporting municipalities, RPCs are one possible source of support for implementing the MVI.

While the VT state team noted that funding has been secured that can be provided to RPCs to help support municipalities with the MVI implementation, RPC engagement participants noted their own capacity concerns. Some participants noted that resources beyond additional funding will be needed to provide municipalities adequate support for the MVI. RPC engagement participants cited a range of resource issues that present barriers to assisting municipalities with tool implementation, including lack of staff and/or staff availability, difficulty obtaining new staff due to resource limitations and other issues that deter potential employees, such as lack of housing in the area for new residents.

Recommendation: Based on RPC input, we recommend that the VT state team further engage RPCs to better understand the type of resources and approaches to tool implementation that are needed for them to support implementing the MVI with municipalities.

Desire for Information Beyond Climate Impacts

Participants expressed a strong desire to better understand what action(s) should be taken based on the climate vulnerability information generated by the tool (e.g., adaptation or resilience strategies) and suggested that this type of information, or information to support their understanding of the climate impacts (e.g., scientific research on local vulnerabilities), be integrated directly into the tool. While integrating some of this information into this iteration of the tool is beyond the scope of this project, the State could consider how best to link to and incorporate information from the Municipal Climate Toolkit currently being developed by ANR.

Recommendations: We recommend that ERG and the VT state team discuss how best to integrate the MVI and Municipal Climate Toolkit, including where and how to link the tool kit, as well as possible tool kit content or concepts that can help address the needs of tool users as indicated through engagement efforts.

More Direct Input from Affected Populations Needed

Engagement participants, particularly those representing or working with affected populations, noted that additional engagement of those populations most vulnerable to climate change is needed when considering how the information generated by the MVI will be used. Participants commented that municipalities do not have adequate input from these vulnerable populations and are often not working closely with community action organizations that represent them. Participants expressed that gathering additional input directly from the affected populations is critical for increasing tool users' understanding of key issues and concerns prior to decision-making based on the MVI tool outputs.

Recommendation: We recommend that additional engagement of affected populations be conducted and incorporated into future iterations of the tool and its resources (e.g., municipal MVI implementation materials or best practices). It could be helpful to encourage municipalities and other tool users to seek input from affected populations when developing resources for implementation; however, through engagement efforts, we understand that municipal officials and RPCs may have limited capacity to include additional outreach into their current duties. Examples of alternative options might include weaving this engagement into other, current State climate-related outreach; future EJ mapping tool development efforts; or a separate engagement effort focused on affected populations or frontline communities that collects additional input that can inform the MVI and forthcoming EJ mapping tool.

4 Conclusions, Recommendations, and Next Steps

This section provides the summary conclusion and recommendations for the MVI's draft purpose, use, function, content, and outputs based on evaluation of existing tools and engagement. The section then describes the next steps in the tool development process based on the evaluation of existing tools and engagement efforts.

4.1 Conclusions

There are several overarching takeaways from the review and evaluation of existing tools and engagement efforts, including:

- ***The MVI needs to be simple to use while providing meaningful information.*** The MVI will most likely be used and gain traction among users if it is user-friendly and provides information that contributes needed outputs to support users' current duties. The evaluation of existing tools and MVI tool engagement efforts both concluded that the tool needs to be simple to use, provide flexible features (e.g., ability to toggle map layers or print information), integrate data from multiple existing tools in one place, and provide information at a scale that is granular enough to be useful at the municipal level. If the tool can also allow for more sophisticated uses of the data, such as being able to download data to overlay with external data sets, it will be even more appealing to larger municipalities and state agencies.
- ***Data may be a limiting factor.*** The evaluation of existing tools helped reveal the array of climate vulnerability factors that could be included in the MVI, and engagement efforts helped refine those factors to include factors that are most important to municipalities, RPCs, and populations that might be most heavily impacted by climate vulnerabilities. Having statewide data for these factors that are granular enough to be informative or helpful at the municipal level may limit the type of factors of climate vulnerability that can be integrated into this first iteration of the tool.
- ***Capacity is a consideration for tool use and adoption.*** During the engagement efforts, municipal participants expressed that there is limited technical and resource capacity to incorporate the use of the MVI. RPCs echoed this concern and expressed their limited capacity to assist municipalities in adopting and using the tool. While State funding may be available to assist RPCs in providing support to municipalities in using the tool, additional consideration will need to be given to the type of support RPCs might provide, their ability to provide that support, and what the roll-out for municipal assistance might look like.

- ***State use of the MVI could foster broader adoption.*** Having state agencies serve as initial tool users by integrating the MVI into their existing, relevant work could help foster tool adoption and use for RPCs and municipalities. By demonstrating how the tool can be used in State efforts as well as efforts involving RPCs and municipalities, these municipalities may be more likely to find value in the tool, thereby increasing the tool's use.
- ***The MVI can continue to evolve.*** Under this project, we are developing the first iteration of the MVI. As additional data become available, more input from tool users and affected populations is collected, and the landscape of climate vulnerability in Vermont continues to evolve, there is potential to have future iterations of the MVI also grow and change. While the current tool will be developed so that any integrated data sources can be updated, the opportunity exists for the MVI and its related resources to continue to be updated and expanded to reflect new information as it becomes available so that the information in the tool provides the most accurate and informative picture of climate vulnerability possible.

4.2 Recommendations

Based on the evaluation of exiting tools and MVI tool engagement efforts, we recommend the following:

- ***Include approach that supports sate, regional, and municipal users of the MVI.*** During interviews and participation from regional and municipal partners, concerns over capacity were raised as a barrier to using the MVI. One way to encourage and support use at the regional and municipal scales is to begin tool implementation by having state agencies incorporate tool use to support existing work. Having the State demonstrate how the tool can be used and the value of using it can help promote tool use among RPCs and municipalities. Beginning with state-level use will also afford the State the time needed to learn from RPCs about the type of resources needed to adopt the MVI tool, support its implementation at the municipal level, and get those resources in place.
- ***Identify and provide resources for tool implementation and support.*** RPCs and municipalities expressed that they have limited capacity to support the use and implementation of the MVI. We recommend that ANR begin by engaging RPCs to better understand the type of resources and approaches to tool implementation that are needed for them to support implementation of the MVI with municipalities. Following that engagement, we recommend developing a plan and training materials for how the tool training and support will be provided at both the RPC and municipal levels.
- ***Continue to seek input.*** We recommend the State consider additional engagement related to the tool's function and use so that this information can be integrated into future iterations of the tool. In particular, we recommend that additional engagement of affected populations be conducted to increase tool users' understanding of key issues and concerns prior to decision-making based on the MVI tool outputs.
- ***Plan to expand and improve the MVI.*** We recommend that ANR plan to not only update but continue to improve the MVI as new data and information about the tool's use are collected or become available.

- ***MVI statement of purpose.*** Based on the evaluation of existing tools, MVI tool engagement, and input from the MVI task group and VT state team, we recommend the following draft statement of purpose for the MVI:

  > The Vermont Municipal Vulnerability Index (MVI) is designed for use by Vermont State agencies, regional planning commissions, municipal staff, communities, and non-governmental organizations to measure vulnerability to climate change at the municipal level for the purposes of informing climate-related planning and decision-making and supporting the professional duties of tool users (e.g., grant-writing, development of local hazard mitigation plans, identification of climate vulnerability hot spots, disaster planning and response). The MVI will measure climate vulnerability based on a range of factors related to the built/physical environment (e.g., buildings, infrastructure), economy and jobs (e.g., unemployment, per capita income), natural hazards (e.g., flooding, extreme temperatures), natural environment (e.g., forest cover, ecosystem services), and social/community (e.g., sociodemographic factors, housing, access to emergency services).

4.3 Next Steps

Based on the findings from the evaluation of existing tools and MVI tool engagement, ERG will take the following next steps toward developing the MVI and its methods:

- ***Determine draft climate vulnerability factors to include in the MVI.*** ERG will develop a comprehensive list of climate vulnerability factors stemming from the evaluation of existing tools and input from engagement participants, the MVI task group, and VT state team members. ERG will then identify data available for each factor, capture information about these data (e.g., source, scale, gaps, limitations), and develop a set of recommended factors to include in the MVI.
- ***Begin defining the MVI framework and methods.*** Based on the information gathered to date, ERG will develop a memo for the VT state team that begins articulating each aspect of the MVI, including:
  - A statement of the tool's purpose.
  - Applications, uses, and audiences.
  - Supporting goals and objectives.
  - Framework, factors, and method, including weighting/scoring of indicators.
  - Data needs.
  - Tool function and outputs.
- ***Begin holding conversations and working meetings with MVI tool partners.*** Following the identification of available data sets and factors of climate vulnerability to include in the tool, ERG will identify tool partners to engage in order to help facilitate tool development. We anticipate the engagement of tool partners to occur throughout the tool development process on an as-needed basis to inform aspects of tool development where additional information or input is needed (e.g., understanding underlying data sets, considering synergies between an existing tool and the MVI).
- ***Conduct an online meeting on the draft framework and factors for MVI tool engagement participants.*** Upon completing the draft MVI factors, framework, and methods, ERG will conduct

an online meeting for the MVI task group and individuals who participated in the MVI tool engagement process. ERG will provide an overview of the draft MVI framework and methods, including how the information gathered through the engagement process was incorporated.

5 References

Flanagan, B.E., Gregory, E.W., Hallisey, E.J., Heitgerd, E.J., and Lewis, B. (2011). A social vulnerability index for disaster management. *Journal of Homeland Security and Emergency Management*, *8*(1). https://doi.org/10.2202/1547-7355.1792

Green Mountain Power. (2021). 2021 integrated resource plan. Accessed March 31, 2023. https://greenmountainpower.com/wp-content/uploads/2021/12/2021-Integrated-Resource-Plan.pdf

Green Mountain Power. (2022). Maps. Accessed March 31, 2023. https://greenmountainpower.com/maps

Headwaters Economics. (2022) A rural capacity map. Accessed March 31, 2023. https://headwaterseconomics.org/equity/rural-capacity-map

Metropolitan Area Planning Council. (n.d.) Climate vulnerability in Greater Boston. Accessed March 31, 2023. https://climate-vulnerability.mapc.org

State of California Department of Public Health. (2021). Climate change & health vulnerability indicators for California. Accessed March 31, 2023. https://skylab.cdph.ca.gov/CCHVIz

State of Vermont Agency of Commerce and Community Development. (2022). Mobile home facts and park registry. Accessed March 31, 2023. https://accd.vermont.gov/housing/mobile-home-parks/registry

State of Vermont Agency of Commerce and Community Development. (n.d.a.). Historic preservation online resource center. Accessed March 31, 2023. https://accd.vermont.gov/historic-preservation/identifying-resources/online-research-center.

State of Vermont Agency of Commerce and Community Development. (n.d.b.). Vermont commercial/industrial site locator. Accessed March 31, 2023. https://vermont-prod.atlas-integrated.com/property?ui=basic&region=All%20Cities&filter=All&forsale=1&forlease=1

State of Vermont Agency of Natural Resources. (2015). Vermont flood ready atlas. Accessed March 31, 2023. https://floodready.vermont.gov/assessment/vt_floodready_atlas#atlas

State of Vermont Agency of Natural Resources. (2020a). BioFinder. Accessed March 31, 2023. https://anr.vermont.gov/maps-and-mapping/biofinder

State of Vermont Agency of Natural Resources. (2020b). Landslides. Accessed March 31, 2023. https://anrgeodata.vermont.gov/datasets/landslides/explore?location=43.920513%2C-72.678150%2C9.19

State of Vermont Agency of Natural Resources. (2020c). Natural resources atlas. Accessed March 31, 2023. https://anrmaps.vermont.gov/websites/anra5

State of Vermont Agency of Transportation. (2018). Statewide highway flood vulnerability and risk map. Accessed March 31, 2023.

https://vtrans.maps.arcgis.com/apps/MapSeries/index.html?appid=f8a6527cf53e45a8896b494848b21e4f

State of Vermont Agency of Transportation. (n.d.) Transportation resilience planning tool. Accessed March 31, 2023. Available at: https://vtrans.vermont.gov/planning/transportation-resilience

State of Vermont Department of Health. (2023). Vermont social vulnerability index. Accessed March 31, 2023. https://www.healthvermont.gov/environment/tracking/vulnerability-indicators

The Nature Conservancy. (2019). Coastal risk explorer. Accessed March 31, 2023. https://maps.coastalresilience.org/maine

Vermont Department of Housing and Community Development. (2020). Planning atlas. Accessed March 31, 2023. https://maps.vermont.gov/ACCD/Html5Viewer/index.html?viewer=PlanningAtlas

Appendix A: Summary of Tool Data Sources

Table 7. Summary of tool data sources.

Data Source	Variable	Tool	Geographic Level
Air Monitoring Network, California Air Resources Board (CARB)	Mean concentration of particulate matter (PM2.5)	California Climate Change & Health Vulnerability Index	Custom geographic region
Air Monitoring Network, California Air Resources Board (CARB)	Ozone concentration exceedance above state standards	California Climate Change & Health Vulnerability Index	Custom geographic region
Atlas of U.S. Presidential Elections	Voter turnout (%)	Rural Capacity Index	County
Automatic Road Analyzer	Input to analyze vulnerability of transportation infrastructure	Transportation Flood Resilience Planning Tool	Custom geographic region
Behavioral Risk Factor Surveillance Survey (BRFSS)	% of adults that reported being diagnosed diabetes	Vermont Heat Vulnerability Index	County
Behavioral Risk Factor Surveillance Survey (BRFSS)	% of adults with current asthma	Vermont Heat Vulnerability Index	County
Behavioral Risk Factor Surveillance Survey (BRFSS)	% of adults that reported being diagnosed with hypertension	Vermont Heat Vulnerability Index	County
Behavioral Risk Factor Surveillance Survey (BRFSS)	% of adults who have obesity based on self-reported height and weight	Vermont Heat Vulnerability Index	County
Behavioral Risk Factor Surveillance Survey (BRFSS)	% of adults who reported being in fair or poor health	Vermont Heat Vulnerability Index	County
Boston Harbor Flood Risk Model storm surge simulation summaries	Simulated area of storm surge	Climate Vulnerability in Greater Boston	Census Tract
Bureau of Economic Analysis, Regional Data Tables	Standard deviation (inverted) in annual per capita income from 2000 to 2019	Rural Capacity Index	County
CAL FIRE	High risk fire hazard zone	California Climate Change & Health Vulnerability Index	Custom geographic region
CalAdapt	Projected number of extreme heat days	California Climate Change & Health Vulnerability Index	Custom geographic region

Data Source	Variable	Tool	Geographic Level
CalAdapt	Percent of population living in 100-year flood zone; areas with 55 inches of sea level rise	California Climate Change & Health Vulnerability Index	Custom geographic region
California Residential Appliance Saturation Survey (RASS)	Percent of households without air conditioning	California Climate Change & Health Vulnerability Index	Utility service areas in California
CDC Rural Urban Classification Scheme	Urban or rural	Rural Capacity Index	County
Ecological Land Units dataset	Places with considerable landscape diversity that may continue to foster biological diversity in the future	VT BioFinder	Custom geographic region
FEMA National Flood Hazard Layer	Fraction of housing units in each census tract that lie within a 1% chance Special Flood Hazard Area	Climate Vulnerability in Greater Boston	Census Tract
FEMA National Flood Hazard Layer	Input to analyze vulnerability of transportation infrastructure	Transportation Flood Resilience Planning Tool	Custom geographic region
FEMA National Flood Hazard Layer	Input to analyze vulnerability of transportation infrastructure	Transportation Flood Resilience Planning Tool	Custom geographic region
First Street Foundation's Flood Factor	Percent of homes that have a 1% annual chance of flooding	Rural Capacity Index	Custom geographic region
Green Mountain Power Public Data	Maps of energy infrastructure and outage areas	Green Mountain Power Maps	Custom geographic region
Gulf of Maine Coastal Program	Roads that are barriers to aquatic organisms	Maine Coastal Risk Explorer	Custom geographic region
Land Type Associations	Places with considerable landscape diversity that may continue to foster biological diversity in the future	VT BioFinder	Custom geographic region
LANDSAT	Images of land surface	Climate Vulnerability in Greater Boston	Census Tract
LiDAR	Input to analyze vulnerability of transportation infrastructure	Transportation Flood Resilience Planning Tool	Custom geographic region
LiDAR	Inland extent of sea level rise or storm surge		Custom geographic region
LiDAR	Locations of roads that would be inundated with sea level rise	Maine Coastal Risk Explorer	Custom geographic region

Data Source	Variable	Tool	Geographic Level
LiDAR	Locations of roads that would be inaccessible with sea level rise	Maine Coastal Risk Explorer	Custom geographic region
Maine E911	Locations of roads	Maine Coastal Risk Explorer	Custom geographic region
Maine E911	Locations of roads that would be inundated with sea level	Maine Coastal Risk Explorer	Custom geographic region
Maine E911	Locations of roads that would be inaccessible with sea level rise	Maine Coastal Risk Explorer	Custom geographic region
Maine E911	Point locations for addressable structures	Maine Coastal Risk Explorer	Locations
Maine E911	Point locations that could be inaccessible for emergency services	Maine Coastal Risk Explorer	Locations
Maine Public Utilities Commission	Hospital locations	Maine Coastal Risk Explorer	Locations
MAPC Land Surface Temperature Analysis Raster Dataset	Average land surface temperature	Climate Vulnerability in Greater Boston	Census Tract
Massachusetts Land Parcel Database	Property locations	Climate Vulnerability in Greater Boston	Census Tract
Massachusetts Land Parcel Database	Percent of housing units in each census tract expected to have a 1% chance of experiencing storm surge	Climate Vulnerability in Greater Boston	Census Tract
National Center for Education Statistics, Integrated Postsecondary Education System Database	Has college or university	Rural Capacity Index	Municipality
National Historical Geographic Information System (2021), U.S. Census Data	Change in population from 2000 to 2020 as a fraction of the 2020 population	Vermont Community Index	County subdivision
National Land Cover Database (NLCD)	% of town area covered by impervious surface	Vermont Heat Vulnerability Index	County
National Land Cover Database (NLCD)	% of town area covered by tree canopy	Vermont Heat Vulnerability Index	County
National Land Cover Database (NLCD)	% of area not covered by tree canopy	California Climate Change & Health Vulnerability Index	Custom geographic region

Data Source	Variable	Tool	Geographic Level
National Land Cover Database (NLCD)	% of area covered by impervious surfaces	California Climate Change & Health Vulnerability Index	
Natural Heritage Database	Vermont's documented natural communities	VT BioFinder	Custom geographic region
NOAA regional land cover	Riparian areas statewide with natural vegetation cover	VT BioFinder	Custom geographic region
Northern Appalachian/Acadian Ecoregion	Areas of diversity in the physical landscape and the riparian network	VT BioFinder	Custom geographic region
Power Almanac	Has head of planning	Rural Capacity Index	Municipality
PRISM Climate Data	Average number of days >= 87 °F	Vermont Heat Vulnerability Index	County
Self-reported data	Location of commercial/industrial sites	Vermont Commercial/Industrial Site Locator	Locations
SGA Structex Structures Damage Database	Input to analyze vulnerability of transportation infrastructure	Transportation Flood Resilience Planning Tool	Locations
SGA Structex Structures Damage Database	Input to analyze flood risk for transportation infrastructure	Statewide Highway Flood Vulnerability and Risk Map	Locations
SSURGO Floodplain Soils	Input to analyze vulnerability of transportation infrastructure	Transportation Flood Resilience Planning Tool	Custom geographic region
Staying Connected Initiative	Locations of rivers, streams, lakes, and ponds and their associated riparian areas and river and stream	VT BioFinder	Custom geographic region
Transportation Analysis Zones (TAZ) database	Input to analyze criticality of transportation infrastructure	Transportation Flood Resilience Planning Tool	Custom geographic region
U.S. Census Bureau (2020), Decennial Census: Population and Race Data	Total county subdivision population	Vermont Community Index	County subdivision
U.S. Census Bureau, American Community Survey (ACS)	Social vulnerability ranking	Maine Coastal Risk Explorer	Town
U.S. Census Bureau, American Community Survey (ACS)	Population living below federal poverty level	Vermont Social Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	Population age 16 and over seeking work	Vermont Social Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	Per capita income (2013 inflation-adjusted)	Vermont Social Vulnerability Index	Town, Block Group

Data Source	Variable	Tool	Geographic Level
U.S. Census Bureau, American Community Survey (ACS)	Population age 25+ without a high school diploma	Vermont Social Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	Population <65 years old without insurance	Vermont Social Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	Population <18 years old	Vermont Social Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	Population aged 65+	Vermont Social Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	Population age 5+ with a disability	Vermont Social Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	% of households with children	Vermont Social Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	Hispanic or non-white race	Vermont Social Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	Population age 5+ who speak English less than "well"	Vermont Social Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	10+ housing units per building	Vermont Social Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	% of housing units that are mobile homes	Vermont Social Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	Housing units with more than one person per room	Vermont Social Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	Households with no vehicle available	Vermont Social Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	Population living in group quarters	Vermont Social Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	% of population aged less than 5 years	California Climate Change & Health Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	% of population 65+	California Climate Change & Health Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	% of population whose income in the past year was below the poverty level	California Climate Change & Health Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	% of population aged 25+ with less than high school educational attainment	California Climate Change & Health Vulnerability Index	Town, Block Group

Data Source	Variable	Tool	Geographic Level
U.S. Census Bureau, American Community Survey (ACS)	% of population employed and aged 16+ working outdoors	California Climate Change & Health Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	% of occupied households with no vehicle ownership	California Climate Change & Health Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	% of households with no one aged 14+ who speaks English	California Climate Change & Health Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	% of population with physical disability (ambulatory disability)	California Climate Change & Health Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	% of population with mental disability (cognitive disability)	California Climate Change & Health Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	% of population without health insurance	California Climate Change & Health Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	% of people without health insurance	Rural Capacity Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	Proportion of individuals 25 years or older with at least a high school diploma	Vermont Community Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	Proportion of households with broadband of any type	Vermont Community Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	Proportion of homeowners that spend more than 30% of their income on housing-related expenses	Vermont Community Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	Change in per capita income from 2010 to 2020	Vermont Community Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	Proportion of individuals with incomes over 150% of the federal poverty level	Vermont Community Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	Change in labor force participation rate among the working age population (20–64 years) from 2010 to 2020	Vermont Community Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	Proportion of the population that is a race or ethnicity other than white non-Hispanic	Vermont Community Index	Town, Block Group

Data Source	Variable	Tool	Geographic Level
U.S. Census Bureau, American Community Survey (ACS)	% of adults with higher education	Rural Capacity Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	% of families below the poverty level	Rural Capacity Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	% of households with broadband	Rural Capacity Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	% of population <5 years old	Vermont Heat Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	% of population 65+	Vermont Heat Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	% of adults working in outside occupations	Vermont Heat Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	% of population 15–34 years old	Vermont Heat Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	% of population living below federal poverty line	Vermont Heat Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	% of adults with no high school diploma	Vermont Heat Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	% of population with non-white race or Hispanic ethnicity	Vermont Heat Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	% of population 65+ and living alone	Vermont Heat Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	% of adults with no health insurance	Vermont Heat Vulnerability Index	Town, Block Group
U.S. Census Bureau, American Community Survey (ACS)	Units per square mile	Vermont Heat Vulnerability Index	Town, Block Group
U.S. Census Bureau, National Historical Geographic Information System	Change in population from 2000 to 2019	Rural Capacity Index	County, sub-county
U.S. Decennial Census	Households	California Climate Change & Health Vulnerability Index	Town, Block Group
U.S. FBI Uniform Crime Reports	Number of violent crimes per 1,000 residents	California Climate Change & Health Vulnerability Index	County
U.S.D.A. Forest Service, Wildfire Risk to Communities	Wildfire risk to homes ranked against other U.S. communities	Rural Capacity Index	Custom geographic region

Data Source	Variable	Tool	Geographic Level
US Fish and Wildlife Service	Roads that are barriers to aquatic organisms	Maine Coastal Risk Explorer	Custom geographic region
UVM SAL Landcover 2016	Building footprints	Department of Housing and Community Development Planning Atlas	Custom geographic region
Vermont Agency of Administration	Per capita municipal budget per capita as of March 2020	Vermont Community Index	County subdivision
Vermont Agency of Commerce and Community Development (ACCD)	Building density, low-moderate income areas, mobile homes	Vermont Planning Atlas, mobile home park registry	Custom geographic level
Vermont Agency of Natural Resources	Ecosystem types, landscape types, conservation regions and design targets, endangered species, landslide locations, river corridors	Vermont Open Geodata Portal	Custom geographic levels
Vermont Agency of Natural Resources	Landslide locations	Landslide hazard mapping	Locations
Vermont Department of Taxes	Total value of taxable property in each county subdivision	Vermont Community Index	County subdivision
Vermont Department of Taxes	% change in total taxable property value (grand list) from 2011 to 2021	Vermont Community Index	County subdivision
Vermont Fish and Wildlife Department	Vermont's documented natural communities	VT BioFinder	Custom geographic region
Vermont Fish and Wildlife Department, Habitat Blocks	Highest priority or priority interior forest blocks; blocks that connect core habitat	VT BioFinder	Custom geographic region
Vermont Hydrographic Dataset	Valley bottoms	VT BioFinder	Custom geographic region
Vermont League of Cities and Towns (2022)	Presence of at least one municipal manager or administrator	Vermont Community Index	Municipality
Vermont Unified Hospital Discharge Data Set	Age-adjusted hospitalization rate for heat illness, per 100,000 persons, per year	Vermont Heat Vulnerability Index	County, urban area
Vermont Vital Records	Age-adjusted mortality rate (annual deaths per 100,000 population)	Vermont Heat Vulnerability Index	Some towns or groups of towns
VOBCIT Bridges	Input to analyze flood risk for transportation infrastructure	Statewide Highway Flood Vulnerability and Risk Map	Locations

Data Source	Variable	Tool	Geographic Level
VOBCIT Culverts	Input to analyze flood risk for transportation infrastructure	Statewide Highway Flood Vulnerability and Risk Map	Locations
VT ACCD	Location of mobile home parks	Mobile Home Facts and Park Registry	Locations
VT ACCD - Division of Historic Preservations	Historic preservation sites	Historic Preservation Online Resource Center	Locations
VT Agency of Natural Resources	Riparian areas statewide with natural vegetation cover	VT BioFinder	Custom geographic region
VTRANS AllRoads	Input to analyze flood risk for transportation infrastructure	Statewide Highway Flood Vulnerability and Risk Map	Custom geographic region
VTRANS AllRoads	Input to analyze vulnerability of transportation infrastructure	Transportation Flood Resilience Planning Tool	Custom geographic region
VTrans Detailed Damage Inspection Reports	Input to analyze flood risk for transportation infrastructure	Statewide Highway Flood Vulnerability and Risk Map	Locations
VTrans Detailed Damage Inspection Reports	Roads or structures with repeated storm damage	Reducing Repeat Damage Tool	Custom geographic region
VTrans Long Structures	Input to analyze flood risk for transportation infrastructure	Statewide Highway Flood Vulnerability and Risk Map	Locations
VTrans Rivers	Input to analyze flood risk for transportation infrastructure	Statewide Highway Flood Vulnerability and Risk Map	Custom geographic region
VTrans Short Structures	Input to analyze flood risk for transportation infrastructure	Statewide Highway Flood Vulnerability and Risk Map	Locations
VTrans Small Culvert Inventory	Input to analyze flood risk for transportation infrastructure	Statewide Highway Flood Vulnerability and Risk Map	Locations

Appendix B: Example Factors Covered by Tool and Domain

Table 8. Example factors by tool and domain.

Tool Name	Built Environment	Economic	Hazards	Natural Environment	Social/Community
BioFinder	Location of state and town highways, bridges, and culverts	*Not identified*	*Not identified*	Natural communities, wetlands, physical landscape, grassland managed agricultural land, etc.	Social vulnerability index identifies areas of vulnerability in the state, Property data, sites of increased vulnerability
Department of Housing and Community Development Planning Atlas	Location of roads, average annual daily traffic, railroad lines	Low-moderate income block groups and their location, county subdivision boundaries	DFIRM floodways, flood hazard areas	Conserved lands; rare, threatened, endangered species, soils-prime agricultural	Low-moderate income areas, state-owned historic sites, County subdivision LMISD ACS, Village center planning buffer
Green Mountain Power Maps	Solar power infrastructure, fiber optic cable location	*Not identified*	*Not identified*	*Not identified*	*Not identified*
Natural Resources Atlas	Roads, railroads, public utilities	*Not identified*	Maps locations of natural features	Woodlands, floodplains, hunting areas, wetlands	Public open space
Vermont Social Vulnerability Index	Large apartment buildings, households with no vehicle	Poverty, unemployment, per capita income	*Not identified*	*Not identified*	Children elderly, disability, minority, limited English, socioeconomic vulnerability, demographic vulnerability, housing/transportation vulnerability
California Climate Change & Health Vulnerability Index	*Not identified*	Percent population living in poverty	Predicted extreme heat days, percent impervious surface	Percent of land without tree cover	Violent crimes per 1,000 people, percent population without vehicle, % households w/out English speaker, % over 65, % over 5, % with a disability, % in poverty

Tool Name	Built Environment	Economic	Hazards	Natural Environment	Social/Community
Maine Coastal Risk Explorer	Bridges, culverts, roads, fish passage barriers	Natural resource occupation, self-employed	Sea level rise, riverine flooding	Wetlands, rivers, conservation lands, wildlife and habitat concentrations	Socioeconomic status, minority status, household composition and disability, housing and transportation, Coastal roads inaccessible to emergency services *(if inundated by sea level rise)*

Appendix C: Measures of Vulnerability Included in the Vermont Social Vulnerability Index

- Poverty, percent of population living below federal poverty level
- Unemployed, percent of age 16 and over unemployed and seeking work
- Per capita income (in 2013 inflation-adjusted $)
- Education, percent of age 25+ without a high school diploma
- Health Insurance, percent of age less than 65 without insurance
- Children, percent of population age less than 18
- Elderly, percent of population age 65 and over
- Disability, percent of age 5 or more with a disability
- Single parent, percent of households with children that have single parent
- Minority, percent of population that are Hispanic or non-white race
- Limited English, percent of age 5 and over who speak English less than "Well"
- Housing / Transportation:
  - Large apartment building, percent of housing units in buildings with 10 or more units
  - Mobile homes, percent of housing units
  - Crowding, percent of housing units with more than one person per room
  - No vehicle, percent of households with no vehicle available
  - Group Quarters, percent of population living in group quarters

Appendix D: Interview Guides

D.1 MVI Tool Users Interview Guide

Thank you for taking the time to speak with me today; your thoughts and feedback will be valuable to this project. To give you a bit of background on this project, the State of Vermont commissioned ERG to develop a Municipal Vulnerability Index for the State of Vermont. The Global Warming Solutions Act mandates the development of a Municipal Vulnerability Index (MVI) that can be used to indicate municipalities' vulnerability to climate change based on a range of social, economic, and biophysical factors. For this project, we are thinking about vulnerable communities as those who may experience disproportionate impacts from climate change based on characteristics such as race, ethnicity, age, income, education, and geographic location.

The tool will be used to identify where Vermont communities are most vulnerable to climate change, with a focus on pressures that climate change will place on Vermont's communities, economy and jobs, environment, and ecology, and including sectors such as transportation, electric grid, housing, emergency services, and communications infrastructure. The MVI will pay particular attention to the challenges faced by rural and under-resourced communities across the state when addressing these pressures. Information generated by the tool may be used to develop local hazard mitigation, climate adaptation plans, or other climate-related plans, or inform decisions about how to prioritize climate-related projects and funding within the communities and, possibly, across the state.

To inform the development of the MVI, we are gathering input from municipal-level stakeholders who may use the tool to ensure that our proposed tool reflects their experiences, expertise, and concerns. Do you have any questions before we begin?

Introduction

In order for us to get a sense of your town's focus and priorities in terms of climate change planning, please describe your understanding of how your town/municipality is thinking about and planning for climate change. For example, is climate change planning a topic in select board meetings, is there a climate change committee, does your town have a hazard mitigation, climate action and adaptation plan and/or energy plan? Does your town have access and regularly use hazard and climate data to understand current and future risks? Include climate change considerations in siting, design, land use, or capital planning? Anything else?

Factors and Vulnerability

1. To begin, please describe the factors or indicators of climate vulnerability that are most important to you and your community. These indicators may be related to:
   - **Natural hazards,** such as flooding, extreme temperatures, landslides, etc.
   - **Natural Environment,** such as information on forest cover, wetland extent, fish and wildlife habitats, ecosystem services, etc.
   - **Built environment**, such as infrastructure, the electric grid, transportation, etc.
   - **Economy or jobs**
   - **Demographic factors,** such as people of color, low income, unemployment rate, limited English speaking population, less than high school education, age (under 5, over 64), access to emergency services

2. What are some of the community characteristics that you think might make [municipality name] vulnerable to the effects of climate change? *As a reminder, we're thinking about vulnerable communities as those who may experience disproportionate impacts from climate change based on characteristics such as race, ethnicity, age, income, education, and geographic location.*
3. Does your town have a definition of social or climate vulnerability?
    - 3a. If so, please describe.

Tool Use and Information

4. Do you know of any data and information that should be included in the tool? Is it local, regional, state or federal scale?
5. Does your town currently use other climate or social vulnerability tools? Or tools to understand other issues such as public health, environmental resources, environmental justice or others? If so, which ones?
    a. [if they name tools] Are there any aspects of this/these tool(s) that you find particularly helpful or unhelpful?
6. Does your town currently use demographic information to inform decision making around climate planning? If so, please elaborate on the type of information that is used and types of decisions informed by that information.
7. How do you think your municipality might use the climate vulnerability information generated by this tool? For example, would you use it for grant applications? Capital planning? Hazard mitigation plan development? Land use, regulations, and design and building codes? Funding requests or support?
8. What type(s) of tool outputs or information generated by the tool would you find most helpful?
9. What type of information do you think would be most helpful for your town to have for developing your local hazard mitigation plan and climate-related plans?
10. What tool functions or features would you like to see incorporated into the MVI? Are there features that would make the tool more or less valuable to you?

Capacity and Barriers to Use

11. Does your town have the staff capacity and capabilities to use this tool?
    a. What municipal position(s) (staff or volunteers) do you expect might use the tool?
    b. How much do you rely on your Regional Planning Commission to assist in the use of these types of tools?
12. When your community has experienced a significant event in the past (e.g., COVID-19, flooding, significant power outage), where does your community draw its support? *Examples may include foodbanks, civic organizations, churches, local government, etc.*
13. Are there any barriers or challenges to tool use that you anticipate? If so, please elaborate.
    a. How might the barriers or challenges be overcome?
    b. Do you see a role for the state in supporting those efforts?

Closing

14. Are there any other considerations for the development of use of the MVI that you would like to share?

15. Is there anything about your town that you were not able to communicate based on our questions?
    a. Are there unique characteristics or concerns that have not been captured that you want to make sure we consider?
16. Do you have questions or concerns regarding how the tool may be used by the State or others?
17. Based on our conversation today, are there other individuals in your community with whom you would recommend we speak in order to gather additional input or perspective on this topic?

Thank you!

D.2 VT Department of Public Service and Utilities Tool Users Interview Guide

Introduction

Thank you for taking the time to speak with us today; your thoughts and feedback will be valuable to this project. To give you a bit of background on this project, the State of Vermont commissioned ERG to develop a Municipal Vulnerability Index for the State of Vermont. The Global Warming Solutions Act mandates the development of a Municipal Vulnerability Index (MVI) that can be used to indicate municipalities' vulnerability to climate change based on a range of social, economic, and biophysical factors. For this project, we are thinking about vulnerable communities as those who may experience disproportionate impacts from climate change based on characteristics such as race, ethnicity, age, income, education, and geographic location.

The tool will be a web-based, geospatial tool that can be used to identify where Vermont communities are most vulnerable to climate change, with a focus on pressures that climate change will place on Vermont's communities, economy and jobs, environment, and ecology, and including sectors such as transportation, electric grid, housing, emergency services, and communications infrastructure. The MVI will pay particular attention to the challenges faced by rural and under-resourced communities across the state when addressing these pressures. Information generated by the tool may be used to develop local hazard mitigation, climate adaptation plans, or other climate-related plans, or inform decisions about how to prioritize climate-related projects and funding within the communities and, possibly, across the state.

To inform the development of the MVI, we are gathering input from various stakeholders including public service departments and utilities (yourselves), representatives who work at the municipal and RPC levels, who may use the tool to ensure that our proposed tool reflects their experiences, expertise, and concerns. PSD shared some background information with us prior to this call, although it was mostly relevant to GMP (the GMP MVI methodology, & GMP Resiliency Zones). Do you have any questions before we begin?

Factors and Vulnerability

1. To begin, please describe the factors or indicators of current and future vulnerability due to climate change that are priority concerns in terms of the infrastructure you maintain or the services you provide. These indicators may be related to:
   - **Natural hazards,** such as flooding, extreme temperatures, landslides, etc.
   - **Natural Environment,** such as information on forest cover, wetland extent, fish and wildlife habitats, ecosystem services, etc.
   - **Built environment**, such as infrastructure, the electric grid, transportation, etc.
   - **Economy or jobs**
   - **Demographic factors,** such as people of color, low income, unemployment rate, limited English speaking population, less than high school education, age (under 5, over 64), access to emergency services
2. What are some of the characteristics of Vermont utilities and infrastructure that have made them vulnerable to past hazard events and disasters?

a. Has your organization considered how climate change is projected to increase the intensity, frequency, duration, and areas affected by these hazards?

3. Can you explain how your department or utility is thinking about or defining resilience?

Tool Use and Information

4. Do you know of any data and information that should be included in the MVI tool?
   a. Is the data and information local, regional, state or federal scale?
      i. Has data and mapping been generated as part of energy resilience initiatives?
   b. Are you aware of any geospatial data or other information that should be included in the MVI tool? This information may include:
      - Location, condition, characteristics, and service populations of energy utilities. Characteristics of the system that increase or decrease vulnerability to damage and disruption of service.
      - Dependencies and interdependencies among assets that make some infrastructure and utility assets more critical to the network or system.
      - Major industrial, military, or institutional customers and any agreements in place for either uninterrupted power or power switching.
      - Identification and location of critical and lifeline assets. Such assets including hospitals, elder care facilities, schools, homes, public safety, transportation, grocery stores, goods movement.
      - Identification of characteristics that make populations more vulnerable to disruptions to power, water, and transportation service and the location of those populations.

   ii. Is this information considered private or public? Can it be included in a public facing tool? Does it include meta-data and source information?

   iii. Are you able to share the information with us directly or provide a point of contact?

5. Does your organization currently use any tools that provide information on hazard and/or climate vulnerability? If so, which ones? *Note to interviewer: ERG reviewed the following energy/infrastructure focused tools: the GMP 2021 Integrated Resource Plan which focuses on steps GMP will need to take to satisfy VT energy needs while complying with VT GHG legislation; GMP Maps which illustrate GMP coverage; Highway Flood Vulnerability and Risk Map; VT Transportation Flood Resilience Planning Tool.*
   a. [if they name tools] Are there any aspects of this/these tool(s) that your department/utility feels are useful and contribute to your ability to answer key questions and lead to outputs that can be used by your department/utility? Any challenges or gaps?

6. What type of information and data should be included in the MVI to increase the likelihood that your department/utility uses MVI tool?

7. What type(s) of MVI tool outputs or information generated by the tool would your department/utility find most helpful? What do you want to ensure we consider or include in the MVI tool?

8. What type of information does your department/utility currently use to assess risks from climate change?

   a. Does your department/utility consider the data and information available adequate to assess risk and plan for climate change?

9. What tool functions or features would increase the likelihood that your department/utility use the MVI tool?

Capacity and Barriers to Use

10. Does your department/utility have the staff capacity and capabilities to use MVI tool?
    a. What staff positions do you expect might use the MVI tool?
    b. Does your department/utility have the capacity to help support updating the MVI tool with data and information regarding your department/utility assets and system?
11. Are there any barriers or challenges to MVI tool use that you anticipate? If so, please elaborate.
    a. How might the barriers or challenges be overcome?
    b. Are there opportunities to integrate the MVI tool into your department's/utilities ongoing work, tools, decision-making processes, capital planning, or other processes?

Closing

12. Are there any other considerations for the development of use of the MVI that you would like to share?
13. Do you have questions or concerns regarding how the tool may be used by the state or others?

Thank you!

D.3 Affected Populations Interview Guide

Introduction

Thank you for taking the time to speak with me today; your thoughts and feedback will be very valuable to this project and inform the approach to and design of the tool and the outputs from the tool. To give you a bit of background on this project, the State of Vermont commissioned ERG to develop a Municipal Vulnerability Index for the State of Vermont. The Global Warming Solutions Act mandates the development of a Municipal Vulnerability Index (MVI) that can be used to indicate municipalities' vulnerability to climate change based on a range of social, economic, and biophysical factors. For this project, we are considering vulnerability to mean disproportionate impacts from climate change based on characteristics such as race, ethnicity, age, income, education, and geographic location.

The tool will be used to identify where Vermont communities are most vulnerable to climate change, with a focus on pressures that climate change will place on Vermont's communities, economy and jobs, environment, and ecology, and including sectors such as transportation, electric grid, housing, emergency services, and communications infrastructure. The MVI will pay particular attention to the challenges faced by rural and under-resourced communities across the state when addressing these pressures. Information generated by the tool may be used to develop local hazard mitigation or climate adaptation plans or inform decisions about how to prioritize climate-related projects and funding within the communities and, possibly, across the state.

To inform the development of the MVI, we are gathering input from community representatives, such as your organization, who represent populations that will be disproportionately affected by climate change to ensure that the proposed tool reflects community experiences and concerns related to climate change vulnerability and the social, environmental, economic, and governance factors that contribute to it.

Factors, Vulnerability, and Community Support

1. Please describe the factors or indicators of climate vulnerability that are most important to you and your community. These indicators may be related to:
   - **Natural hazards,** such as flooding, extreme temperatures, or landslides
   - **Natural Environment,** such as information on forest cover, urban tree cover, wetland extent, fish and wildlife habitats, and ecosystem services.
   - **Built environment**, such as infrastructure, homes and buildings, the electric grid, transportation, critical assets such as schools and hospitals.
   - **Economy or jobs,** such as industries and jobs affected by climate change as well as emerging industries due to climate change.
   - **Demographic factors,** such as people of color, low income, unemployment rate, limited English speaking population, less than high school education, age (under 5, over 64), access to emergency services
2. What characteristics of people in your community or the community(ies) you work with might make them vulnerable?

3. What climate vulnerabilities and risks do you believe are most important for the community(ies) that you represent? Climate vulnerabilities may include exposure to extreme temperatures, degraded air quality, flooding, and more.
4. What are the underlying conditions that affect the way that vulnerability is experienced by the community that you represent?
5. When your community has experienced a significant event in the past (e.g., COVID-19, flooding, significant power outage), where does your community draw its support? *Examples may include foodbanks, civic organizations, churches, local government, etc.*
    a. What type of assistance do these groups provide?

Tool Use and Information

6. How would you like municipalities to use the climate vulnerability information generated by this tool? For example, do you imagine them using it to support grant applications? Capital planning? Hazard mitigation plan development? Land use, regulations, and design and building codes? Funding requests or support?
7. What type(s) of tool outputs or information generated by the tool would you find most helpful?
8. Does your organization use any tools to inform your work on climate, public health, social vulnerability, environmental resources, or other? If so, which ones?
9. Are there any concerns or considerations regarding how the tool might be used to inform climate-related decision-making that you would like to share? If so, please elaborate.

Closing

10. Is there any other feedback that you would like to share regarding the development of the MVI or its use that we have not yet discussed?

Thank you for your time.

Appendix E: Discussion Questions for Regional Planning Commission Meeting

Factors and Vulnerability

1. To begin, please describe the factors or indicators of climate vulnerability that are most important to your RPC and the communities that is serves. These indicators may be related to:
   - **Natural hazards,** such as flooding, extreme temperatures, landslides, etc.
   - **Natural Environment,** such as information on forest cover, wetland extent, fish and wildlife habitats, ecosystem services, etc.
   - **Built environment**, such as infrastructure, the electric grid, transportation, etc.
   - **Economy or jobs**
   - **Demographic factors,** such as people of color, low income, unemployment rate, limited English speaking population, less than high school education, age (under 5, over 64), access to emergency services
2. What population(s) do you consider to be vulnerable in your community?

Tool Use and Information

3. Do you know of any data and information that should be included in the tool? Is it local, regional, state, or federal scale?
4. How do you think you might use the climate vulnerability information generated by this tool? For example, would you use it for grant applications? Funding requests or support? Research projects? Comprehensive energy plans? Technical assistance or support to municipalities and community organizations?
5. What type(s) of tool outputs or information generated by the tool would you find most helpful?
6. What type of information would be most helpful to you in developing planning and research documents, programmatic work, funding and technical support to municipalities or community organizations?
7. Does your organization use other climate or social vulnerability tools? Tools to understand other issues such as public health, environmental resources, environmental justice or other? If so, which ones?
   a. Are there any aspects of this tool that you find particularly helpful or unhelpful?
8. What tool functions or features would you like to see incorporated into the MVI? Are there features that would make the tool more or less valuable to you?

Capacity and Barriers

9. Does your organization have the staff capacity and capabilities to use this tool?
   a. What staff position(s) would likely use the tool?
10. In the past, when the communities you serve have experienced a significant event (e.g., COVID-19, flooding, significant power outage), where do they typically draw support for their community? *Examples may include foodbanks, civic organizations, churches, local government.*

11. Are there any barriers or challenges for tool use that you anticipate? If so, please elaborate.
12. How might the barriers or challenges be overcome?
13. Do you anticipate using the tool to provide technical support and assistance to municipalities and community organizations?
    a. Do you see a role for the state to support you in doing so?
        i. If so, what role would be most helpful for the state to play?
    b. Are there certain tool outputs that would be most useful for your organization in providing this support? Such as maps, fact sheets, vulnerability scores or factors, or other?
    •

Closing

14. Are there any other considerations for the development or use of the MVI that you would like to share?
15. Do you have questions regarding how the tool may be used by the State or others?

Appendix F: Discussion Questions for Municipal Online Meeting

Tool Use and Information

1. What information would be helpful for your town to have to better understand its vulnerability to climate change impacts?
2. What information does your town currently use to understand climate vulnerability for efforts such as grant applications or planning processes?
3. Which of the following would be most useful to your town:
    a. Maps depicting current and future hazards due to climate change
    b. Maps with social, economic, environmental data
    c. Fact sheets that generate a snapshot of vulnerability within each town
    d. Rankings of vulnerability based on climate, social, economic, and environmental data and information

Capacity and Barriers to Use

4. Does your town have staff or volunteer capacity to use climate vulnerability data and information to inform hazards, planning, capital planning, grant applications, or other processes?
    c. Would a geospatial tool make this work easier?
        i. If not, why?
5. When your community has experienced a significant event in the past (e.g., COVID-19, flooding, significant power outage), where does your community draw its support?
6. What barriers or challenges do you currently have in developing town LHMPs, emergency plans, grant applications, or incorporating climate data into decision-making?
    c. How could this tool assist you with this work?

Concerns and Considerations

7. Do you have any concerns related to the development or use of the MVI tool?
8. Are there any other considerations for the development or use of the MVI that you would like to share? Such as those pertaining to:
    a. Accurately capturing each town's vulnerability?
    b. Use of the tool to direct resources?
    c. Efforts around planning, engagement, and outreach?
    d. Prioritizing actions at the state or town scale?