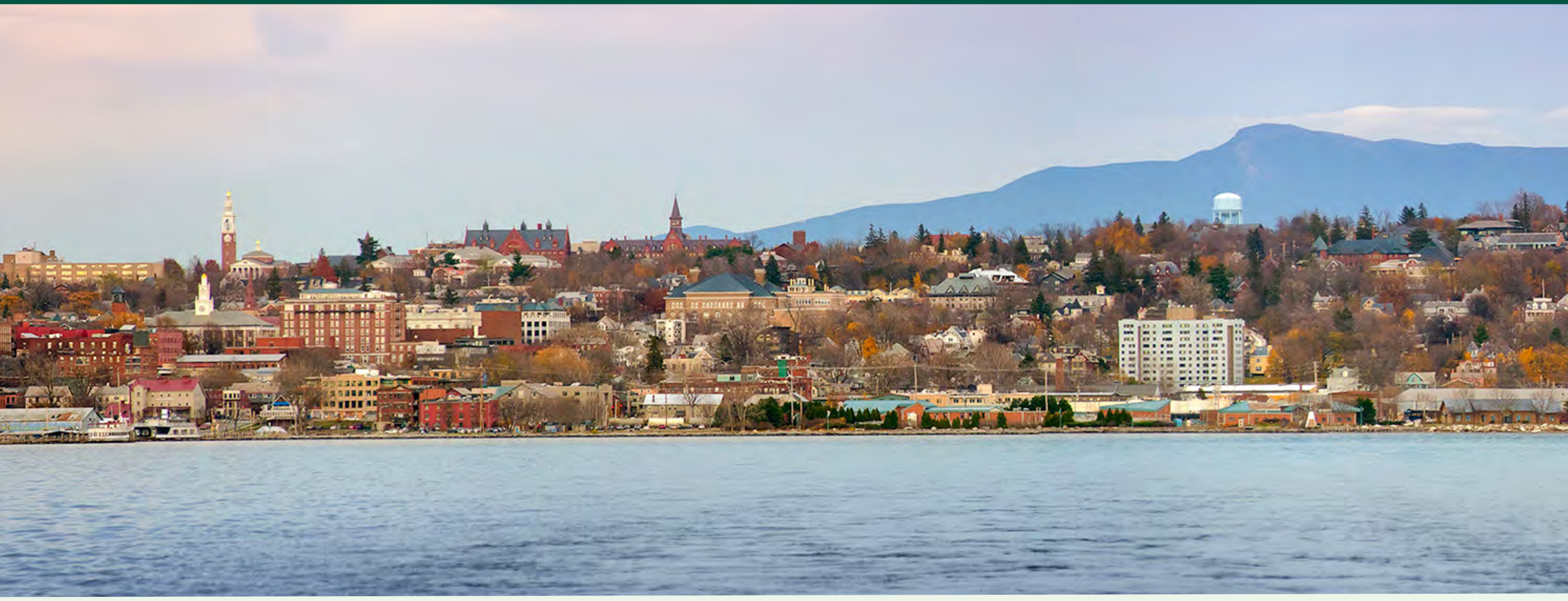

CHAPTER 9

COMMUNITY DEVELOPMENT

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VERMONT CLIMATE ASSESSMENT

The University of Vermont

GUND INSTITUTE FOR ENVIRONMENT

The Nature Conservancy

9 COMMUNITY DEVELOPMENT

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9.1 KEY MESSAGES

1. Flooding is the most likely natural disaster to occur in Vermont and should be accounted for in all community development and planning efforts in the state; however, extremes will become more common, so community development and planning efforts should also account for chronic hazards, such as drought.
2. Systems interconnections are essential to consider in community development and planning of future climate change scenarios, particularly in the context of disasters.
3. Vermont is expected to continue to have a favorable climate under future climate change projections, however, there is very little information to predict if the state will face an influx of climate migration.
4. Engaging in planning is essential for Vermont communities to access federal funding and to prepare for current and future climate change impacts, including population growth, flooding, and droughts.
5. Climate change will not impact all communities equally; the needs and capacity of vulnerable populations should be considered with all community planning efforts.

9.2 INTRODUCTION

Vermont encompasses 9,216.66 square miles (U.S. Census Bureau, 2010), has a population of 623,989 (U.S. Census Bureau, 2019), and is known for natural beauty and rural character. Vermont is composed of 251 cities, towns, and villages. Like in much of New England, local government occurs at the town level, not the county level, and many of the elected officials serve in a voluntary capacity (Paul & Milman, 2017). Over the years, the state has designed many efforts to combat development pressures, such as from an influx of second home buyers that threatened farmland and open space (DeWeese-Boyd, 2005).

This chapter applies a *resilience thinking* lens to community development (Table 9-1). At its core, community development can be thought of as the participatory processes and decision-making needed to make progress in a community. Or, as defined by Lotz (1971, p. 315), “community development is a general name to define the complex processes of socio-economic development and change.” Resilience thinking views communities as social-ecological systems (e.g., human communities are heavily interlinked with the natural environment) that, when faced with a disturbance (in this case, climate change and subsequent disasters), will either persist, adapt, or transform (Folke et al., 2010). Additionally, resilience thinking views social-ecological systems (i.e., communities) in terms of complexity theory, which emphasizes cross-scale interactions and integrated systems (Folke, 2006). By applying a resilience thinking lens to community development in the context of climate change, this chapter seeks to understand the likely ways climate change will cause disturbances in communities; to identify efforts the state of Vermont and its communities can undertake to persist, adapt, and/or transform; and to utilize community development strategies that form a holistic perspective to break down systemic silos.

Table 9-1: Resilience components and their application for community development and Vermont communities

Resilience component	What this means for community development	What this means for Vermont communities
Resilience of social-ecological systems (Folke et al., 2010)	Communities, in this case, are the social-ecological systems. Communities rely on and are influenced by the natural world; and in turn they also impact the surrounding environment.	This means that the interconnections between Vermont communities and the environment are important to consider in the context of resilience to climate change.
Resilience in the context of complex systems	Resilience theory and thinking is tied to complexity theory. Complexity theory describes systems defined by cross-scale interactions, emergent properties, and integrated systems (Folke, 2006).	For Vermont communities, implementing resilience thinking in the context of complex systems means that planning for resilience in the face of climate change should account for the connections between multiple systems (e.g., food, energy, water, the economy, environment, etc.) and should consider how the local scale connects to the regional and state scales, which connects to the national scale in terms of systems connections, decision-making, and other community actions.
Systems resilience principles: the 4 Rs - robustness, redundancy, resourcefulness, and rapidity (Cimellaro, Reinhorn, & Bruneau, 2010)	Systems resilience principles are often attributed to physical infrastructure systems, but they can be attributed to social, ecological, and economic systems as well. The four Rs refer to qualities of a system that can promote or enhance resilience. Robustness refers to strengthening a system so that it resists damage or disturbance. Redundancy means that there are backup systems or resources in case a disturbance breaks or destroys something that is relied on. Resourcefulness is often considered in terms of "capacity": does a community or system have the resources and capacity to respond to a disturbance? Rapidity means how quickly a response can be mobilized, for example, how quickly services can be restored following a disturbance.	In Vermont communities, these elements are essential to include in planning processes, especially those related to disasters and emergency management. Vermont communities rely on a number of infrastructure and other systems, so it is important to consider the "four Rs" in planning for these systems.

Resilience component	What this means for community development	What this means for Vermont communities
Resilience thinking vs. resilience as an outcome	While early academic work tended to consider "resilience" as an outcome-oriented concept, the field has come to view resilience as a process-oriented concept (Matyas & Pelling, 2015). In other words, resilience is more a way of thinking about a system and how to make decisions about it, as opposed to an outcome or a goal to be achieved. Resilience thinking is advocated, given the complex nature of human communities.	For Vermont, this means that resilience should not be thought of as a fixed outcome. Resilience should be thought of as a way of making decisions about community development. Resilience thinking allows communities, planners, and decision-makers to consider what resilience means within specific contexts and define the characteristics that would characterize improvement.
Social cohesion	Social cohesion, also called social capital or social infrastructure, refers to the bonds between individuals and social networks. In resilience research, social cohesion has shown to be an important factor in communities that fare better than others following disturbances (Townshend et al., 2015).	For Vermont, this means that the social ties between individuals and social networks should be accounted for when planning for or implementing resilience-building projects.
Diversity, equity, inclusion, and justice (DEIJ)	Climate change will not impact all areas and all populations equally.	For Vermont, this means that DEIJ should be accounted for in all planning and resilience-building efforts. This could mean purposely analyzing data by demographic or spatial group instead of in aggregate, considering how resources and services can be distributed equitably, and ensuring that community members (especially from populations that may face inequitable impacts) are included in the planning, development, or policy process.

Communities rely on a number of infrastructure systems, also called critical infrastructure systems or lifeline systems, for their health and well-being. Infrastructure systems include food, energy, water, communications, transportation, and healthcare. Within a community, lifeline systems are heavily linked with one another, so damage to one system can cause subsequent damage to the other systems. These infrastructure systems exist in economic and social systems (including governmental, legal, and cultural systems). Climate change will have effects on these systems (think loss of ski tourism and maple sugaring, alone) that will reverberate into each other.

This chapter will explore how climate change is already, or likely to, impact Vermont communities and the interconnected systems upon which they rely. The other chapters within this Vermont Climate Assessment provide in-depth coverage of the impact climate change will have on individual systems and sectors. This chapter builds from the material covered in the other chapters, so the reader is encouraged to peruse those chapters for more information on individual systems.

This chapter will first detail the climate change impacts that are most relevant to Vermont in the context of community development and present some adaptation and mitigation strategies for each. Next is a discussion of how climate change is likely to impact the "lifeline" systems that Vermont communities rely on so that community or regional planners can take into consideration these systems interconnections when making development decisions. Finally, this chapter details community- and state-level planning efforts in progress and provides examples of other efforts being undertaken in various cities in the United States that Vermont could consider.

9.3 CLIMATE CHANGE IMPACTS RELEVANT TO COMMUNITY DEVELOPMENT

Key steps to increase resilience, especially resilience as applied to community planning, are to identify likely future scenarios and threats and then ensure that there is a plan in place to both mitigate the effects of those scenarios and recover from events quickly. In that vein, this section will summarize a few likely threats that Vermont should account for in planning efforts: disaster declarations, flood events, droughts, and potential impacts from climate migration. This is not an exhaustive list.

9.3.1 Disaster Declarations

Disasters in Vermont previously declared by the Federal Emergency Management Agency (FEMA) indicate which kinds of hazards Vermont should account for in community development decisions and planning efforts (Table 9-2).

Table 9-2: FEMA disaster declarations in Vermont (FEMA, n.d.) as of October 2021, in order by type and most recent date. Rows shaded grey indicate that the disaster declaration included flooding.

Type of Declaration	#	Date(s) of Declaration
COVID-19 Pandemic	2	March 13, 2020; April 8, 2020
Tropical Storm Henri	1	August 22, 2021
Severe Storms and Flooding	27	September 29, 2021; January 17, 2020; June 14, 2019; July 30, 2018; January 2, 2018; August 16, 2017; July 29, 2015; June 11, 2014; August 2, 2013; June 13, 2013; November 8, 2011; July 8, 2011; June 15, 2011; September 12, 2008; July 15, 2008; August 3, 2007; May 4, 2007; September 23, 2004; September 12, 2003; July 12, 2002; January 18, 2001; July 27, 2000; June 30, 1998; July 25, 1990; September 11, 1989; June 18, 1984; August 30, 1969
Severe Winter Storm	3	February 3, 2015; January 29, 2014; January 14, 2009
Severe Storm, Tornado, and Flooding	2	June 22, 2012; August 15, 2008
Tropical Storm Irene	2	September 1, 2011; August 29, 2011
Severe Storm	1	December 22, 2010
Snow	1	April 10, 2001
Tropical Storm Floyd	1	November 10, 1999
Severe Ice Storms, Rain, High Winds and Flooding	2	January 15, 1998; August 5, 1976
Excessive Rainfall, High Winds, and Flooding	1	July 25, 1997
Extreme Rainfall and Flooding	2	June 27, 1996; August 16, 1995
Ice Jams and Flooding	2	February 13, 1996; March 18, 1992
Heavy Rain, Snowmelt, and Flooding	1	May 12, 1993
Drought	1	September 6, 1977
Severe Storms, Flooding, and Landslides	1	July 6, 1973
Flooding	1	March 17, 1964
Drought and Impending Freeze	1	November 27, 1963

As shown in Table 9-2, forty-two of the fifty-two FEMA disaster declarations since 1963 have included flooding. Nine of the fifty declarations have been related to winter storms, snow, or ice storms and two of the fifty were for drought. Based on this history, it is clear that people involved in community development, especially planners, should include severe storms and flooding in all future scenarios and planning efforts. More prolonged dry spells and drought are expected in coming decades, so they should also be considered in planning and community development (see the Climate Change in Vermont chapter and Water Resources chapter).

9.3.2 Flooding

As exemplified by Tropical Storm Irene and the majority of disaster declarations since 1963, Vermont has a history of flooding, and climate change is projected to increase the frequency and severity of flood events in the state. The Water Resources chapter and Climate Change in Vermont chapter discuss the causes and impacts of flooding across the state of Vermont. This section will focus on flooding in the context of human communities: what has been done and can be done to reduce the impacts of flooding on Vermonters and their communities.

9.3.2.1 Flood Mitigation Strategies

Since Vermont has already experienced flooding and is projected to face increased threats of flooding in the future, this section describes some strategies to build resilience to flooding. The "International Lake Champlain-Richelieu River Study Board" is conducting a study to better understand the "the causes, impacts, risks and potential solutions to flooding in the basin" (International Joint Commission, 2020). A summary report (International Lake Champlain-Richelieu River Study Board, n.d.) and full report (International Lake Champlain-Richelieu River Study Board, 2019) are available. The report cites natural geographical and meteorological factors that affect flooding (e.g., physical geography, changes in weather patterns, the baseline lake level, and vegetation within the Richelieu River), but it also cites anthropogenic changes. These anthropogenic changes include population growth and land use changes (such as development in the floodplain, wetlands loss, and impervious surfaces), channel alterations and instream construction, and flood storage reservoirs (International Lake Champlain-Richelieu River Study Board, 2019). These anthropogenic factors mean that community development and planning decisions can affect future flood impacts, and therefore development decisions should be carefully considered.

A key flood mitigation resource in the state and to environmental justice, Flood Ready Vermont (State of Vermont, 2021g) is a resource to support community planning. It provides information on flood impacts to the state, strategies to mitigate flood risk and impacts, and planning resources. Importantly, it notes that flood impacts are not shared equally among Vermont residents. For example, Tropical Storm Irene and the spring flooding of 2011 destroyed 154 mobile homes in parks in Vermont, and 12% of mobile home parks in the state are located in floodplains (Baker et al., 2014).

Flood mitigation resources and strategies are described below.

- **Community Rating System**: Currently, seven Vermont communities are receiving discounts on their National Flood Insurance Program (NFIP) premiums through their communities' participation in the Community Rating System (CRS) (FEMA, 2019). CRS is a program through which communities receive increasing discounts in flood insurance premiums by demonstrating how they have undertaken certain flood risk reduction actions. These actions range from education and outreach through posting information at risk areas to participating in buyout programs to remove properties from the floodplain. As this program can be complicated, a Community Rating System Green Guide was released in 2017 to aid communities in undertaking some of the more environmentally friendly actions (Association of State Floodplain Managers, 2021).

- **Emergency Relief and Assistance Fund (ERAF)**: ERAF provides state funding as a match for federal funding received after federally declared disasters (State of Vermont, 2021c). Through ERAF, the state will pay additional amounts if the damage occurs when a community has taken certain protective or preventative actions. The Lake Champlain Sea Grant has summarized these actions through Watershed Scorecards, such as for the Lamoille, Missisquoi, and Winooski Watersheds (Lake Champlain Sea

Grant, 2021). Additionally, participation in the Community Rating System can help communities qualify for ERAF.

- **Buy-outs and Encroachment Removal:** Buyouts and encroachment removal refer to when the state or federal government purchase properties in a floodplain (often repetitive loss properties) and remove the structures from the floodplain. Buyouts and open space preservation are actions specified to increase a community's rating within the Community Rating System. In Vermont, buying out homes in vulnerable areas as a flood mitigation strategy began after the flooding from Tropical Storm Irene (Davis, 2017). Vermont is pursuing the buyout of 130 residences with funding through the FEMA Hazard Mitigation Grant Program with a Housing and Urban Development Community Development Block Grant match portion (State of Vermont, 2021f).

- **Flood-proofing and Elevating:** Another flood mitigation strategy is to flood-proof and elevate structures, such as through elevating the bottom floor of the structure, elevating utilities (e.g., electricity), switching from a basement to an above-grade crawl space, and providing vents so that flood water can enter and exit a space freely (State of Vermont, 2021b).

- **Floodplain, Wetland, and River Corridor Restoration:** A key flood mitigation strategy is to preserve and restore floodplains and river corridors. These ecosystems can buffer communities from negative flood and other climate change impacts. A study of the Otter Creek wetlands and floodplains in Middlebury, Vermont estimated that upstream flood mitigation by wetlands and floodplains would provide damage reductions of 84–95% during Tropical Storm Irene and 54–78% in reductions averaged across ten other flood events (Watson et al., 2016). In a study of the Lake Champlain-Richelieu River Watershed, wetlands were shown to be an important part of the watershed, and the study recommended they be maintained as storage areas in the upper parts of the watershed (Rousseau, 2020).

- **Planning and Funding**: Vermont and Vermont communities are engaging in many planning efforts and have leveraged federal funding sources. These will be described below in the section “Vermont Planning in the Face of Climate Change.”

9.3.2.2 Stormwater Management via Green Stormwater Infrastructure

Another flood mitigation strategy is to improve the stormwater management system. Stormwater management refers to the systems that deal with water from rainfall, flooding, and other water-related events to reduce potential damages from increased water levels. Green infrastructure (GI) is a type of stormwater management and flood mitigation strategy that involves the use of environmentally friendly or natural materials (e.g., green roofs, rain gardens, bioswales). GI has been used in Vermont’s urban areas long before state and United States Environmental Protection Agency (EPA) stormwater standards were made available. In Vermont, the 2017 Vermont Stormwater Management Manual Rule and Design Guidance added green infrastructure strategies into the design requirements for certain projects (Vermont Agency of Natural Resources, 2017) and the state supports a GI manual for homeowners (Vermont DEC, 2018b). The Green Infrastructure Collaborative is a partnership between the Lake Champlain Sea Grant and the Vermont Department of Environmental Conservation that promotes GI practices in Vermont. The state strongly supports GI, as evidenced by this explanation: “Humans rely on GI for a variety of ecological goods and services, such as clean water and air, carbon sequestration, flood control, and climate change mitigation. GI can also increase property values, enhance tourism and recreational opportunities, create jobs, and improve human health and well-being” (State of Vermont, 2021d). Nature-based solutions for stormwater management also utilize wetlands and forests to retain water during extreme water highs and lows. Groups like The Nature Conservancy Vermont protect land and thus provide these nature-based solutions. Other groups working on nature-based solutions for water management (e.g., riparian tree planting) include the new Watershed Forestry Program with Lake Champlain Sea Grant, the Natural Resource Conservation Service, the Intervale, multiple local watershed groups, and American Forests.

Several United States cities have resilience plans that deploy green infrastructure. These plans can serve as examples for Vermont communities seeking to integrate GI into their flood mitigation and stormwater management strategies. Following are strategies communities have used to increase GI.

- **Integration into Street/transportation Projects**: Recognizing the ability of GI to create multiple benefits, especially as compared to traditional stormwater management techniques, some cities are targeting GI implementation in conjunction with street improvement projects (e.g., City of Berkeley, 2016, p. 34).
- **Demonstration Projects**: Demonstration projects can raise public awareness and garner public support for GI implementation (e.g., City of New Orleans, 2015, p. 39).
- **Green Infrastructure and Stormwater Management Plans**: Several United States cities have developed plans dedicated to implementing GI and stormwater management (e.g., Oakland, CA has both a GI plan and a stormwater management plan) (City of Oakland, 2016).
- **Dedicated Funding to Green Infrastructure**: Cities have dedicated funding sources for the implementation of GI projects (e.g., Honolulu, HI has a stormwater enterprise fund) (City and County of Honolulu, 2019).
- **Education and Outreach**: Lake Champlain Sea Grant has a stormwater management curriculum (GI focus) for middle and high school students and builds capacity for teachers to teach the topic (accessible online at go.uvm.edu/stormwatered) (Stepenuck & Eaton, 2020).
- **GI Certification Programs**: There is a national GI certification program that could be adopted in Vermont (EnviroCert International, Inc., 2021). Lake Champlain Sea Grant is considering a state certification program that would include GI maintenance, such as has been done in New Hampshire at the Stormwater Center (University of New Hampshire, 2021).

It is worth noting that many GI projects or programs are suited to municipal activities. While some GI projects can be implemented by businesses or residences (e.g., green roofs, rain gardens), the materials or installation may be cost-prohibitive (e.g., renting a backhoe for rain garden development) and therefore more limited in scope without wider programming or support.

9.3.3 Drought

While drought was only declared as a FEMA disaster twice in the past fifty-five years, Vermont will experience greater variability in water-related extremes: an increase in overall precipitation yet more frequent dry-spells and drought. More information on how climate change may increase droughts in Vermont is found in the Extreme Events section of the Climate Change in Vermont chapter. In the context of community development, it is important to consider the variability in precipitation that the state will experience. The state is projected to have an overall increase in the amount of annual precipitation and experience periods of drought. This variable presents planning challenges for communities.

Droughts can impact Vermont communities in terms of agricultural production, water supply, impacts to forestry and wildlife, and ultimately, human health. As stated in the Water Stress section of the Agriculture and Food Systems chapter, drought conditions in Vermont will become more variable and directly impact growing seasons. For example, the state experienced droughts for much of the 2016, 2018, and 2020 growing seasons, and as of May 2021, 75% of the state is in moderate drought (NOAA & National Integrated Drought Information System, n.d.). In 2020, farmers reported at least $27 million in crop losses from the drought (McCallum & Picard, 2020).

Three out of ten Vermont households get their drinking water from private wells (Vermont Department of Health, 2021a), and about 60% of Vermonters rely on groundwater for drinking (VT DEC, 2018b). Drought can limit these households' access to water supply. Towns with already limited water supply will be further stressed by drought conditions. Efficient water use and water systems are increasingly necessary (see the Water Resources chapter). For example, the company Fresh Water Haulers in Underhill has seen an increase in the number of dry wells they have been asked to replenish. They reported, “I’ve seen this going on for about six years now. Every year it gets a little drier” (McCallum & Picard, 2020).

On a brighter note, the stormwater management strategies listed above may be able to decrease flooding and increase access to water during times of drought (McCallum & Picard, 2020). For more information, see the Water Supply section of the Water Resources chapter.

9.3.4 Climate Migration

Climate change is a slow and steady process punctuated by severe events. Consequently, people may decide to move to more favorable locations either slowly as long-term decisions or quickly and in larger pulses in response to disasters. In Vermont, there are two kinds of impacts of climate-induced changes and migration. The first are the direct results of climate change – for example increased flooding or droughts that may leave certain parts of the state less habitable than previously and lead to migration to other areas. The second are the more indirect effects of a changing climate and potential in-migration from other regions both nationally and internationally. Thus, while Vermont itself may not be exposed to certain risks, other communities that find themselves vulnerable to climate change impacts like extreme heat (Winkler & Rouleau, 2020) and coastal sea level rise (Hauer, 2017) may look for safer options. Some scholars have speculated that populations in at-risk regions may consider migrating to safer, less vulnerable areas (Hauer, 2017). Some climate projection maps indicate that Vermont may remain a “favorable” location under future conditions (Shaw et al., 2020). An example of climate migration is a family who “moved to Vermont last year from Richmond, Va., where they had a small farm with chickens and rabbits. [...] they had considered installing solar panels on their property and going off the grid, but southern Virginia's increasingly hot summers, combined with the bleak ecological prognosis, compelled them to go north instead. [...] ‘We figured that people are going to be on the move in the decades to come, so we wanted to move to a state that had already done some work as far as renewables are concerned,’ [the family] said” (Edgar, 2021).

Such speculation has led to questions for policymakers, government officials, and local communities about how and whether to plan for an influx of *climate migrants*. There is currently no data to suggest that any such in-migration is on the immediate horizon. Indeed, while Vermont has a long history of both labor migration and a robust refugee resettlement program, both are relatively small in scale and concentrated in the northern parts of the state. In fact, for well over a century, Vermont has grappled with an *out-migration* dynamic, especially of youth, that state leaders have attempted to address (Bolduc & Kessel, 2015). The main population growth centers in Vermont are primarily in Chittenden County and the metropolitan area surrounding its main city of Burlington; it is here that the majority of both international and national migrants to Vermont settle. Issues of transportation access, housing and employment availability, and a lack of diversity in rural areas have contributed to these spatial settlement patterns (Bose, 2014). Studies of resettled refugees, mainly from Bhutan, Bosnia, Burma, Congo, Iraq, Somalia, Sudan, and Vietnam, within Chittenden County (where nearly all have been placed) suggest that integration has been largely a success, with strong levels of employment, home ownership, entrepreneurship, and educational outcomes (Bose, 2020).

Climate migration brings into question the agency of those moving to new locations; climate migration can occur voluntarily and involuntarily. For example, Tacy, Hanson, and Poulin (2020) conducted an assessment of climate migration in Vermont and concluded that the largest group of people migrating to Vermont will likely be voluntary “amenity migrants” (e.g., white, wealthy, and making an intentional decision to move to the state). The next most common groups likely to move to Vermont are those in search of work due to collapsed industries and disaster migrants (i.e., those fleeing a disaster in another region) (Tacy, Hanson, & Poulin, 2020). If climate migrants do come to Vermont, they are likely to settle in Chittenden County and smaller towns with “amenity value” (Tacy, Hanson, & Poulin, 2020), continuing trends seen during the in-migration patterns during the COVID-19 pandemic. Involuntary climate migrants may be fleeing a disaster that destroyed homes and have no choice other than to move. Involuntary migrants also may include refugees who may have had no choice but to settle in Vermont. Considering the agency of migrants brings into question: just because amenity migrants are most likely to move to Vermont, is this equitable? Should the state consider programming and services to ensure that those most impacted by climate change and climate change-induced disasters (both in-state and out of state) have the same opportunity to move to more favorable climatic conditions?

One thing is clear when it comes to how climate migration will impact Vermont: there is a lot of uncertainty, many questions remain, and there are many important avenues for future research. Questions remain as to what kind of infrastructure and planning is needed to provide appropriate support to potential climate migrants. for example, what kinds of support in terms of housing and employment should be considered for migrants from other parts of the United States? For international migrants, what language or cultural support might be available? What kinds of capacities—numbers of in-migrants and available resources—should local communities plan for? What kinds of community planning strategies (e.g., low-impact development, smart growth strategies, changes to zoning and land use regulations) should be in place to prevent amenity migrants from buying undeveloped land that could otherwise serve flood mitigation or carbon sequestration services? Future research could investigate trends in home sales following hurricanes, wildfires, or other climate change-related disasters to better understand what kinds of migration pulses could be expected due to extreme events.

9.3.4.1 Migration Associated with COVID-19

Migration due to the COVID-19 pandemic could shed light on the potential impacts of climate-induced migration. The pandemic spurred “urban flight,” in which residents of urban areas moved to more suburban or rural areas with lower population densities and (perceived or actual) lower rates of COVID-19 transmission. Vermont saw a 38% increase in residential property sales to out-of-state buyers in 2020 (Figure 9-1), with over 1,000 more property sales in 2020 than in 2019 (VCGI, 2021). Stowe had the highest number of out-of-state residential property buyers in 2020, with $132,100,000 in sales (VCGI, 2021). Overall, sales were greatest in southern Vermont, the Mad River Valley, and Lamoille and Chittenden counties (Petenko, 2021).

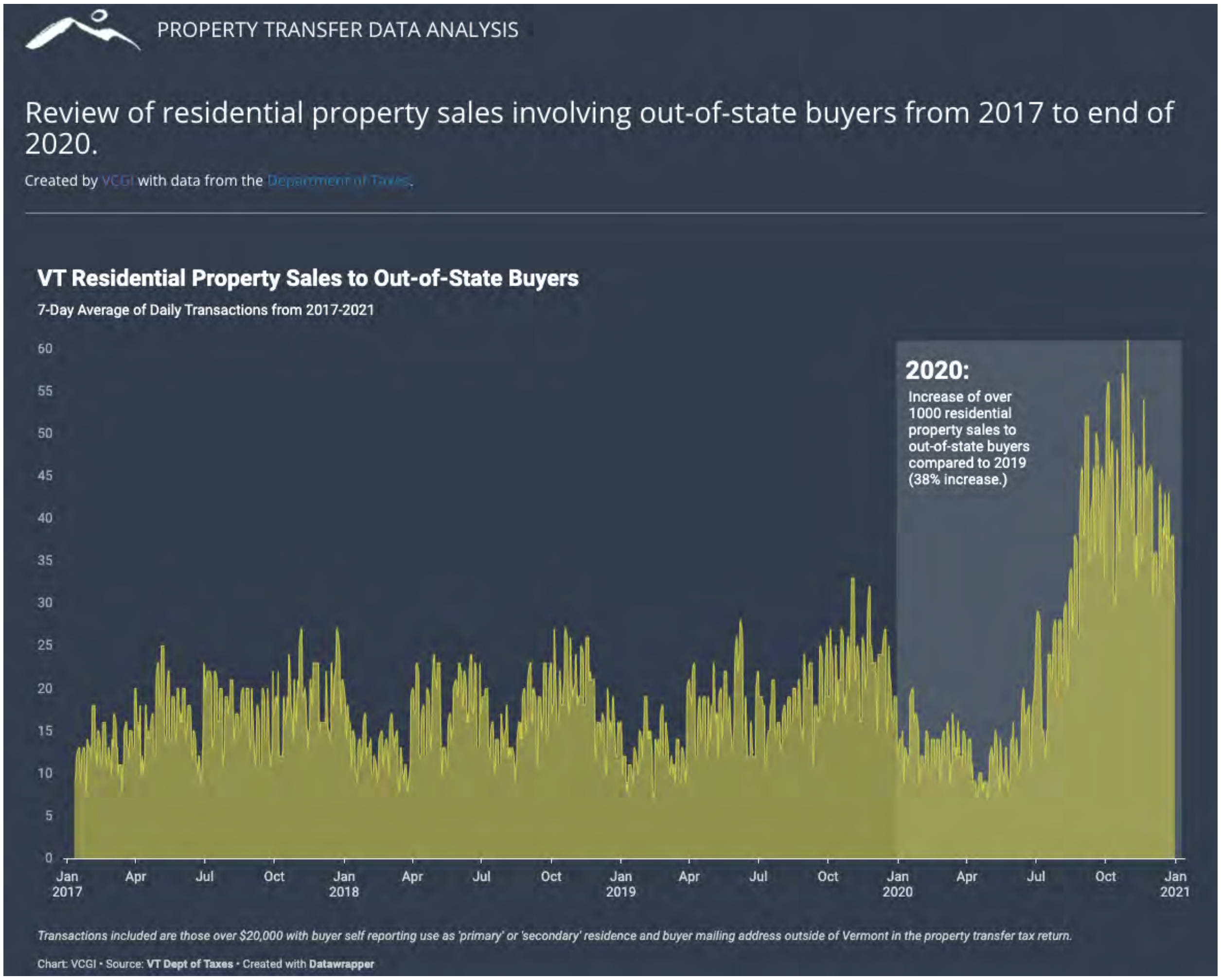

Figure 9-1: Vermont housing sales since 2017 to out-of-state buyers. Graphic created by VCGI with data from the Department of Taxes (VCGI, 2021)

COVID-19-related migration also had an impact on housing prices. A cross-city analysis (Honolulu, Houston, Santa Clara, Irvine, and Des Moines) of housing prices in the United States during the pandemic found that only Honolulu showed a decrease in housing prices. Houston, Santa Clara, Irvine, and Des Moines all had housing price increases (Wang, 2021). Given this data, it is possible that climate migration may exacerbate Vermont's existing "crisis of affordability" (Heintz, 2020), however, future research is needed.

Urban flight (i.e., people fleeing urban areas during the pandemic to avoid high transmission rates of COVID-19) in the United States was largely by "younger, whiter, and wealthier" populations fleeing to areas to which they were socially connected (e.g., sheltering with family and friends or in second homes) (Coven et al., 2020, p. 1). Consequently, the regions receiving pandemic-migrants were shown to have higher cases of COVID-19, which suggests that "urban flight was a vector of disease spread" (Coven et al., 2020, p. 1).

Both the pandemic's impact on housing prices and urban flight raise questions of equity about who is able to purchase a home and who is able to move out of more at-risk areas. Both questions are key to future planning surrounding climate change and climate migration. A Vermont Public Radio interview described how Vermont has too few homes for sale and how the uptick in home sales during the pandemic have led to affordability concerns (Wertlieb & Smith, 2021). The interview reported that buyers who were "super strong financially" and "out-of-state buyers who may be able to put more cash down, for example, than somebody who's [already living] in-state" were often winning bids (Wertlieb & Smith, 2021). Higher-income populations were also more easily able to move out of less-desirable urban areas during the pandemic, and as a result, communities of color, who often had less agency and ability pick up and leave less-desirable circumstances, were impacted disproportionately by the pandemic (Golestaneh et al., 2020).

Vermont could consider the COVID-19 pandemic a glimpse into future climate migration events. Climate change does not often create brand-new challenges, it more often exacerbates existing challenges and inequities. Many questions and uncertainties remain about how climate migration will impact Vermont, so the pandemic could serve as a starting point for planning and future research.

9.4 INFRASTRUCTURE SYSTEMS AND THEIR INTERCONNECTIONS IN THE CONTEXT OF CLIMATE CHANGE

Vermont communities rely on infrastructure systems for their well-being. These systems, also called lifeline or critical infrastructure systems, are projected to be negatively impacted by climate change. This section applies a nexus approach to community development in Vermont. A nexus approach is a methodology in which systems' interconnections are intentionally accounted for or investigated in the context of any research or planning endeavor, in this case, community development in the context of climate change. Applying a nexus approach in the context of implementing climate change adaptation and resiliency planning is important because the infrastructure systems on which communities rely do not operate in isolation; they have many interdependencies. The key infrastructure systems to consider in the context of community development and planning and climate change are water, transportation, communications, energy, food, and healthcare infrastructure. The following subsections highlight the key climate change impacts to each infrastructure system and the interconnections between systems that are most relevant to the state of Vermont.

Other Vermont Climate Assessment chapters cover individual systems in greater depth; the purpose here is to focus on aspects of the infrastructure systems relevant to community development and planning and introduce key infrastructure interconnections. Please refer to the Water Resources, Energy, Agriculture and Food Systems, and Human Health chapters for more information. Additionally, resources on flood resilience and critical infrastructure are available from the Department of Homeland Security (Department of Homeland Security, n.d.).

9.4.1 Water Infrastructure

In Vermont, 30% of households obtain drinking water from private wells (Vermont Department of Health, 2021a). Aside from newly dug wells, these water sources are not regulated by the state of Vermont or EPA. According to the 2019 Vermont Infrastructure Report Card, the state's drinking water system received a score of C- (mediocre), the stormwater system received a score of D+ (poor), the dams received a score of C (mediocre), and the wastewater system received a score of D+ (poor) (ASCE, 2019).

Following are concrete examples of how water infrastructure is critical to other infrastructures in the state.

- ***Water - Health***: Water and water quality are essential for human health and well-being. Disasters or flooding can disrupt the municipal water system, which can leave communities without water or without safe drinking water. For example, after Tropical

Storm Irene, many Vermonters were concerned about whether the flood waters and stormwater runoff had contaminated their well water. Neither the state nor EPA regulate well water testing, so it is important for individuals to be proactive about procuring testing (Vermont Department of Health, 2021a).

- ***Water - Energy***: The energy system often requires water for hydropower generation or geothermal ground source heating (Renewable Energy Vermont, 2021). Eighty-five hydroelectric generation facilities currently operate in Vermont and on its borders (State of Vermont, 2021e).

- ***Water - Economy***: A recent study found that phosphorus reduction in Lake Champlain would benefit the economy by increasing tourism and the value of real estate (Gourevitch et al., 2021). At Missisquoi Bay, alone the study estimates that eliminating phosphorus inputs would benefit tourism by $28.5 million and property sales by $11.2 million (Gourevitch et al., 2021).

- ***Water - Recreation***: Harmful algal blooms, which thrive under the warmer temperatures projected in Vermont under climate change, negatively impact lake tourism. As discussed further in the Water Resources chapter, harmful algal blooms cause many industries to shut down, and many tourist establishments cannot operate (e.g., an increase in the number of beach closure days).

9.4.2 Transportation Infrastructure

According to the 2019 Vermont Infrastructure Report Card, the state's bridges and roads each received a score of C+, which equates to *mediocre* (ASCE, 2019). As of 2017, Vermont had 14,174 miles of local and state roadways, 806 miles of the National Highway System, 2,709 miles of the State Highway System, and 139 miles of Class 1 town highways (ASCE, 2019). The damage from Tropical Storm Irene highlighted the vulnerabilities of the state's transportation system and inspired the Vermont Agency of Transportation (VTrans) to create the Vermont Transportation Resilience Planning Tool (TRPT) in 2019 (Esri et al., 2019). The Vermont TRPT seeks, "to improve the resilience of Vermont's highway network to floods and erosion by providing data and tools to inform planning and investment decisions." Instead of only trying to recovery from damages as quickly as possible, the tool can be used to identify vulnerabilities to proactively reduce or avoid damages in the future (Schliff et al., 2018, p. 1).

Following are examples of how other infrastructure systems depend on the transportation infrastructure system.

- ***Transportation - Food***: The food system relies on the transportation system to distribute agriculture products and to resupply grocery stores, and the transportation system limits access to food when severe snow storms or extreme weather events block roads, and therefore access to food. Reflection of the deep connections between the food system and the transportation system makes it clear that there is an urgent need to examine supply chains in the context of climate change. Many cities and states rely on national and global supply chains, which can be threatened by climate change (Heard et al., 2017). As stated in the Vermont Agriculture and Food System Strategic Plan 2021–2030, "Bolstering short and reliable regional food supply chains will reduce our exposure to global food system disruptions and meet the needs of our most vulnerable communities" (Claro et al., 2021, p. 7). More information on the food system in Vermont is available in the Agriculture and Food Systems chapter.

- ***Transportation - Health***: Transportation infrastructure is linked to health in terms of the improved air quality potential resulting from switching to electric vehicles (EVs) and other alternative fuels to reduce emissions. Transportation is also critical to health in terms of ensuring transportation along supply chains of pharmaceuticals and other medical supplies and via access to healthcare facilities during a natural hazard or disaster.

- ***Transportation - Energy***: Blocked roads and damaged bridges following a disaster can limit the ability of response teams to reach and repair downed power lines and other energy system disruptions. A Seven Days article interviewed people in towns that had been cut off from transportation and energy during Tropical Storm Irene. One person reported, "'Bath told me she was supposed to start student teaching on Monday, but without electricity or a phone or a reliable way to get off the mountain, she's in a holding pattern.'" And, "'We're so cut off here. It could be a month before our electricity comes back on. It could be three days,' she said. 'It's just totally overwhelming.'"(Ober, 2011a).

- ***Transportation - Economy***: During disasters, particularly flood events, it is common for roadways to become impassible due to damage or blocked by debris. Employees may not be able to reach their workplaces due to transportation system disruptions, and supply chains can also be disrupted. For example, Tropical Storm Irene damaged the roads and bridges around the state and as a Seven Days article stated, "roads in and around Killington were swept away, isolating residents and businesses for weeks" (Levitt, 2012).
- ***Transportation - Environment****:* In Vermont, the transportation sector is the leading source of GHG emissions, mostly from private cars. In 2010, transportation was responsible for 51% of the city of Burlington's GHG emissions (Kelley, 2013).

9.4.3 Communications Infrastructure

- Many people in Vermont have access to broadband and internet, but a "digital divide" remains: currently, 60,000 homes lack broadband (McCallum, 2021b). Vermont is currently developing a ten-year telecommunications plan (State of Vermont, 2021a) that meets the new requirements for broadband deployment established by Act 79 (Vermont Pub. L. No. 79, H.513, 2019). Communications infrastructure can be impacted by climate change in several ways, including: increases in temperature and precipitation can impact wireless transmissions through reduced signal range and weakened quality, and disasters slow response and recovery by limiting access to infrastructure to conduct repairs. On the other hand, it is possible that climate change could stimulate innovation and "accelerate the rate of technology change" (Ospina et al., 2014, p. 23).

- ***Communications - Health and Emergency Preparedness***: Lack of communications can leave communities without the ability to request help, which can put health and safety in jeopardy. Lack of communications can also interrupt response and recovery efforts following a disaster. Conversely, a study of healthcare workers in Vermont and New York following Tropical Storm Irene and Hurricane Sandy reported that "response and service organizations had to counter false information, rumor, and speculation while attempting to reach populations that lacked electricity, internet, and phone service. A noted dual challenge was how to provide continuous, needed information from a source that could be accessible should utilities go out and how to ensure that the public knew about this information source ahead of the disaster" (Walsh et al., 2015, p. 157). According to a *Seven Days* article, "After [Tropical Storm Irene], many Bethel residents were unable to access emergency information about their town, Nikolaidis explains. Her own family didn't have power or telephone service for five days; cut off from town by the washed-out road, they knew little about what was happening in the village" (Picard, 2014). In response, the Vermont Council on Rural Development launched the Digital Economy Project, which aims to build resilience through providing digital infrastructure to Vermont towns that previously lacked it (Picard, 2014; Vermont Council on Rural Development, n.d.-d). The Digital Economy Project has "delivered Front Porch Forum to every town in Vermont, created twenty-six free Wi-Fi zones/hotspots and twenty-five new municipal websites, and advised over 120 nonprofits and 260 small businesses" (Vermont Council on Rural Development, n.d.-d).

- ***Communications - Economy***: As the pandemic showed, many jobs, representing a strong portion of the economy, rely on communications infrastructure. Additionally, having an online business presence, such as a website, can increase businesses' resiliency. For example, Rochester, Vermont was isolated with no power or services for a week following Tropical Storm Irene. Beth Frock, owner of Boysenberry Smart Clothes in Rochester, found no outside traffic, even once basic services had been restored. This caused Frock to obtain a part-time job to make ends meet (Ripley, n.d.). In response, the Vermont Small Business Development Center, a partner in the Vermont Digital

Economy Project, assisted Frock in creating a website for Boysenberry Smart Clothes so that her company can remain competitive even when there are local disruptions (Ripley, n.d.).

9.4.4 Energy Infrastructure

The connections between the energy system and climate change are clear: energy sources are a significant contributor of CO_2 emissions. There are three types of electric utilities in Vermont: investor-owned, municipal electric departments, and member-owned rural electric cooperatives (State of Vermont, 2017). According to the 2019 Vermont Infrastructure Report Card, the state's energy system received a score of B-, which equates to *good* (ASCE, 2019). Current transmission lines are not able to accommodate the increases in renewable energy sources that are being deployed across the state, a key challenge (McCallum, 2021a).

- ***Energy - Food***: Most Vermonters purchase food from food retailers such as grocery stores. These retailers rely on the energy system to operate the buildings and refrigerate fresh and frozen food. With the projected increase in storm events, a loss of power can result in the closure of food retailers and consequent food spoilage. A Seven Days guide to preparing for Hurricane Sandy recommends, “Set your refrigerator and freezer to their coldest settings (remember to reset them back to normal once power is restored). During an outage, do not open the refrigerator or freezer door unnecessarily. Food can stay cold in a full refrigerator for up to twenty-four hours and in a well-packed freezer for forty-eight hours (twenty-four hours if it is half-packed)” (Picard, 2012).

- ***Energy - Water***: Power outages can cause disruptions in water treatment plants and the ability to pump water, including from private wells. A Seven Days guide to preparing for Hurricane Sandy suggests, “If your water supply could be affected by a power outage (a well-water pump system), fill your bathtub and spare containers with water. Water in the bathtub should be used for sanitation purposes only, not as drinking water. Pouring a pail of water from the tub directly into the bowl can flush a toilet” (Picard, 2012).

- ***Energy - Transportation***: A power outage can disrupt traffic signals and charging infrastructure for electric vehicles. Also, power is required to pump fuel at gas stations, so lack of power can disrupt the ability to operate vehicles. For more information about the links between energy and transportation, see the discussion of vehicle electrification in the Energy chapter.

- ***Energy - Health***: Increasing adoption of renewable energy sources and energy efficiency technologies will help reduce GHG emissions and improve air quality. Also, many services that are critical to health (such as hospitals, food retailers, and water treatment facilities) rely on power to function. Loss of power to these critical facilities can lead to food and waterborne illnesses and limit access to health care. Loss of power in winter can cause hypothermia. Loss of power in summer heat can lead to heat exhaustion. For more information on the health impacts related to the energy system and GHG emissions, see the Human Health chapter.

- ***Energy - Communications***: Power outages can disable or disrupt communications systems, such as internet access and cell service. The lack of digital communication can impact emergency response. In a study of the multifunctionality of country stores in Vermont, interviewees noted that their local country stores served as central hubs. With power out for almost a week during Tropical Storm Irene, people could not get information without power or internet, so the stores ran generators and served as important hubs (Morse, 2018).

- ***Energy - Environment***: Non-renewable forms of energy generation impacts the environment through GHG emissions. Switching to renewable sources of energy has environmental co-benefits in terms of air quality improvements and GHG reductions. Additionally, the energy system can have additional negative impacts to the environment during disasters. For example, flooding caused by Tropical Storm Irene ruptured a fuel tank in a municipal office building in Waterbury, turning “the basement into an oily pool” (Remsen, 2015).

- ***Energy - Economy***: Vermont has seen an increase in solar panel and array deployment, benefitting the environment through reduced GHG emissions and supporting the economy. Kelley and Flagge (2014) summarize, "Vermont's solar sector also rests on a firm foundation: the net-metering program that the legislature put in place seventeen years ago. Net metering enables users of renewable energy to get credit for the excess power their systems contribute to the state's electrical grid. Solar currently accounts for more than 90% of the energy homes and businesses are selling back to utilities."

9.4.5 Food Infrastructure

The Agriculture and Food Systems chapter discusses the food system in detail primarily in terms of production. The focus in this Community Development chapter is the impact of climate change on food retailers, known as critical commercial services in academic literature. There is a strong culture of prioritizing locally grown and made products, which represent 13.9% of food purchases in Vermont (Claro et al., 2021, p. 5). The Vermont Agriculture and Food System Strategic Plan 2021–2030, released in February 2021, "confirms the need to prioritize our agricultural land base, infrastructure, and food security in order to increase Vermont farm and food system resilience to the impacts of climate change" (Claro et al., 2021, p. 7).

- ***Food + Water - Health***: Vermonters do not just rely on food broadly, they require access to fresh, healthy food for their well-being. The food system is linked to health in terms of power outages limiting refrigeration and water treatment during extreme events, which can lead to food and waterborne illness (Romero-Lankao & Norton, 2018).

- ***Food - Economy***: Vermont is America's leading producer of maple syrup. A report by the United States Department of Agriculture shows that Vermont's maple syrup production was 21% lower in 2021 than in 2020, a result of weather changes related to climate change (National Agricultural Statistics Service et al., 2021).

- ***Food - Environment***: Agricultural runoff and GHG emissions can negatively impact the environment. The Vermont Agriculture and Food System Strategic Plan 2021–2030 provides goals and objectives for how to improve farm stewardship to improve water quality. For example, there are specific methods and targets to ensure that agricultural pollutants do not exceed the Total Maximum Daily Load (TMDL) of phosphorus runoff into Lake Champlain (Claro et al., 2021).

- ***Food - Energy***: One way to reduce GHG emissions and increase renewable energy sources is to use waste from food and agriculture as organic material for biofuel generation. For example, the Energy chapter describes how Vermont has a “Cow Power” program, which seeks to capture methane produced from manure to burn as biofuel to generate electricity (Green Mountain Power, 2020).

9.4.6 Healthcare Infrastructure & Health

The Vermont Department of Health summarizes hospital infrastructure in the state: “There are fourteen non-profit hospitals and network of health care systems spread throughout Vermont including: eight small critical access hospitals, five mid-size rural hospitals, two academic medical centers, a Veterans Administration hospital, and five designated psychiatric inpatient facilities” (Vermont Department of Health, 2021b). Vermont hospitals and other healthcare facilities are susceptible to flood damage and rely on other systems to remain operational, including transportation for people to access the facilities, energy and water systems to run the facilities, and food to feed patients. Severe weather events can cause a breakdown in these infrastructures. For example, during Tropical Storm Irene, the state complex was inundated by flood waters, which “forced the emergency evacuation of fifty-one psychiatric patients—but not before they spent the night in the dark on the top floors of the state hospital with emergency fire alarms blaring for hours” (Remsen, 2015).

- ***Health - Environment***: Health can be impacted by air quality, increased heat, increased disease vectors (e.g., ticks and mosquitos), increased harmful algal blooms, and threats to drinking water from flood damage or hazardous spills. See the Human Health chapter for more detailed information on how the changing environment will impact the health of Vermonters.

- ***Health - Economy***: The economy depends on a healthy workforce. Additionally, healthcare is the most prominent industry in Vermont, employing approximately 50,000 residents (International Lake Champlain-Richelieu River Study Board, 2019).

9.4.7 The Economic System

Climate change-related disasters have varied effects on the economy. For example, following Tropical Storm Irene, "jobless claims nearly doubled in the first two weeks after the storm, peaking at 1,179 on September 3. Hard-hit Killington Resort initially filed a mass claim for 300 displaced employees but was able to put many of them back to work within a few weeks … . [...] On the other hand, the devastation created a surge in demand for construction work—the industry hardest hit during the recession in Vermont. Between 2007 and 2010, almost a fifth of all construction jobs in the state disappeared. Labor officials estimate 400 workers are presently employed rebuilding roads, bridges and flood-damaged structures" (Bromage, 2011). A "Stuck in Vermont" broadcast from Seven Days reporting on Wilmington, Vermont one month after Tropical Storm Irene found that the small town had more than forty flood-damaged businesses and 120 flood-related job losses; for such a small town, Irene nearly destroyed its economic center (Sollberger, 2011).

- ***Economy - Water Quality***: Harmful algal blooms, a proliferation of cyanobacteria that causes poor (or dangerous) water quality, reduced property values for shoreline properties in St. Albans Bay. The town of Georgia lowered the property values of thirty-seven lakefront properties by $50,000 each due to the blue green algae found in their waterfront (Hallenbeck, 2015). Harmful algal blooms can leave the lake unusable for recreation, which reduces the appeal of lakefront living (Hallenbeck, 2015). For more information on the health impacts of harmful algal blooms, see the Human Health chapter and for more information on water quality, see the Water Resources chapter.

- ***Economy - Floodplains***: A study of Otter Creek wetlands and floodplains in Middlebury, Vermont found that the floodplains reduce flood damages by 54–78%, with an annual value of flood mitigation services between $126,000 and $450,000 (Watson et al., 2016).

- ***Economy - Crop Production***: A United States Department of Agriculture report on crop production shows that Vermont's maple syrup production is down 21% compared to 2020 due to climate-related changes (NASS, 2021).

- ***Economy - Disaster Displacement:*** In an economic impact assessment of Tropical Storm Irene, it was estimated that Washington County would lose $32.7 million in income from the decrease of spending within the county due to relocated workers (U.S. Department of Commerce, 2012).

9.4.8 Social infrastructure

Social infrastructure, also called civic infrastructure or social cohesion, has been shown to strengthen communities and be a key contributor to community resilience (Chriest & Niles, 2018). Social infrastructure, or social capital, is classified as either "bridging" or "bonding." Bridging social capital improves intergroup linkages, where bonding social capital benefits intragroup linkages (Manyena et al., 2019). Project 14 is an initiative through the University of Vermont that connects student researchers with local newspapers with the goal of improving local news coverage and information-sharing in target areas throughout the state (University of Vermont, n.d.). Reilly (2021) describes a strong basis for information-sharing in the state: "Vermont already has many of the pieces in place for these efforts to make an impact, from strong media organizations like VPR, VTDigger and Seven Days, to active local governments, one of the highest rates of citizen volunteerism in the country, and a legislature and governor who are willing to work together to solve our challenges." Vermont author Bill McKibben credits Vermont's social cohesion as a reason that residents were initially receptive of economic closures and social precautions of the COVID-19 pandemic. He writes, "Vermonters entered the pandemic with remarkably high levels of social trust," and notes, "The state motto is 'Freedom and Unity,' and there's no question that, for the duration, Vermont's emphasis is on the latter" (McKibben, 2020).

- ***Social infrastructure - Economy***: A 2013 report on civic health and the economy states that factors such as social cohesion were predictors of a community's ability to withstand unemployment, such as during a recession (Levine & Kawashima-Ginsberg, 2013) or after a flood. Likewise, social cohesion can be useful in times of climate-related disasters (e.g., floods).

- ***Social infrastructure - Disaster Recovery***: A study of social capital following Tropical Storm Irene in Vermont revealed that "the strength and success of Vermont's recovery can be attributed to the combination and coordination between different types of social capital inherent of informal community efforts and the formal disaster framework" (Consoer & Milman, 2016, p. 171). For example, after over 700 residences had been destroyed or damaged by Irene flood waters, at least sixty second homeowners offered their vacation homes or condos to flood victims (Ober, 2011b).

- ***Social infrastructure - Food Security***: A study of social capital in rural Vermont following Tropical Storm Irene found that "rural communities with high levels of social capital display resilience and adaptation to food insecurity after extreme weather events" (Chriest & Niles, 2018). For example, residents of Moretown, Vermont organized a "meal train" in the aftermath of Tropical Storm Irene to help feed flood victims (Ober, 2011c).

9.4.9 Systems Interconnections as Co-Benefits

There are not only potential negative, cascading impacts between different systems; it is also important to consider potential positive "co-benefits" that can result between connected systems. Many resilience, adaptation, sustainability, or mitigation efforts can provide benefits far beyond the initial action or project. Considering the co-benefits of an effort can help actualize the true return on investment.

9.4.9.1 Example: Urban Forestry

Systems interconnections can be viewed as both negative, cascading impacts (as described above) where damage to one system negatively impacts the other systems to which it is connected and as positive co-benefits, in which changes to one system will benefit or improve the other systems to which it is connected. In the context of community development, urban forestry is a great example of how changes in one system (here, forestry) can provide positive changes in other systems.

Tree cover has been shown to improve air quality, help with the negative impacts of increased or extreme heat (such as the urban heat island effect), reduce flood impacts and improve water quality, and reduce energy costs through increased shading (see the Climate Change in Forests chapter for more information). Additionally, forests and tree cover have been shown to connect to diversity, equity, inclusion, and justice in that lower-income communities are more often associated with less tree cover, which deprives them of the many benefits listed in the prior sentence. As such, several cities in the United States have designed actions to build resilience around forests and tree cover; some examples are described below.

- **Trees for water quality**: Honolulu has an action entitled, "Minimize Economic and Property Risk within the Ala Wai Canal Watershed" (City and County of Honolulu, 2019, p. 100), which includes protecting forests as a method of addressing water quality and ecosystem health.
- **Trees for urban cooling**: To promote cooling, Honolulu has an action entitled, "Keep O 'ahu Cool by Maintaining and Enhancing the Community Forest" (City and County of Honolulu, 2019, p. 98), and Los Angeles has an action entitled, "Develop and launch a neighborhood retrofit pilot program to test cooling strategies that prepare for higher temperatures" (City of Los Angeles, 2018, p. 70), which seeks to promote cooling through increased vegetation and tree plantings.
- **Trees for equity**: To ensure that the benefits of tree cover are equitably distributed, Los Angeles has an action entitled, "Plant trees in communities with fewer trees to grow a more equitable tree canopy by 2028" (City of Los Angeles, 2018, p. 73) and another entitled, "Increase access to open space in underserved neighborhoods" (City of Los Angeles, 2018, p. 80).

In summary, several cities highlight the importance of forests and tree cover to increasing community resilience in the context of climate change. Vermont should consider community tree cover (increasing it, conserving it, ensuring its equitable distribution) as a method of improving air and water quality, reducing flood impacts, and reducing energy use through tree cover shading (which reduces use of air conditioners). Increasingly these strategies may be developed at the local level with support from state agencies or non-governmental organizations (see Climate Change in Forests Chapter).

9.4.9.2 Example: Food-Energy-Water Nexus

A classic example of co-benefits is the potential benefits associated with linking food, energy, and water systems (known as the food-energy-water nexus in academic literature). For example, prior to Magic Hat Brewing's move from South Burlington to New York, the brewery had installed a digester that was able to turn waste from the beer-making process (food) into energy through the use of a biodigester (McCallum, 2021a). Recently, an article by Seven Days (McCallum, 2021a) described how Franklin Foods plant, which produced Hahn's, a cream cheese, was looking into using the protein-laden wastewater from the cheese making process in an on-site digester to create methane, an energy source. With Franklin Foods, the potential lies in reusing protein-rich wastewater that the local wastewater treatment system did not have the capacity to treat and creating a local renewable energy source. The limitation was that the energy grid was not able to sustain another source of renewable energy.

9.4.9.3 Example: Vermont Council on Rural Development's Climate Economy Initiative

The Vermont Council on Rural Development (VCRD) has a Climate Economy Initiative, which seeks to promote the economic opportunity that results from the need for strategies that reduce energy use and carbon emissions (Vermont Council on Rural Development, n.d.-c). The initiative postulates that the climate change challenge of needing to reduce energy use and the associated carbon emissions can produce co-benefits in terms of stimulating green economic growth. For example, Grassroots Solar and Harry Hunt Architects are two Vermont businesses that embrace green economic growth as a co-benefit to climate action. Grassroots Solar, a solar company in Dorset, Vermont, seeks to help customers achieve energy independence through solar installations. Harry Hunt Architects, an architecture firm in Stowe, Vermont designs low-carbon homes ,so that less energy is needed for heating and cooling (Vermont Council on Rural Development, n.d.-a, n.d.-b). For more information, there is a "Progress for Vermont" report and action plan from the Vermont Climate Change Economy Council, which was founded by the VCRD (Vermont Climate Change Economy Council, 2016). This report makes recommendations for how the state can stimulate economic activity while addressing climate change.

9.4.9.4 Example: Water Quality Benefits to Implementing Flood Mitigation

A classic example of co-benefits is ecosystem services, the natural, non-monetary benefits associated with ecosystems and the natural environment. Protecting and conserving floodplains, wetlands, and forests (all examples of natural infrastructures) serve to both mitigate flood impacts and improve water quality (Singh et al., 2018). For example, wetlands provide ecosystem services in the form of flood attenuation and carbon storage, and they absorb phosphorus that can lead to degraded water quality (Singh et al., 2019). Additionally, in a study of open space protection and flood mitigation in the United States, open space preservation improve flood mitigation and improve water quality, and property values were increased along the perimeter of the preserved areas (Brody & Highfield, 2013).

9.4.10 Infrastructure Interconnections in the Context of Disasters

As described above, one of the most likely climate change impacts to face the state of Vermont is an increase in the frequency and severity of flood events. Given this likely scenario, this section describes systems interdependencies that have been noted in academic literature during flood and hurricane events. The objective is to demonstrate how systems interdependencies are relevant to Vermont and how they should be accounted for in relevant state, regional, or community planning.

The literature has highlighted how damage to the energy (de Bruijn et al., 2019) and transportation systems during a flood or other acute event will negatively impact nearly all other systems to which they are connected (Raub, Stepenuck, & Panikkar, 2021). For example, during the 2013 flood in Boulder, Colorado, six of the seven key roads adjacent to creeks became impassable, and the flood waters damaged the energy system, causing a power outage (Romero-Lankao & Norton, 2018). The lack of power resulted in many Boulder residents throwing away spoiled food due to the lack of refrigeration, and the damaged transportation system prevented deliveries, resulting in food shortages in the flooded area (Romero-Lankao & Norton, 2018). In a study of a hypothetical flood event in Florida, blocked roads were shown to limit access to food, reduce access to downed power lines for repair, and prevent the evacuation of those in severely impacted areas (de Bruijn et al., 2019). Food and water were also shown to impact health in that the lack of power for refrigeration and sanitation increased the prevalence of food and waterborne illnesses (Romero-Lankao & Norton, 2018).

Some mitigating factors in Boulder included use of radios and landlines when the communications system went down due to the power outage and use of a backup generator in a wastewater treatment plant that otherwise had lost power due to the power outage (Romero-Lankao & Norton, 2018). In a simulated hurricane, intentionally increasing the inventory at grocery stores and other critical commercial services in anticipation of a medium-scale (Category 3) hurricane event can reduce disruptions to food access in the surrounding community (Ni et al., 2019).

In Vermont, Tropical Storm Irene demonstrated the vulnerability of each infrastructure system cited as examples of interdependencies above. Tropical Storm Irene occurred on August 28, 2011 and caused extreme flood damage in Vermont, impacting 225 of Vermont's 251 towns (Anderson et al., 2020). Most notable was the damage to over 300 long-span bridges (Anderson et al., 2020). Additional damages included to state highway, municipal roads, and railroads, power outages to about 73,000 customers, Boil Water Notices in thirty public water systems, and hazardous waste and fuel spills (Pealer, 2012). The main office for Vermont Emergency Management in Waterbury was flooded, and thirteen communities were left with no passable roads to enter or exit the town (Pealer, 2012). Mobile home parks in the state were particularly hard hit; 154 mobile homes in parks were destroyed (Baker et al., 2014).

Prior studies demonstrate that pre-disaster planning and policy "result in lower disaster losses and serve to enhance community resilience" (Kim & Marcouiller, 2020, p. 1). A cost-benefit analysis of hazard mitigation found that $4 in future savings results from every $1 spent on infrastructure mitigation (Figure 9-2) (Multi-Hazard Mitigation Council, 2019).

National Institute of BUILDING SCIENCES

	ADOPT CODE	ABOVE CODE	BUILDING RETROFIT	LIFELINE RETROFIT	FEDERAL GRANTS
Overall Benefit-Cost Ratio	11:1	4:1	4:1	4:1	6:1
Cost ($ billion)	$1/year	$4/year	$520	$0.6	$27
Benefit ($ billion)	$13/year	$16/year	$2200	$2.5	$160
Riverine Flood	6:1	5:1	6:1	8:1	7:1
Hurricane Surge	not applicable	7:1	not applicable	not applicable	not applicable
Wind	10:1	5:1	6:1	7:1	5:1
Earthquake	12:1	4:1	13:1	3:1	3:1
Wildland-Urban Interface Fire	not applicable	4:1	2:1	not applicable	3:1

Figure 9-2: Infographic by the National Institute of Building Sciences depicting the overall benefit-cost ratio of adopting up-to-date building codes in terms of hazard mitigation for riverine flooding, hurricane surge, wind, earthquakes, and fire (Multi-Hazard Mitigation Council, 2019)

Combining a systems interconnection (nexus) approach with the study of resilience is relatively new. For example, a systematic literature review found only twenty peer-reviewed academic studies that have combined the fields of coastal resilience (often in the context of flood or hurricane events) and a food-energy-water nexus approach (Raub, Stepenuck, & Panikkar, 2021). A document analysis of eleven United States city resilience plans found little evidence that a food-energy-water-transportation nexus had been applied in the development of the resilience plans (Raub et al., 2021). Although many emergency operations plans may use a coordinated approach, this has not spread to resilience planning per se. This serves as a call for future research and application.

9.5 VERMONT PLANNING IN THE FACE OF CLIMATE CHANGE

Planning is necessary to effectively account for current and future threats and conditions of any kind. Planning for the effects of climate change, such as from increased flooding, can reduce damages and better prepare for damages that cannot be avoided. Planning has been shown to be an important tool to build resilience and in emergency management (Burby et al., 1999; Cucuzza, Stoll, & Leslie, 2020; Nelson & French, 2002). The state and its communities are currently undertaking a variety of planning efforts in response to climate change. This section will cover the planning efforts at the state level, state and local-level land use planning, local-level hazard mitigation planning, and, finally, resilience planning and efforts to build community resilience.

9.5.1 Statewide Emergency Plans

Planning in Vermont occurs at multiple scales: state, regional, and local or community. At the statewide scale, Vermont has a State Emergency Management Plan and a State Mitigation Plan.

- The State Emergency Management Plan can be found here: https://vem.vermont.gov/plans/state.
- The 2018 FEMA-approved State Hazard Mitigation Plan (Vermont Emergency Management, 2018) can be found here https://vem.vermont.gov/plans/SHMP.

9.5.2 State and Local Level: Land Use Planning and Implementation

In Vermont, land use planning occurs at both the state and local levels, as described by Claro et al. (2021): “Vermont is divided among eleven regional planning commissions (RPCs), each with a regional land use plan, and as of 2017, 84% of Vermont municipalities had also adopted a municipal plan. State planning statutes require regional and municipal plans to include a land-use map and policies for preservation of natural and scenic resources, as well as sections on other topics related to the food system such as economic development, flood resilience, housing, and transportation” (p. 167). Land use planning is important in the context of climate change, as it can promote environmentally friendly outcomes and it can be essential in mitigating community flood risk. At the state level, Act 250 is the seminal land use regulation, and the state planning goals found in 24 VSA section 4302 are the main state land use regulations. Municipal plans and zoning and subdivision regulations are key to land use planning implementation at the local level. Increasing fragmentation of forests is a concern of many Vermonters, as discussed in the Climate Change in Forests chapter.

9.5.2.1 State Level: Act 250

Act 250 is the state-level Land Use and Development Law in Vermont. Act 250 was passed in 1970 with the intent to preserve the "environmental, social, and aesthetic character of the state in the face of development pressure" (Smith, Sandler, & Goralnik, 2013). This act requires that developers of projects of a certain size (e.g., commercial greater than ten acres) or number of housing units (e.g., residential with more than ten units within a five-mile radius) obtain a Land Use Permit from the District Environmental Commission, in addition to any local or subdivision permits (Geiger, n.d.). Small developments, including single homes on small parcels, may not be subject to Act 250 restrictions (see the Climate Change in Forests chapter for more on land use change). Act 250 requires development projects to meet ten criteria as related to (State of Vermont Natural Resources Board, 2021):

1. Water and air pollution
2. Water supply
3. Impact on water supply
4. Erosion and capacity of soil to hold water
5. Transportation
6. Educational services
7. Municipal services
8. Aesthetics, scenic, and natural beauty
9. Conforms to development and land use plans
10. Local and regional plans

9.5.2.2 Smart Growth Development

Smart Growth Development promotes compact development of settlements and urban centers that are separated by rural countryside, thus combating urban sprawl. Dense development can reduce total impervious surface in a municipality, reducing flood runoff. However, if not done well, stormwater concerns in urbanized areas can create local flash floods. Concentrating development in existing centers in Vermont also must be done with flooding in mind, as many of our developed areas were in flood-prone areas and continuing to invest in some of these areas is not prudent under increasing flooding.

- **Vermont Smart Growth Collaborative**: The Vermont Smart Growth Collaborative (Vermont Natural Resources Council, 2012) released the State of Vermont Smart Growth 2007 Progress Report, which examined state policies and spending between 2003 and 2006 (Levine et al., 2007). The 2021 update to the 2007 progress report will be available later in 2021 and will examine state policies and spending between 2013 and 2019 (Vermont Natural Resources Council, 2021).

- **Vermont Natural Resource Council efforts on smart growth**: The Vermont Natural Resources Council (VNRC) "promotes land use planning that creates communities that are environmentally sustainable, economically viable, and resilient" using smart growth principles. VNRC is in the Vermont Smart Growth Collaborative along with Conservation Law Foundation, Preservation Trust of Vermont, and others.

9.5.2.3 Local Level: Zoning

Planning can be implemented through the use of local zoning ordinances. For example, a study of zoning ordinances in 32 United States communities (of which, Burlington, Vermont was included) found that communities that included sustainability principles within their zoning ordinances were more likely to achieve sustainability than those that did not (Jepson & Haines, 2014). More specifically, zoning is an important tool to mitigate flood risk by regulating development in flood-prone areas. Zoning, often through ordinances, can "regulate the development of flood-prone areas, introduce building codes, convert built up areas to nature, relocate buildings, and raise public awareness, in order to lower flood risk" (Hudson & Botzen, 2019, p. 2). Zoning ordinances typically occur at the town level.

9.5.3 Local Hazard Mitigation and Local Emergency Management Planning

To be eligible for some federal grant funding through FEMA, communities can participate in the National Flood Insurance Program and adopt Local Hazard Mitigation Plans. Currently, Vermont communities have a total of thirty FEMA-approved Local Hazard Mitigation Plans (Two Rivers Ottauquechee Regional Commission, n.d.).

The State Emergency Management Plan mandates that all municipalities must review and update their Local Emergency Management Plan (LEMP) every year. These plans are required to access state post-disaster matching funding through ERAF (Emergency Relief and Assistance Fund). All municipalities qualify for a state match of 7%, but those with mitigation plans, LEMPs, adopted road and bridge standards, and participation in the National Flood Insurance Program can qualify for a 12.5% match. Those that also adopt river corridor regulations or that take part in FEMA's Community Rating System can qualify for a 17.5% match. LEMPs are not publicly available, as they contain personal contact information; however, a template and other resources are available on the Vermont Emergency Management website (Department of Public Safety Vermont Emergency Management, 2021).

Box 9-1: Federal Funding via FEMA Grants

A study of how top-down flood mitigation strategies were implemented by southern Vermont communities found that “inadequate and poorly timed distribution of funding” was a barrier to implementing the suggested flood mitigation strategies (Paul & Milman, 2017, p. 14). This study suggests that state-mandated or suggested adaptation measures build in accessible funding mechanisms that can be accessed early in the implementation process (Paul & Milman, 2017).

FEMA provides several grant programs to help communities both prepare for and respond to hazards and emergencies. The following is an abbreviated list of FEMA grant programs available to Vermont communities. See FEMA (2021c) for a comprehensive list and details for how to apply.

- **Hazard Mitigation Assistance Grants**: Provides funding for removing or reducing risk prior to a disaster via the Hazard Mitigation Grant Program (HMGP); Building Resilient Infrastructure and Communities (BRIC), a new program as of September 2020 (FEMA, 2021a); Flood Mitigation Assistance (FMA) Grants; and Pre-Disaster Mitigation Grants.
- **Preparedness Grants**: These funds are for non-disaster-related efforts and include the Emergency Management Performance Grant Program, Assistance to Firefighters Grants Program, Homeland Security Grant Program, and many more (FEMA, 2021e).
- **Resilience Grants**: Available for dam safety and earthquake preparedness.
- **Emergency Food and Shelter Program**: This program provides assistance to ongoing local efforts to provide food, shelter, and other support services to those at risk of, or who are currently experiencing, hunger or homelessness (FEMA, 2021b).

9.5.4 Efforts to Build Community Resilience and Resilience Planning

Many communities across the United States have written, or are currently writing, plans for how they will build resilience against climate change and other shocks and stresses. While Vermont does not currently have a state resilience plan, it has undertaken several resilience building or measuring efforts and could consider writing a plan in the future. The state does have a Hazard Mitigation Plan, which has many of the characteristics of a natural hazard resilience plan (Vermont Emergency Management, 2018). "Climate change" is mentioned forty-seven times in the state plan. Climate change is not considered a direct hazard, but rather a driver of hazards such as floods, drought, ice-storms, etc.

Also, as is common in the emergency management field, planning and preparing for one disaster, if done well and holistically, increases resilience to other forms of disaster. For example, planning for structural collapse prepares for flood damage to homes. Preparing for structural fire prepares for post-flood fires (a common occurrence with woody debris and spilled fuel tanks). So, while a community may not be directly confronting climate change, it most likely is doing many resilience actions under another name. Lastly, good community planning creates resilience in that it is building community dialogue skills and a system for public information and decision-making. These are as essential as subject-specific plans in effective community planning.

9.5.4.1 Resilience Resources for Vermont Communities

- **Flood Resilience Checklist for Vermont Communities**: This checklist was created for those engaging in Municipal Plan updates, Hazard Mitigation Plans, and other planning efforts. Its objective is to increase a community's resilience (Vermont Department of Housing and Community Development, 2016).

- **Resilient Communities Scorecard**: The VNRC developed the Resilient Communities Scorecard (Vermont Natural Resources Council, 2013) to be a tool for Vermont communities to use in building resilient communities.

- **Resilient Vermont**: The Resilient Vermont Network "is a new collaboration of organizations and agencies in Vermont that are working to advance climate resilience. The Network is working to improve alignment, coordination, communication, and strategic impact across a range of issues related to climate resilience" (Resilient Vermont, n.d.). Resilient Vermont released a report entitled "Vermont's Roadmap to Resilience" that provides recommendations for how to build resilience to climate change (Institute for Sustainable Communities, 2013).
- **Act 16 Flood Resilient Planning**: In 2013, Vermont created a flood resilience goal (V.S.A. 24, section 4302(c)14) and a flood resilience element for regional plans (V.S.A. 24, section 4348a(a)11) and municipal plans (V.S.A. 24, section 4382(a)12) through Act 16 (Vermont H. 401 Act 16, 2013). For plans adopted after July 1, 2014, Act 16 specifies that a flood resilience element must be incorporated within all municipal plans, and regional plans must meet the flood resilience elements and goals. Municipal plans seeking regional approval must also meet the state planning goal (V.S.A. 24, section 2450).
- **Flood Resilience Planning Resources:** The Central Vermont Regional Planning Commission provides a list of resources for flood resilience planning, including information for municipal plans, floodplain fact sheets, and fluvial erosion hazard maps and language (Central Vermont Regional Planning Commission, 2021).
- **Flood Ready Vermont**: Flood Ready Vermont provides a list of resources for municipalities seeking to write or update their Municipal Plans to include a flood resilience element (Flood Ready Vermont, 2021).
- **Vermont Planning Manual (https://accd.vermont.gov/community-development/town-future/municipal-planning-manual):** This is the main manual for municipal planning in Vermont. Many of the concepts of municipal planning, especially land use, natural resources, and capital budgeting, make a community resilient (State of Vermont Agency of Commerce and Community Development, 2021).

- **FEMA's Hazard Mitigation Planning:** FEMA has developed a process for planning to lessen the effects of natural hazards through the development of mitigation plans. This process is designed to meet federal guidelines for such a plan (FEMA, 2021d).

- **Vermont Department of Environmental Conservation Hazard Area Bylaws:** These are model bylaws available for communities that "have been pre-reviewed by FEMA and meet or exceed the requirements of the National Flood Insurance Program" (Vermont DEC, 2021).

9.6 TRACEABLE ACCOUNTS

Traceable accounts describe the confidence level—the degree of certainty in the scientific evidence—for each key message resulting from this chapter. This analysis is based on the U.S. Global Change Research Program guidance in the Fourth National Climate Assessment (USGCRP, 2018).

Confidence level	**Very high**	**High**	**Medium**	**Low**
Description	Strong evidence (established theory, multiple sources, confident results, well-documented and accepted methods, etc.), high consensus	Moderate evidence (several courses, some consistency, methods vary, and/or documentation limited, etc.), medium consensus	Suggestive evidence (a few sources, limited consistency, models incomplete, methods emerging, etc.), competing schools of thought	Inconclusive evidence (limited sources, extrapolations, inconsistent findings, poor documentation and/or methods not tested, etc.), disagreement or lack of opinions among experts

Key Message 1: Flooding is the most likely natural disaster to occur in Vermont and should be accounted for in all community development and planning efforts in the state. However, extremes will become more common, so planning should also account for chronic hazards, such as drought.	
Finding	There is a high confidence level that flooding will be the most likely disaster to occur in Vermont.
References	(FEMA, n.d.)

Key Message 2: Systems interconnections are essential to consider in community development and planning in the context of future climate change scenarios, particularly in the context of disasters.	
Finding	Medium confidence: Incorporating systems interconnections in the context of resilience and planning is relatively new, however, there is evidence to suggest it is important to continue.
References	(Raub, Stepenuck, & Panikkar, 2021; Raub et al., 2021)

Key Message 3: Vermont is expected to continue to have a favorable climate under future climate change projections, however, there is very little information to predict if the state will face an influx of climate migration. Future research is needed.	
Finding	Low confidence: There is little information to predict how climate migration will impact Vermont; more research is needed.
References	(Tacy, Hanson, & Poulin, 2020)

Key Message 4: Vermont communities must engage in planning to access federal funding and to prepare for current and future climate change impacts, including population growth, flooding, and droughts.	
Finding	There is a very high confidence level that planning is essential to prepare communities for the impacts of climate change. Planning has shown to be an effective tool to build resilience and in emergency management.
References	(Burby et al., 1999; Cucuzza et al., 2020; Nelson & French, 2002)

Key Message 5: Climate change will not impact all communities equally; the needs and capacity of vulnerable populations should be considered with all community planning efforts.	
Finding	Very high confidence: It is well proven that climate change impacts are not equitably distributed. For example, in Vermont, trailer park communities were negatively impacted by flooding during Tropical Storm Irene.
References	(Adger, 2010; Baker, Hamshaw, & Hamshaw, 2014; Cutter et al., 2008; Shi et al., 2016; Thomas et al., 2013; Van Zandt et al., 2012)

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9.8 REFERENCES

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