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Natural Disaster Resilience Guide

Planning and Technology Solutions

Acknowledgments

This booklet, created by the Tennessee Valley Authority (TVA), is an informational compilation of existing concepts, examples, resources and considerations, gathered to provide a resource for communities and local power companies (LPCs) as they explore implementation of connected community solutions. This booklet is not meant to prescribe the details of how an individual community should implement a specific solution.

This Natural Disaster Resilience Guide resource supports one of the Connected Communities initiative focus areas: Enhance Community Resiliency. Visit the Connected Communities website for more information.

SECTION 1

Introduction

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Enhancing Resiliency to Help Communities Thrive

Enhancing resiliency is a priority for communities across the TVA service region and was identified by stakeholders as one of the Connected Communities initiative's four focus areas. In the face of increasingly extreme weather events, ensuring communities are prepared to withstand adverse events is essential. Without strong planning for resiliency, a severe weather event could easily wipe out a community's investments to become more connected. The Connected Communities initiative works to enhance community resiliency by guiding communities in developing plans and resources to minimize the impacts of events like natural disasters and cyber threats. By improving resiliency, communities can more readily endure and recover from disaster events and focus their resources on creating a thriving place to live and work into the future.

Communities can more readily withstand disaster events by improving resiliency.

STRENGTHENING COMMUNITY RESILIENCY

There are several approaches communities can take towards strengthening resiliency. This resource guide aims to help communities take the first steps towards becoming more prepared to withstand the impacts of natural disasters by:

1 Identifying and assessing risks for natural disasters common to the TVA region

2 Exploring technology solutions to support resiliency strategies

3 Understanding planning and policies to adapt to local needs

4 Providing examples and case studies of how other communities have used technology to prepare for and respond to natural disasters

5 Referencing other resources that can help communities achieve goals related to enhancing community resiliency and natural disaster preparedness

Enhancing community resiliency begins with developing a plan to help communities effectively prepare infrastructure, businesses and residents to quickly recover from adverse events. This resource guide details the processes, tools and technologies communities need to build a solid foundation and the ability to withstand an uncertain future.

Defining Community Resilience

Understanding Resilience and Preparedness

Natural disasters are severe and extreme weather and climate events, such as hurricanes, droughts, floods, wildfires, winter storms and tornadoes. Each community requires a tailored plan to build resilience in the face of increasing natural disasters.

The National Institute of Standards and Technology (NIST) states that "community resilience is the ability to prepare for anticipated hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions. Activities, such as disaster preparedness—which includes prevention, protection, mitigation, response and recovery—are key steps to resilience."[1]

An integral element of building a community's resilience is increasing community preparedness. The Federal Emergency Management Agency (FEMA) established a National Preparedness Goal that defines what it means for communities (and together the whole nation) to be prepared for disasters: "A secure and resilient nation with the capabilities required across the whole community to prevent, protect against, mitigate, respond to, and recover from the threats and hazards that pose the greatest risk."[2]

FEMA defines a whole community to include:

- individuals and families, including those with access and functional needs
- business, faith-based and community organizations
- nonprofit groups
- schools and academia
- media outlets
- levels of government including state, local, tribal, territorial and federal partners

FIVE MISSION AREAS

The National Preparedness Goal describes five mission areas[3] that cover the capabilities needed for achieving preparedness. The Connected Communities initiative will continue to explore how best to provide guidance to the disaster-impacted communities that need it most. The information presented in this guide focuses on technology and planning solutions to support preparedness for natural disasters across the prevention, protection and mitigation mission areas.

1

Prevention

Avoid, prevent or stop the threat of hazards, including public information sharing for awareness.

✔ *Focus in this guide*

2

Protection

Protect people and places from hazards, including the presence of critical infrastructure.

✔ *Focus in this guide*

3

Mitigation

Reduce the impact of hazards, including community plans to understand and prepare for future resilience.

✔ *Focus in this guide*

4

Response

Protect people and places after a disaster has occurred, including the restoration of basic services to communities.

5

Recovery

Help communities impacted by a disaster recover effectively, including actions that restore, strengthen and revitalize the community.

SECTION 2

Defining Community Resilience

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Benefits of a Resilient Community

Investing time and resources into preparing for natural hazards and building community resilience can offer many benefits:

Economic Benefits

Each $1 invested in disaster preparedness can prevent $7 worth of disaster-related economic losses.[4]

Housing Benefits

Resilience work reduces the risk of property damage, ensuring disasters displace fewer residents and more businesses remain functional.

Environmental Benefits

Natural disasters such as wildfires pose environmental threats like air pollution and habitat loss. Being prepared to prevent, protect against and mitigate natural disasters helps protect the environment.

Community Benefits

Resilience initiatives help communities protect residents from disaster-related injury or loss of life and minimize disruptions to utility services, which are critical to the continuity of critical services.

SECTION 3

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Identify and Assess Risks

Types of Natural Disasters to Plan for in the TVA Service Region

The first step in becoming more prepared to withstand natural disasters is to understand what types of disasters are a risk to your community. The TVA region faces risk from several natural hazards, including:

Inland Flooding

Inland flooding is the partial or complete submersion of normally dry land in freshwater. According to the U.S. Department of Housing and Urban Development (HUD), inland flooding can impact a community's infrastructure by interrupting services, causing health and safety risks and accelerating terrain erosion. In the TVA territory, inland flooding risk is the highest within the Tennessee River watershed area.

Wildfire

Northern Mississippi and East Tennessee are most at risk of wildfires, which can result in property damage, poor air quality and accelerated erosion. Wildfire risk in the TVA service region is relatively low compared to other parts of the country but is expected to more than double in the next 30 years.[5] This growing risk is due to a combination of changes in humidity patterns, as well as rising temperatures and drought conditions which increase fuel in the form of drier vegetation.

Water Risks

Southern Kentucky, northeast Mississippi and areas surrounding Memphis and Knoxville are vulnerable to various water risks including drought, seasonal variability and water quality. Droughts reduce the quantity and quality of water supplies and increase the chances of wildfire, particularly during heat waves.

Tornadoes

According to the National Weather Service, Tennessee experiences tornado threats year round. The annual average number of tornadoes reported in Tennessee grew 62% from the 20-year periods of 1980-1999 to 2000-2019. The threat is worsened by the fact that nearly half of all tornadoes that touch down in Tennessee occur at night, increasing corresponding fatalities.[6]

Extreme Temperatures

Tennessee is exceptionally vulnerable to extreme temperatures. In the City of Nashville, for example, the changing climate is predicted to worsen extreme heat more than any other weather threat.[7] But it's not just the heat; in December of 2022, the extreme cold during Winter Storm Elliot resulted in the highest 24-hour electricity demand supplied in TVA history, negatively affecting generating capacity and resulting in a financial impact of around $170 million.[8]

Identify and Assess Risks

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Data Resources and Tools

There are a variety of resources available to help identify what natural hazards may be of concern to your community.

Community Resilience Toolkit

TVA communities can leverage HUD's Community Resilience Toolkit[9] to understand the different types of natural disasters and their impacts. This HUD toolkit can also be used to conduct a natural hazard risk assessment, which includes the following steps:

- Identify how natural hazards might affect your community through natural hazard factsheets

- Consider actions to increase your community's resilience to these natural hazards

- Identify funding streams to implement resilience actions

Connected Community Map Resource

The Connected Communities initiative's map resources are another tool for understanding threats to your community. These maps draw on publicly available data to highlight areas in the TVA region at risk for common natural hazards, including wildfire risk (Figure 1) and flood risk (Figure 2). Communities can access an interactive version[10] of this resource on the initiatives' Community Information Hub.
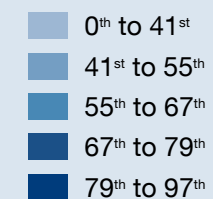

FIGURE 1

Wildfire Risk Percentile

0th to 41st
41st to 55th
55th to 67th
67th to 79th
79th to 97th
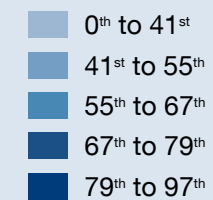
Census tract level data, 2022

Source: Council on Environmental Quality

FIGURE 2

Flood Risk Percentile

0th to 41st
41st to 55th
55th to 67th
67th to 79th
79th to 97th

Census tract level data, 2022

Source: Council on Environmental Quality

SECTION 3

Identify and Assess Risks

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Additional Resources

In addition to the resources shared above, communities can leverage the following publicly available data resources and tools to plan for current and future risks of natural disasters:

1

National Risk Index

Created by FEMA, the National Risk Index[11] allows users to explore the risks of 18 natural hazards across the United States. Each county and census tract has a calculated baseline risk measurement. This tool can support creating reports or exporting data for users to explore their community's risk or conduct community-based risk comparisons.

2

Wildfire Risk to Communities

The U.S. Department of Agriculture (USDA) Forest Service created the Wildfire Risk to Communities website[12] to offer interactive maps, charts and resources to help communities understand, explore and reduce wildfire risk. By leveraging weather data from the National Weather Service and community data from the U.S. Census Bureau, the map offers an overview of various risks such as wildfire likelihood, risk to homes and vulnerable populations.

3

U.S. Climate Resilience Toolkit's Climate Mapping for Resilience and Adaption Tool (CMRA)

The Climate Resilience Toolkit[13] portal provides communities with access to maps showing the location of current climate-related hazards including wildfires, droughts, inland flooding, coastal flooding and extreme heat. Users can also use the CMRA Assessment Tool to view projected changes to climate conditions in their communities and see how assets such as people, property and infrastructure could be affected over the next century. Under the Federal Policies tab, users can access information on federal policies relevant to climate adaptation and federal funding opportunities available for climate resilience projects.

4

Disaster Risk and Mapping Tool

The National Centers for Environmental Information under the National Oceanic and Atmospheric Administration (NOAA) provides communities with an interactive mapping tool[14] and downloadable data. This tool allows users to view and overlay maps featuring data on disaster cost and frequency (in geographical and timeline formats) as well as risk and vulnerability for the following seven climate risks: drought, flooding, freeze, severe storm, tropical cyclone, wildfire and winter storm.

5

Resilience Analysis and Planning Tool (RAPT)

FEMA provides Geographic Information System (GIS) mapping through RAPT[15] to help users understand their communities by visualizing more than 100 preloaded data layers. These layers provide insights on community resilience indicators from peer-reviewed research, current U.S. Census demographic data, infrastructure data and data on weather, hazards and risk. This tool also offers analysis assistance and print and download functions.

6

Neighborhoods at Risk

The Neighborhoods at Risk tool[16] features interactive maps, charts and resources to help communities identify neighborhoods that may face the negative impacts of climate change, such as flooding and extreme heat. It presents data on characteristics in two categories: people (e.g., people with disabilities, rental housing units and families in poverty) and climate exposure (e.g., flood risk, tree canopy, impervious surface and 500-year floodplain areas). Community leaders can use this tool to prioritize improvements, identify vulnerabilities, inform land use and policy decisions, develop mitigation plans and support grant proposals.

7

Risk Factor

The Risk Factor tool[17] makes it easy for users to understand risks to residential properties including flooding, wildfire, heat and wind. Allowing users to search for specific property addresses, this free tool enables users to access targeted reports and maps on damage estimates, event history, building downtime and preventative solutions.

Identify and Assess Risks

Equity and Environmental Justice Considerations

According to FEMA, historically underserved communities experience a greater risk of impacts from natural disasters. Due to a lack of resources and capital, underserved communities see differences in preparedness, mitigation measures and recovery time for social and economic activity after a disaster.[18]

To account for the higher risk disadvantaged neighborhoods face, communities seeking federal funding are required to incorporate equity and environmental justice into disaster preparedness and response strategies as part of the Justice40 Initiative.[19]

Communities seeking federal funding are required to incorporate equity and environmental justice into disaster preparedness and response strategies.

Federal Government Resources

The federal government provides several online tools that can help communities explore equity considerations:

1

The Climate and Economic Justice Screening Tool (CEJST)

CEJST[20] is a mapping tool specifically developed to provide an official government definition of a "disadvantaged community," which allows federal agencies to better target Justice40 investment benefits. CEJST identifies census tracts that are marginalized, underserved or overburdened by pollution. Communities highlighted as disadvantaged on the CEJST map experience one or more environmental, climate or other burdens and face associated socioeconomic burdens.

2

Environmental Justice Screening and Mapping (EJScreen) Tool

The EJScreen Tool[21] is another tool that provides national data on environmental and demographic indicators. The EJScreen tool is particularly useful to visualize how a community compares to the rest of the region in relation to 13 environmental indicators and seven socioeconomic indicators.

Identify and Assess Risks

Case Study: Kentucky Tornado Recovery

On December 10, 2021, tornadoes tore through Kentucky communities including Mayfield, Dawson Springs, and Bowling Green, causing an estimated $305 million in damages to infrastructure. In response, several federal assistance programs,[22] listed on the next page, were executed.

Federal disaster planning and response efforts played a significant role in helping Kentucky communities and residents recover from the destruction and devastation caused by tornadoes. To further prepare for inevitable disasters, local utilities such as West Kentucky Rural Electric Cooperative Corporation (WKRECC) are working on creating their own crisis response plans to improve their community's ability to respond to future events and minimize risk. Developing local plans allows community members to give input on how to prepare for disasters and what resources must be available to meet needs efficiently and effectively in the wake of adverse events.

ESTIMATED

$305M

in damages

to infrastructure

FEDERAL ASSISTANCE PROGRAMS EXECUTED IN RESPONSE TO DAMAGES

1 FEMA Individual Assistance

Under FEMA's Individuals and Households Program, households across 16 counties received federal assistance totaling more than $15.9 million. $11.5 million went to housing assistance and $4.4 million to other needs assistance.

2 Temporary Housing

The FEMA's Direct Temporary Housing program provided temporary housing for 55 families. FEMA also offered up to 18 months of temporary rental assistance to nearly 1,600 families while they repaired their tornado-damaged homes or looked for other permanent housing.

3 U.S. Small Business Administration

Nearly $59.8 million was approved for 654 disaster loans for homeowners, renters and businesses. $50.6 million was allocated in home loans and $9.2 million in business loans.

4 FEMA's Public Assistance Program

More than $30.6 million was approved for western Kentucky to help communities with the cost of repair, rebuilding and emergency work, including reimbursements for debris removal, damaged roads and infrastructure.

5 Role of Local Long-Term Recovery Groups in the City of Mayfield

The tornadoes in Mayfield, Kentucky, destroyed 257 homes and most of the historic town center. Recovery groups helped affected communities by providing temporary rentals, assistance with utility and security deposits, repairing survivors' homes, supplying essential home appliances and meeting transportation needs for medical appointments, work and school. Additionally, the Mayfield Graves County Long-Term Recovery Group placed 25 affected families into existing vacant homes in the community through their Home for the Holidays program.

Solutions and Case Studies

This section provides examples of strategies other communities are using to prepare for natural disasters, along with case studies of specific communities' experiences with disaster preparedness. After assessing your community's risks using the tools introduced in the previous section, refer to the examples in this section as you consider what types of investments and strategies may be a good fit for your community.

Technology Solutions

Technology and infrastructure solutions can help prepare a community to better withstand the impacts of natural disasters. This section provides an overview of several technology-related solutions a community may consider implementing. For more information on technology applications for resiliency, refer to the HUD Community Resiliency Toolkit[9], which outlines actions to take for each type of natural disaster, or the IEEE Implementation Methodology of the Resilience Framework[23] for information on critical infrastructure implementation.

SOLUTIONS COVERED IN THIS SECTION

- Scenario Planning Models
- Emergency Communications Systems
- Resilience Hubs
- Geographic Information Systems (GIS)
- Dark Fiber

- Sensors
- Microgrids
- Electric Vehicles (EVs)
- Batteries
- Robots/Drones
- Artificial Intelligence (AI)

Solutions and Case Studies

Scenario Planning Models

Scenario planning modeling helps communities explore alternative future scenarios to better anticipate challenges, identify skill or foundational gaps, develop strategies, engage stakeholders and assign resources effectively. By considering a range of potential scenarios, communities can proactively plan and build resilience.

The American Planning Association's (APA) Community Resilience Scenario Planning Model (CRSPM)[24] is an example of a toolkit that communities can use to update existing plans or develop a resilience plan and implementation strategy. The model provides a clear way to visualize stormwater flow at the property level using interactive design components that allow the user to test the effects of potential changes to the land. Users can choose a location, create a template and then apply that template to other locations, replicating the analysis. The insights provided by the CRSPM toolkit can be used for public workshops, stakeholder groups and in the planning, review and testing of design alternatives.

Emergency Communications Systems

Emergency communications systems enable community members to better prepare for natural disasters by quickly alerting individuals that an emergency is occurring, giving people more time to protect themselves and their property. These systems also enable the clear distribution of information throughout an emergency, such as evacuation notices and safety instructions. Examples of systems that can help notify community members of a disaster include:

- **Reverse 911 systems**, which allow authorities to send emergency notifications to residents within a specific geographic area. These systems can be used to provide information about evacuation orders, severe weather alerts or other critical updates.

- **National public alert systems**, such as Wireless Emergency Alerts (WEA), deliver emergency messages, such as AMBER alerts and severe weather warnings, to cellular phones within a geographically targeted area.

- **Community sirens or warning systems** are outdoor speakers designed to emit a loud, attention-grabbing sound to alert the community of emergencies, such as severe weather, chemical spills or other immediate threats in real time. They are particularly useful for areas prone to natural disasters. These sirens can be located in trusted public places such as schools, government buildings or stadiums.

- **Emergency radio channels** allow emergency management agencies, first responders and community members to communicate during a crisis. Communities typically use these channels to coordinate rescue operations, provide updates and issue instructions. Mobile apps designed specifically for emergency communication can distribute critical information to residents. These apps may include features such as push notifications, emergency contact lists, real-time updates and interactive maps.

Solutions and Case Studies

Resilience Hubs

Resilience hubs (sometimes called resiliency hubs) are facilities within a community created to support residents before, during and after emergencies by providing reliable energy, distributing resources, coordinating communication and offering other essential services.[25] In the wake of disasters, resilience hubs typically provide power with a combination of renewable energy such as solar and battery energy storage, and can include microgrids.[26]

Ensuring communities' continued access to power is a crucial component of ensuring residents living in disadvantaged communities are not disproportionately impacted by disasters. For example, disadvantaged individuals may struggle to afford replacements of essential items such as refrigerated food or medicine after power outages, while middle- and upper-income residents may not have the same issue. Services provided by resilience hubs can vary based on the specific threats and unique needs of the communities they serve.

Resilience hubs promote the efficient and equitable allocation of resources by consolidating essential services and supplies, making it easier to distribute aid effectively to those in need. Beyond immediate response capabilities, resilience hubs also promote community cohesion and long-term resilience efforts by creating a space for coordinated planning and information sharing among residents. Ideally, resilience hubs are located in a place community members already go to for services and programming, such as libraries, health centers, recreation centers or community-based organizations.

Geographic Information Systems (GIS)

GIS is often used during emergency management to leverage population and area-specific data to create virtually any type of map that can help mitigate, respond to or recover from a natural disaster. With widespread, open-source GIS software available, GIS has a relatively low startup cost to local governments and disaster relief organizations. The use cases for GIS technology can range from forecasting severe storms and analyzing their movements to creating emergency response maps that proactively identify parts of communities most at risk. However, the cost of training employees to use the software or hiring a GIS specialist may be a potential barrier for smaller communities with limited resources.

Dark Fiber

Dark fiber refers to fiber optic cable networks that are installed but may have excess fiber strands that are unused by the network owner. Dark fiber can be leased or purchased to create a private network with higher speeds and security. In terms of disaster preparedness, fiber optic networks are proven to be more durable than the copper cable infrastructure that is often used. While many ISPs already offer fiber optic connection to communities, purchasing or leasing dark fiber could help local governments and disaster response organizations communicate effectively during natural disasters without encountering bandwidth issues. TVA has leased surplus dark fiber strands on its own communications networks to various entities for over 35 years, which could be an option for enhancing the resiliency of your community's connectivity.

One way residents become aware of tornadoes is via tornado sirens. Tornado sirens alert residents of current storms to encourage them to take shelter immediately. The sirens work off a radio signal and fiber link. Dark fiber is one solution to ensure sirens stay connected and notify residents of local weather conditions.

Solutions and Case Studies

Sensors

Sensors and Internet of Things (IoT) devices play a large role in disaster prevention as they are typically on the front line of natural disaster detection. Examples of sensors that could help a community enhance its disaster response include:

- **Air quality sensors** are used throughout the United States to understand air quality conditions, which are determined by measuring the amount of pollutants in the air, including particulate matter (smoke, dust, dirt, soot and salt) and ground-level ozone (caused by emissions from industrial facilities, electric utilities, vehicle exhaust and chemical solvents). Sensors provide real-time data at a specific location, which helps communities determine the current conditions of specific geographic areas.[27]

- **Environmental sensors** monitor various factors like temperature, humidity, wind speed and atmospheric pressure to assess weather conditions, identify potential hazards and inform response strategies.

- **Water sensors** measure water levels, flow rates and water quality parameters. These are used to monitor flooding, assess water contamination and support flood forecasting and early warning systems.

- **Structural health monitoring sensors** monitor the structural integrity of buildings and infrastructure during and after disasters. They detect vibrations and irregularities, providing insights into the safety and stability of structures.

- **Seismic sensors** detect and measure seismic activity, which includes vibrations and movements of the Earth's crust. They play a crucial role in earthquake early warning systems, as they detect the initial seismic waves and provide rapid alerts to affected areas before more destructive waves arrive.

Microgrids

Microgrids can help maintain a community's power supply during disasters. The National Renewable Energy Laboratory (NREL) defines a microgrid as "a group of interconnected loads and distributed energy resources that acts as a single controllable entity with respect to the grid. It can connect and disconnect from the grid to operate in grid-connected or island mode."[28] By dispersing electricity generation across several smaller sources rather than a single large generator, communities can avoid sustaining significant power loss during a natural disaster due to a single point of failure in a grid.

Microgrids function by connecting homes and buildings to multiple generation sources in a bidirectional system where electricity can flow to and from loads within the local grid. The flow of electricity throughout the grid is managed by a microgrid controller software that can adapt to and adjust for variables such as variations in energy costs and failure of generators within the microgrid.
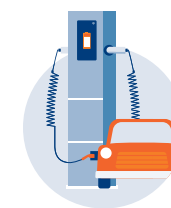
Electric Vehicles (EVs)

EVs can offer bidirectional charging that allows their owners to temporarily power their homes (referred to as vehicle-to-home, or V2H) or send energy back to the grid (referred to as vehicle-to-grid, or V2G). This technology enables EVs to become a major asset during disaster recovery as owners can independently power their homes. If EVs are used in tandem with a local microgrid, their advantages during a disaster are even greater as a fleet of EVs can provide a substantial amount of power back onto the microgrid. Additionally, as communities begin to incorporate larger EVs into their transportation systems, such as school or commuter buses, these vehicles can also provide large stores of power to areas facing loss of power.

SECTION 4

Solutions and Case Studies

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Batteries

Battery storage systems can play a vital role in enhancing a community's resilience to natural disasters. Batteries can provide reliable backup power to residences and businesses and are particularly important for supplying critical infrastructure such as hospitals, emergency shelters, communication centers and water treatment facilities. Batteries can ensure essential services remain operational during power outages, enabling prompt response and recovery efforts. Battery storage systems can be deployed in mobile units to provide power in temporary evacuation centers or areas where infrastructure has been severely damaged. Mobile power systems can support charging stations for electronic devices, provide lighting and run essential equipment.

Battery storage systems also enable time-shifting of energy usage, meaning excess electricity generated during non-disaster periods can be stored in batteries and used during emergencies. This helps balance energy supply and demand, especially when the main power grid is offline or undergoing repairs. Time-shifting energy usage also reduces strain on the grid and minimizes the risk of cascading failures, which occur when one problem causes a chain reaction of other failures, leading to widespread outages. More broadly, storage can help stabilize the power grid by providing grid services such as frequency regulation, voltage support and load balancing. These functions are crucial during and after natural disasters when the grid is under stress. Battery systems can rapidly respond to fluctuations, ensuring a stable and reliable electricity supply.

One model for implementing battery storage for resiliency is community storage.[29] This is the concept of using energy storage systems within a community to provide various benefits and services, utilizing a shared ownership model similar to community solar projects. For example, this may involve financing a battery project using conventional methods, but with ownership structured as a power purchase agreement among community members, neighborhoods or subsidized by local government.

Community storage projects are often owned or operated by utilities and can be part of community solar initiatives. While shared storage assets among customers are not as common as shared solar projects, they may become more commonplace in the future as the community solar market grows. Further education and local policy alignment are needed to support the widespread deployment of community storage and ensure the fair distribution of benefits among participants.

Robots/Drones

Aerial drones are highly versatile tools for inspecting areas affected by disasters. Their enhanced versatility allows them to capture angles difficult to reach by planes and satellites and to often fly closer to the ground for higher-quality footage. Additionally, images and visual data can be synthesized from a network of drones to capture detailed information from large areas in significantly less time than manned aerial vehicles. These drones can also come with AI capabilities to perform real-time analysis and decision-making without constant supervision.

During disasters, robots can be deployed for rescue and recovery operations in conditions that would be exceedingly dangerous for human rescue workers, reducing the potential loss of life.

Solutions and Case Studies

Artificial Intelligence (AI)

AI models can be trained on pre-existing data to predict future outcomes, which makes this technology instrumental for disaster preparedness and resilience. Using satellite images and meteorological and seismic data, AI can forecast future disasters with a high confidence level.

In addition to disaster forecasting, AI can be used to optimize a response strategy during disasters. With access to a wide array of data sources such as local alerts, news and susceptibility and resiliency indicators, first responders can use AI to more accurately assess which areas to prioritize during a disaster.

While using AI for disaster preparedness and disaster response is relatively new, the use cases are promising. For example, the nonprofit Sustainable Environment and Ecological Development Society (SEEDS) has worked closely with Microsoft and Gramener to develop the Sunny Lives AI model[30], which predicts and generates local risk information that provides early warnings for impending disasters. The model uses satellite imagery read by the system to identify homes facing the highest risk of damage or destruction within each community. SEEDs can then recommend preventative actions to reduce at-risk populations' vulnerability to incoming disasters. AI models for disaster prediction and preparedness will likely become a viable and beneficial tool for communities facing increasing frequency and threats of natural disasters in the coming years.

Solutions and Case Studies

Technology Case Studies

This section introduces several case studies demonstrating how communities are leveraging technology-related solutions to enhance resilience. Visit the Community Information Hub for more comprehensive summaries of each of these case studies.

RESILIENCE HUB CASE STUDIES

Metropolitan Branch Library Resilience Hub[31]

In late 2022, Fulton County, Georgia, set up a resilience hub at Metropolitan Branch Library to provide a physical space that is equipped with resources needed to serve vulnerable communities during emergencies. The facility is prepared to provide emergency power, water and food using sustainable and resilient technologies including solar power, battery storage, electric vehicle charging, rainwater harvesting systems and community gardens.

Baltimore Community Resiliency Hub Program[32]

Baltimore's Community Resiliency Hub Program connects frontline community organizations with the resources needed to respond to natural disasters or emergencies, especially in under-resourced neighborhoods. While several government and community-based organizations are involved in running the program, Baltimore's Office of Sustainability is the lead agency responsible for growing and managing it as part of Baltimore's Disaster Preparedness Plan.

GIS CASE STUDIES

GIS used for Emergency Response Training in Taiwan[33]

The National Science and Technology Center for Disaster Reduction (NCDR) in Taiwan has developed a war game simulation called the Flooding Wargame Simulation Platform for Training and Emergency Response. This platform was built using 3D GIS technology and aims to evaluate the effectiveness of flood-based emergency response plans and procedures. It simulates various types of flooding disasters to help officials understand different disaster scenarios and determine the suitability of their response plans.

GIS used for Flood Mitigation in Salem, Oregon[34]

To understand what is happening in 90 miles worth of streams and corresponding risks, Salem's Public Works Department created a "Stream Crew" initiative where workers can use a mobile app to quickly document conditions, such as water level and debris jams. The mobile app uses GIS to allow workers to report the conditions of streams in real time, automatically marking and tracking specific locations where conditions are reported.

GIS used in Kentucky Tornado Response[35]

After the devastating hurricanes of 2021, Kentucky Emergency Management (KYEM) established a GIS team to curate data resources for emergency responders in a Response Portal. The portal compiled data from various sources into swipe maps, incident map viewers and executive map viewers. Infrastructure impacts, including data regarding water, wastewater and electric outages, were shown on infrastructure-specific web maps.

Solutions and Case Studies

MICROGRID CASE STUDIES

EPB & The City of Chattanooga Microgrids[36]

EPB and the City of Chattanooga collaborated on the Power to Protect project, developing a microgrid for the Police Services Center and Fire Department headquarters. The microgrid includes solar panels, a battery storage system and a diesel generator.

Marine Corps Logistics Base Albany Microgrid[37]

Marine Corps Logistics Base Albany, a military base in southwest Georgia, is the first in the military to reach net zero, generating as much electricity as it consumes. The base includes a microgrid that functions independently of the civilian power grid and utilizes renewable energy, making it easier to use local power sources and harder for hackers to attack.

AmerisourceBergen Microgrid in Texas Winter Storm[38]

During a February 2021 winter storm in Texas that left millions without power, wholesale pharmaceutical company AmerisourceBergen utilized a microgrid system to continue operations. The company partnered with advanced microgrid provider, PowerSecure, to create an energy-as-a-service solution powered by vehicle engines. The system provides full facility backup during emergencies and participates in demand response programs to alleviate grid stress and generate utility savings.

AI CASE STUDY
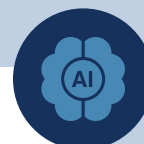
AI for Remote Damage Assessment[39]

xView2, an AI project developed by the U.S. Department of Defense in collaboration with research partners, has shown promise in aiding disaster response efforts. By utilizing machine-learning technology and satellite imagery, xView2 can quickly identify, categorize and assess building and infrastructure damage in disaster areas, providing valuable information for first responders and recovery experts.

ROBOT/DRONES CASE STUDY

Drones used for Hurricane Ian Response[40]

In the wake of Hurricane Ian in September 2022, drones were used across southwest Florida to help with disaster preparedness and emergency response. Before the storm, drones mapped out areas to understand the pre-storm condition of buildings and streets. In the aftermath of Ian, live video footage and data collected by drones assisted emergency response leaders in making quick decisions about where to deploy resources for rescue, recovery and relief efforts.

SYNTHETIC RESILIENCY MODELING CASE STUDY

Synthetic Resiliency Modeling on Extended Power Outages[41]

TVA and EPRI are collaborating with Nashville Electric Service (NES) and the City of Nashville to model an extended power outage in Nashville and the potential benefits of placement and adoption of distributed energy resources (DERs) across the city. The project explores how a citywide outage scenario would affect different parts of the city, recognizing that the impact of outages varies between populations and neighborhoods (e.g., those with and without backup power supply at their homes or businesses).

Planning Solutions

Natural Disaster Planning

Communities wanting to enhance their resilience to natural hazards should develop and implement plans adapted to their local demographic, economic and geographic needs. The process starts with local governments identifying common natural disaster risks their community faces and analyzing areas vulnerable to these risks. Hazard mitigation plans (sometimes referred to as resiliency plans or disaster mitigation plans), compile communities' long-term strategies for reducing the impact of disasters across multiple sectors, such as infrastructure and economic development. Plans serve as a guide for risk-informed decision-making at the local level. Resiliency plans can be incorporated into or cross-referenced within a community's comprehensive plan (e.g., general plan, master plan). This allows a community to develop, document and share a vision for the future of the community.

FEMA's State Mitigation Planning Policy Guide[42] and Local Mitigation Planning Policy Guide[43] define the requirements that state and local governments' mitigation plans must meet to receive FEMA's approval. The guides enable consistent evaluation and approval of state and local mitigation plans, ensuring compliance with FEMA's mitigation planning requirements.

Communities are encouraged to build their own FEMA-approved mitigation plan that identifies hazards, assesses risks and vulnerabilities and develops mitigation strategies at a local level. Section 201.1(b) of 44 CFR[44] explains that "The purpose of mitigation planning is for state, local and Indian tribal governments to identify the natural hazards that impact them, to identify actions and activities to reduce any losses from those hazards and to establish a coordinated process to implement the plan, taking advantage of a wide range of resources."

In addition to the benefits of mitigation planning, the FEMA mitigation planning process is required for communities to be eligible for certain FEMA assistance. To maintain grant eligibility, mitigation plans must be updated, formally adopted by each participating jurisdiction's governing body (state or local) and then submitted for FEMA approval every five years. More information on specific FEMA grants can be found in the funding section of this guide.

FEMA's Local Planning Requirements

Planning Process

A description of the planning process used to develop the plan.

Risk Assessment

A risk assessment that specifies the hazards that can affect jurisdictions participating in the mitigation plan.

Mitigation Strategy

A mitigation strategy that provides the long-term blueprint for reducing the losses identified in the risk assessment.

Plan Maintenance

A process for how the plan will be maintained, including how progress will be tracked and new information will be added.

Plan Update

A reflection on how current conditions have changed since the last plan, including an assessment of current development patterns and pressures and an evaluation of any new hazards or risks.

Plan Adoption

The plan must be adopted by local governing bodies to demonstrate commitment to the hazard mitigation plan's goals and actions.

High Hazard Potential Dams (HHPD)

All dam risks must be included in the local hazard mitigation plan for the local government to be eligible for HHPD grants.

State Requirements

The plan must meet state requirements, if applicable.

For a more detailed description of the requirements of Local Mitigation Plans refer to Title 44 CFR § 201.6.[45]

Planning Solutions

Planning Resources

There are a variety of publicly available resources that communities can use in the development of resilience plans. Several planning resources are highlighted below.

1

Community Driven Climate Resilience Planning Framework

Published by the National Association of Climate Resilience Planners (NACRP), this framework[46] aims to define and build climate resilience through culturally relevant, democratic processes that meaningfully engage vulnerable and impacted communities. The framework is intended for community-based organizations developing, advocating for and implementing climate solutions. Other audiences include public sector officials and philanthropic institutions developing funding for climate change strategies. According to this framework, communities need capacity in three areas to effectively address climate impacts:

- The capacity to put forward a vision and assert a set of community priorities
- The capacity to assess community vulnerabilities and assets
- The capacity to build community voice and power

Each of these capabilities includes a case study illustrating how U.S. communities have used it, providing tangible examples of how to adapt the framework to local circumstances.

2

Accelerate Climate Resilience with Local Planning, Policies, and Practices

The Model Forest Policy Program (MFPP) offers four 90-minute webinars[47] tackling how to integrate climate resilience into existing plans, policies and practices, and how to implement these climate adaptation plans. More specifically, course learning objectives include:

- Identify opportunities to get adaptation plans off the shelf and into action.
- Frame adaptation strategies for easy integration into local planning, policy and practice.
- Apply practical adaptation solutions to comprehensive planning and land use codes and ordinances.
- Bring climate resilience to an integrated water resource management approach.
- Create or update a hazard mitigation plan with climate resilience strategies.

3

Planning for Infrastructure Resilience Guide

In partnership with NOAA's Office for Coastal Management, the American Planning Association (APA) built this guide[48] to point planners to tools for addressing climate and other natural hazards. The guide helps planners make informed decisions with the best available science and consider future conditions when allocating resources. Highlights include:

- Chapter 4, "Planning Tools for Infrastructure Resilience", discusses the foundation for a strong infrastructure resilience plan. This chapter provides guidance on community engagement, regional considerations and the functional aspects of integrating plans for hazard mitigation, climate adaptation, open space and infrastructure systems.
- Chapter 6, "Standards, Guidelines, And Regulations for Resilient Infrastructure Development", goes into detail on guidelines, regulatory approaches to existing infrastructure and specific adoption strategies for infrastructure resiliency guidelines and regulations. After communities have assessed how climate change might affect them, the next step is to develop standards and guidelines that align with local zoning, land use and other related regulations around building infrastructure that is resilient and adaptable. This chapter also offers planners strategies to speed up the adoption of local guidelines and regulations to advance community and infrastructure resilience.

4

Implementing the Steps to Resilience, A Practitioner's Guide

Developed by NOAA in partnership with the University of North Carolina Asheville's National Environmental Modeling and Analysis Center (NEMAC) and the U.S. Climate Resilience Toolkit[49] (CRT), this free guide[50] helps U.S. communities understand and adapt to climate variability and climate change. The guide is organized by the Steps to Resilience (StR) framework.[51] For each StR step, the guide provides specific objectives, a list of resources and implementation examples. This guide can be used by practitioners during training as a workbook or as guidance when working with a community to implement StR.

5

Resilient Rural America Project

MFPP also offers a free online training program for resilient land use "to help rural communities become more resilient to extreme weather and changing climate conditions." The self-guided training[52] consists of two modules, a downloadable workbook and a series of worksheets. Users must create a log-in for a free account to access the online portal. Each module takes an estimated 15-20 hours to complete, plus time for researching local information.

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LONG-TERM PLANNING CASE STUDY

Leveraging StR to Prepare for Expected Climate Change Impacts[53]

Asheville, NC

A team of researchers with UNC Asheville's National Environmental Modeling and Analysis Center (NEMAC) identified wildfires as one of the main climate-related threats facing the 90,000 Asheville residents. In addition to wildfires, floods present a threat, as shown by the 2004 tropical storms Ivan and Frances in which 11 people lost their lives and 140 homes were destroyed by flooding and landslides in western North Carolina. Following the tragedy, the research team helped develop a climate resilience assessment to support the city's preparedness for climate-related threats using the U.S. Climate Resilience Toolkit. The resulting citywide resilience plan was subsequently incorporated into Asheville's 2018 comprehensive plan.

Partnerships

Together, NEMAC, NOAA's National Centers for Environmental Information and private-sector consultants organized by The Collider Innovation Center created a climate science community for the City of Asheville.

Method

The NEMAC team created a series of climate resilience planning workshops for Asheville using the Climate Resilience Toolkit's StR framework.

Explore Hazards

NEMAC and city leaders identified three primary stressors: heavy precipitation (which can cause flooding and landslides), drought (leading to water shortages and wildfires) and temperature variability (with extreme heat events).

Assess Vulnerability and Risks

This step involved identifying vulnerable physical infrastructure in the city. Nearly 4% of Asheville's residential properties and 17% of its commercial properties are vulnerable to flooding events. For wildfire risk assessment, residential properties are evaluated and assets are identified that are most susceptible to wildfires.

Investigate Options

In spring 2017, 14 city departments involved in the assessment began investigating the options to address the identified threats using the information collected in the previous steps.

Prioritizing Actions and Implementation

By mid-2017, resilience-building options were prioritized and findings from the planning process were integrated into the city's comprehensive plan.

Lessons Learned

- Cross-jurisdictional collaboration is critical to adopting innovative solutions, many of which are outside of government control and therefore require fostering partnerships with other stakeholder groups.

- Cities can benefit from having a dedicated sustainability officer.

Outcomes

- Adopted the Climate Resilience Assessment[54] published on April 2018 as part of the comprehensive plan, "Living Asheville."[55]

- Produced Asheville Climate Resilience Resource Guide[56] updated June 2019.

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LONG-TERM PLANNING CASE STUDY

Regional Resiliency[57]

Chattanooga, TN

Over the past few years, the Chattanooga area has experienced various extreme weather events disrupting essential services and negatively impacting the community. Such events include record rainfall and flooding, excessive heat and wildfires and tornadoes. Improving greater Chattanooga's resiliency has become a high priority, and the City of Chattanooga is currently spearheading an effort to create a comprehensive mitigation plan for the region. The plan is built on the input of local public and private partners.

Partnerships

The City of Chattanooga and regional public and private partners.

Method

Interested parties and stakeholders share their resiliency ideas by completing the Chattanooga Resilience Strategy Workbook[58]. Participants identify a specific action that, if accomplished, will enhance Chattanooga's resilience.

Proposed actions should consider any factors that may reduce current or future impacts of climate-related hazards as well as other types of stress events. The Resilience Action Development Questions[59] document is also available to assist participants in developing their ideas.

FORMS OF ACTION

Policies
Regulatory or incentive-based measures

Programs
Education, outreach and social

Structural Projects
Asset enhancements, new infrastructure or environmental restorations

Desired Outcomes

- Compile all of Chattanooga's identified resilience needs into a single section of the plan to serve as a blueprint for reducing Chattanooga's overall vulnerability and enhancing its resilience.

This initiative is currently ongoing in the City of Chattanooga and will continue to yield insights and results. To stay updated on progress, visit the City of Chattanooga Regional Resiliency website[57] to sign up for their newsletter.

Planning Solutions

Creating a Plan

To build resiliency in your own community, it's important to take steps towards creating a plan or incorporating natural disaster mitigation and response into existing plans. Being prepared for inevitable adverse weather events is a crucial element in keeping communities connected and safe while enhancing the quality of life for residents. While a variety of resources exist to assist communities in disaster planning, the following high-level steps are repeated in every suggested planning process:

Identify Risks

Identify risks and assess vulnerabilities in your community.

Engage Community

Engage a representative group of community members to understand their awareness of current resources and unmet needs.

Create a Plan

Work with key stakeholders to create a plan or update an existing plan to respond to current threats and meet needs.

Finalize Plan

Finalize plan and establish a regular cadence for repeating the above steps to ensure the plan stays current.

Additional Resources

The following resources, along with others presented in this document, help communities remove barriers to hazard mitigation planning and understand steps they can take to mitigate, prepare for and respond to natural disasters.

1

NIST's Six-Step Process for Community Resiliency

This six-step process[60] provides a practical and straight forward approach to planning.

2

U.S. Climate Resilience Toolkit

The U.S. Climate Resilience Toolkit[49] helps communities learn about potential climate hazards and how to protect vulnerable assets.

3

FEMA's Hazard Mitigation Grant Program

FEMA's Hazard Mitigation Grant Program[61] provides funding to support communities in hazard mitigation planning.

4

Connected Communities Guidebook

This resource[62] provides guidance on how to develop a plan for making your community more "connected."

5

Community Assessment Tool

This tool[63] in the CIH presents example milestones that can help shape a community's vision and plans for the future.

Funding

Funding Opportunities for Natural Disaster Preparedness: FEMA Funding

FEMA provides grants to state, tribal, territorial and local governments, as well as certain types of nonprofits through their Public Assistance Program. This funding enables communities to more quickly respond to and recover from major disasters or emergencies. Communities can receive assistance covering costs related to debris removal, implementing emergency protective measures and restoring public infrastructure. FEMA provides assistance for hazard mitigation procedures during the recovery process to encourage communities to protect damaged facilities from future disasters.

To be eligible for certain funding, communities must have disaster mitigation and response plans in place. Specifically, local governments, including special districts, are required to have FEMA-approved mitigation plans to receive FEMA funds. As noted previously, to maintain grant eligibility, mitigation plans must be updated, formally adopted by each participating governing body and then submitted for FEMA approval every five years. Additional eligibility criteria is listed to the right.

ELIGIBILITY

In addition to having disaster mitigation and response plans in place, additional eligibility criteria may include:

Eligible Applicants

Eligible applicants include state, territorial, tribal and local governments or private nonprofit organizations.

Eligible Facilities

Eligible facilities include buildings, public works systems, equipment or natural features.

Eligible Activities

Work is categorized as either "emergency" or "permanent" and must be 1) required as a result of the declared incident, 2) be located within the designated disaster area and 3) be the legal responsibility of the applicant.

Eligible Costs Covered

Funding is tied directly to eligible work and must be adequately documented, authorized, necessary and reasonable. Examples include labor, equipment, materials, contract work as well as direct and indirect administrative costs.

In the event of a natural disaster, FEMA funds may be the best fit for recovery efforts and rebuilding infrastructure. FEMA funding is available to state, tribal, territorial and local governments.

FEMA FUNDING OPPORTUNITIES

- Public Assistance Program[64]
- Fire Management Assistance Grants (FMAG)[65]
- Building Resilient Infrastructure and Communities (BRIC)[66]
- Hazard Mitigation Grant Program (HMGP)[61]
- Hazard Mitigation Grant Program Post Fire[67]
- Flood Mitigation Assistance Grant Program (FMA)[68]
- Rehabilitation of High Hazard Potential Dams (HHPD)[69]

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Project-Specific Funding Guidance

Outside funding opportunities available to support natural disaster resiliency and mitigation planning include grants, loans, rebates and tax credits. Funding is administered through a variety of channels encompassing federal, state and local government agencies. Understanding what type of opportunity is a good fit for your project and community is crucial for securing and maximizing the benefit of external funding.

Federal funding opportunities can be a good fit for large-scale projects that show high impact and have robust teams of support. For example, the Bipartisan Infrastructure Law (BIL) offers significant funding to enhance the resilience of electric infrastructure against disruptive events such as extreme weather. The Inflation Reduction Act (IRA) provides tax credits, grants and loans to help fund clean, distributed energy projects, including community solar projects and microgrids. Municipal and non-taxpaying entities can now capture value from tax credits through direct pay. It is important to note that while federal grants may generally offer larger dollar amounts, the application process as well as reporting and compliance requirements often create a heavy administrative burden.

Federal funding opportunities can be a good fit for large-scale projects that show high impact and have robust teams of support.

Other federal programs with funding available for energy improvements that contribute to community resilience include:

- The Energy Improvement in Rural and Remote Areas (ERA) program[70] provides financial investment and technical assistance for community-driven clean energy projects and solutions that are replicable and scalable.

- The Empower Rural America (New ERA) program[71] provides funding to member-owned rural cooperatives to: 1) make energy efficiency improvements to eligible transmission systems; 2) purchase, build or deploy renewable energy, zero-emission systems or carbon capture systems; or 3) to purchase renewable energy.

States in TVA's service territory offer a variety of community-accessible programs for clean water, rural downtown redevelopment, sewer overflow mitigation, community development and more. State funding sources can help communities prepare their infrastructure for a natural disaster or make improvements to infrastructure in the wake of adverse events.

Funding Opportunities Database

More information on funding can be found on the Community Information Hub through the Connected Communities website, where you can access a searchable Funding Opportunity Database.[72]

Funding

Additional Funding Resources

There are several resources communities can leverage for additional guidance on finding and securing funding for resiliency projects:

1

MFPP Funding Guide

The MFPP team compiled a Climate Resilience Funding Guide[73] to help communities identify financial support for climate adaptation projects. It provides a quick overview of 34 grant programs supporting climate adaptation work and lists eligibility criteria, matching requirements, grant cycle dates and funding range.

2

U.S. Climate Resilience Toolkit

NOAA created the U.S. Climate Resilience Toolkit (CRT),[49] a free web portal offering a catalog of more than 500 digital data tools that can be used in the process of building resilience, community engagement and climate action plans. Through this portal, users can access data tools such as AirNow: Air Quality Index (AQI) Monitoring and Forecasts, ACIS Climate Maps and the Food Access Research Atlas.

3

Climate.gov Funding Opportunities

Housed in the U.S. Climate Resilience Toolkit[49] website, this page[74] offers resources and links to fact sheets and funding guides sourced from government entities and private foundations. These resources can be helpful for city officials and partners in planning adaptation and mitigation efforts. The BIL and IRA resources listed are particularly helpful for communities.

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SECTION 7

Resources

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SECTION 6

Funding

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