Climate Vulnerability and Adaptation Report for Salisbury, Maryland

2023

EcoAdapt™

Meeting the challenges of climate change

Cover photos:
(Top) Salisbury Waterfront; (Lower left) Salisbury Field Operations Staff; (Lower right) former Mayor Day recognizes Clean Streets Secretary Craig Faunce with award for street litter abatement. All photos courtesy of the City of Salisbury.

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Table of Contents

Introduction 5

Project Methods and Workshop Activities 6

Overview of Climate Projections 12

Vulnerability Assessment and Adaptation Strategies 14

Transportation 14

Open Space 21

Conclusions 30

Appendix A. Workshop Participants and Breakout Group Assignments for Salisbury, MD 32

Appendix B. Climate Changes and Impacts for Salisbury, MD 33

Introduction

The effects of climate change, which are already being experienced in Salisbury, Maryland, will continue for decades to come. These changes include higher average temperatures, more extreme heat, changes in precipitation intensity and seasonal distribution and increased risk of flooding, and sea level rise. Climate-related impacts, coupled with pre-existing challenges such as lack of affordable housing, population growth and increasing demand for transportation and social services, aging infrastructure, and fragmented and inequitably distributed open space, have significant implications for the people, infrastructure, and environment of Salisbury.

The purpose of this report is to improve the understanding about local climate change impacts and vulnerabilities and present adaptation responses that can help reduce community vulnerability and/or increase resilience. The report synthesizes the results of a 2-day workshop held in April 2023 at Salisbury University. This workshop brought together 13 stakeholders from across Salisbury to evaluate community vulnerability and develop adaptation strategies for two focus areas of importance to the community: transportation and open space. A third group, housing, did not have sufficient participation to form a focus group, but climate change and potential impacts for housing are included in this report. The tools that this workshop provided could be applied to conduct a vulnerability assessment for housing and climate change in Salisbury.

The subsequent sections in this report are described below:

- **Project Methods and Workshop Activities** – Provides an overview of the climate adaptation planning process, workshop series, and selection of pre-existing conditions and climate stressors.
- **Overview of Climate Projections and Impacts** – Presents a summary of current and projected climate changes for the community.
- **Vulnerability Assessment and Adaptation Planning Results** – Summarizes vulnerability and adaptation information for each of the three focus areas.
- **Conclusions** – Highlights common concerns, impacts, and adaptation strategies across the different focus areas.

Project Methods and Workshop Activities

Climate Adaptation Planning Overview

Climate change adaptation refers to how we prepare for, respond to, and recover from changes we are already experiencing and/or are expected to experience. *Adaptation*, which focuses on managing the impacts of climate change, can be distinguished from *mitigation*, which refers to efforts intended to decrease the potential for climate change itself (e.g., by reducing greenhouse gas emissions or enhancing carbon sequestration). The adaptation planning process (Figure 1) intentionally integrates the consideration of climate change into plans, programs, projects, and operations and is meant to be iterative.

While there are many different climate adaptation planning frameworks, they generally consist of the same steps: (1) project scoping, (2) assess vulnerability, (3) identify adaptation strategies, (4) implement those strategies, and (5) monitor, evaluate, and adjust strategies, as needed.

These steps are described below:

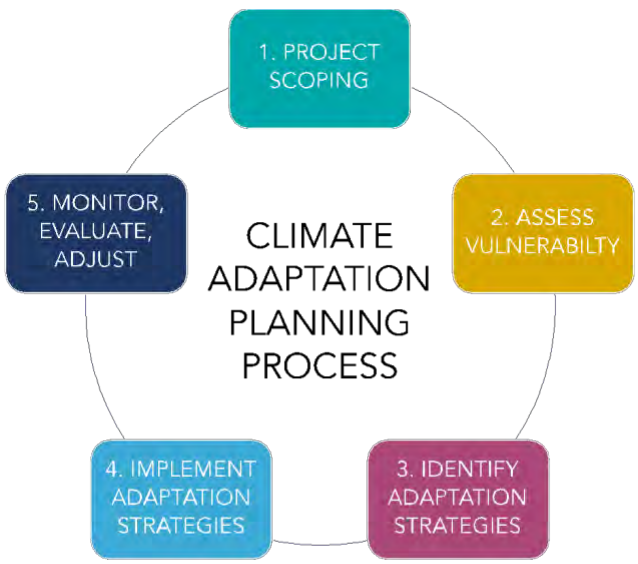

Figure 1. Steps in a Basic Climate Adaptation Planning Process

1. **Project scoping**. This step includes identifying goals and desired outcomes of the process, establishing the geographic boundaries and timeframe of interest (i.e., near-term = 0–20 years; mid-term = 25–50 years; long-term = 50+ years), identifying and engaging with key stakeholders and partners, and identifying key climate stressors and pre-existing conditions (i.e., stressors that already affect a community). Completion of this step is critical to providing the foundation for a clear and efficient adaptation planning process.

2. **Assess Vulnerability**. Vulnerability assessments improve understanding of how climate change is likely to affect a community and its ability to respond to those impacts.

Vulnerability assessments include considering the likelihood of exposure to climate change, the consequence of that exposure, and the community's capacity to adapt to those impacts. These assessments include consideration of the following three components of vulnerability:

- **Likelihood** is the degree to which a community is exposed to significant changes in climate and considers both the anticipated direction and magnitude of change.
- **Consequence** is the degree to which a community is affected by exposure to a changing climate and considers both the anticipated impacts of climate stressors as well as the impacts of pre-existing conditions.
- **Adaptive capacity** is the ability to adjust to climate change to minimize potential damages, take advantage of opportunities, or cope with consequences.

Likelihood and consequence together give an estimation of risk that, when combined with adaptive capacity, provides an overall picture of vulnerability (Figure 2). It is important to evaluate all three components—likelihood, consequence, and adaptive capacity—to gain a holistic perspective of the factors that are driving vulnerability.

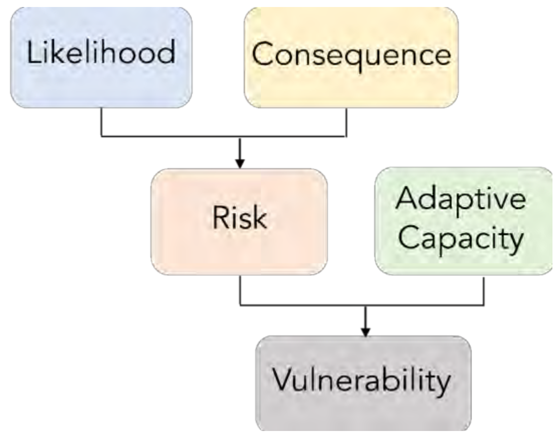

Figure 2. Components of Vulnerability

The vulnerability assessment step of the adaptation planning process includes evaluating the impacts of climate change on a community; characterizing the community's ability to minimize or cope with impacts; assigning likelihood, consequence, and adaptive capacity rankings; and summarizing overall vulnerability based on rankings, impacts, and adaptive capacity information. The resulting level of vulnerability is assessed using risk matrices that incorporate these components (Figure 3).

RISK CALCULATOR MATRIX

Likelihood	Consequence			
	Negligible	Moderate	Major	Catastrophic
Rare	Low	Low	Low	Low
Unlikely	Low	Moderate	Moderate	High
Likely	Low	Moderate	High	Extreme
Almost Certain	Low	High	Extreme	Extreme

VULNERABILITY CALCULATOR MATRIX

Risk	Adaptive Capacity		
	Low	Moderate	High
Low	Low	Low	Low
Moderate	Moderate	Moderate	Low
High	High	Moderate	Moderate
Extreme	High	High	Moderate

Figure 3. Matrices for Assessing Level of Risk and Vulnerability

3. **Identify Adaptation Strategies**. Adaptation strategies aim to reduce the negative effects or take advantage of the opportunities provided by climate change. The goal of this step is to identify adaptation strategies that reduce risk (limit exposure or minimize consequence) and/or enhance resilience (increase adaptive capacity). Understanding what drives vulnerability to climate change (likelihood, consequence, adaptive capacity, or some combination of these) provides a good starting point for identifying possible adaptation strategies. General types of adaptation strategies that may be considered include programmatic; capital improvements and infrastructure; coordination and/or collaboration; knowledge and evaluation; and plans, regulations, and policies. To help decide which actions to prioritize for implementation, it can be helpful to articulate co-benefits (e.g., greenhouse gas reduction, public health improvement, water quality improvement, etc.) and conflicts or challenges (e.g., unintended consequences on people or community assets).

4. **Implement Adaptation Strategies**. When a list of adaptation strategies has been generated and prioritized, they must be put into action. Developing an adaptation implementation plan for each prioritized strategy helps communities articulate how and when (e.g., immediately or within the next 5 years) the strategy should be implemented, leads and partners responsible for implementation, existing resources and those that are still needed, and potential barriers to implementation.

5. **Monitor, Evaluate, and Adjust**. Climate change adaptation planning should be an iterative process, and monitoring and evaluation are essential components that allow communities to make progress while also adjusting actions based on project outcomes and new information. For example, post-implementation monitoring of adaptation strategies helps to determine whether the strategies are having their intended effect and when or where adjustments might be needed. Developing a monitoring and evaluation plan is critical to minimize wasted time, money, and effort. These plans should identify desired outcomes, parameters to monitor and the method to do so, thresholds that may signal desired outcomes are not being met, and possible alternative strategies to pursue if these thresholds are crossed.

Tools Used in the Workshop

Climate Change Adaptation Certification Tool

The Climate Change Adaptation Certification Tool (CCAC)[1] is intended for use during regulatory or procedural review processes being carried out as part of routine community functions. The CCAC can be applied to decisions about any project or proposal that will involve the use of public funds, has a life cycle of greater than 5 years, and can affect public good (e.g., fiscal expenditures, capital planning, permitting, infrastructure design, and siting). Applying the CCAC to these decisions allows explicit evaluation of future conditions on project function and longevity, increases understanding of the long-term sustainability of a project at the funding or permitting phase, and considers how to reduce community risk that could arise from actions that become a liability under future conditions. The CCAC process includes three steps:

1. Identify climate change risk factors
2. Evaluate climate impact on a project
3. Determination of project review

Rapid Vulnerability and Adaptation Tool

The Rapid Vulnerability and Adaptation Tool (RVAT)[2] for Climate-Informed Community Planning was developed to make climate adaptation planning a simple, direct, and feasible process for communities. The purpose of the tool is to improve understanding of community vulnerability to climate impacts and to develop implementable solutions that reduce vulnerability and/or increase resilience. The RVAT is designed to cover the major steps of a basic climate adaptation planning process, which include the following:

1. Project scoping
2. Vulnerability assessment
3. Adaptation strategy development
4. Adaptation implementation

[1] https://ecoadapt.org/data/documents/2022EcoAdaptCCAC_Maryland.pdf

[2] https://ecoadapt.org/data/documents/RVAT_2022_fillable.pdf

The RVAT includes step-by-step instructions for completing a vulnerability assessment and provides detailed guidance for helping develop adaptation solutions for any focus area or issue of interest to a community. In this workshop, the RVAT was used to assess vulnerability and solutions for focus areas of particular interest to the Salisbury community, as described below, but it is a tool that can be used broadly for a wide range of issues[3].

Workshop Series Overview

The Salisbury Change Adaptation Workshop series[4] was held at Salisbury University on April 24 and 25, 2023. The first day of the workshop focused on discussing climate impacts and assessing vulnerability, and the second day focused on developing adaptation strategies. Workshop activities for each day are discussed in more detail below.

Climate Adaptation Workshop Activities: Day 1

The first day focused on orienting participants to the workshop series, introducing climate adaptation planning and the steps involved, identifying and prioritizing pre-existing conditions (i.e., stressors that currently impact the community), presenting climate change projections and discussing impacts, introducing and completing the first step of the CCAC, and completing the first two steps of the RVAT (project scoping, including prioritizing pre-existing conditions and climate stressors and evaluating adaptive capacity, and conducting the vulnerability assessment).

Workshop activities were divided between presentations, large group discussions, and breakout group activities. Workshop participants were divided into groups to address two focus areas: (1) Transportation and (2) Open Space.

Workshop participants, including affiliations and breakout group assignments, can be found in Appendix A.

Project Scoping: Identifying Pre-Existing Conditions and Climate Stressors

As part of the first step of the RVAT (project scoping), workshop participants were asked to identify pre-existing conditions for Salisbury (i.e., stressors that already impact the community). Participants collectively identified more than a dozen pre-existing conditions that, through discussion and ranking in each breakout group, were narrowed down to top priority conditions (bolded items represent top three conditions selected by the group):

- Group 1, Transportation: **Aging infrastructure; population growth and increasing demand on services; lack of adequate revenue sources to complete projects;** lack of pedestrian and cycling infrastructure, lack of adequate staffing and labor pool; outdated

[3] See how other communities have used the tool at the workshop at http://ecoadapt.org/programs/awareness-to-action/nsf-workshops
for additional examples of how the RVAT has been used for a variety of topics.

[4] The workshop support page (https://ecoadapt.org/workshops/salisbury-april2023-workshop) includes links to presentation slides and all other workshop materials.

street design, population displacement, and workforce transportation challenges

- Group 2, Open Space: **Inequitable amount of and access to open space, including insufficient public and non-motorized transportation infrastructure; non-native, invasive species; fragmentation of open space and disconnection with green infrastructure;** lack of understanding by community of open space goals; safety concerns; and lack of and heterogenous distribution of trees

Major climate stressors for Salisbury were identified by workshop facilitators (Appendix B) and included increasing precipitation, increasing hurricane frequency and intensity, sea level rise and increasing coastal storm surge and flooding, and extreme heat.

Conducting the Vulnerability Assessment

The identified pre-existing conditions and climate stressors provided the basis for the second step of the RVAT (vulnerability assessment). Both breakout groups explored the intersection of these conditions and climate stressors to identify the impacts of greatest concern for their focus area. For each of these impacts, the groups assessed the primary components of vulnerability:

- *Likelihood* of the impact occurring
- C*onsequence* to the community were the impact to occur
- The consequent *risk* resulting from the product of likelihood and consequence
- *Adaptive capacity* of the community in terms of the staff and resources that the relevant jurisdictional and/or community groups have available to address the impact

These rankings were then used to determine risk (resulting from the intersection of likelihood and consequence) and overall vulnerability for that impact, based on matrices provided within the RVAT worksheets. The results of this vulnerability assessment formed the foundation for the adaptation solutions work during Day 2 of the workshop.

Climate Adaptation Workshop Activities: Day 2

On Day 2, the breakout groups focused primarily on identifying adaptation strategies that would reduce the impacts of greatest concern for each focus area and then developing implementation plans for priority strategies (the third and fourth steps of the RVAT, respectively).

Workshop participants were also introduced to a network mapping tool and given login information to access it (https://network-mapping-41fb1.web.app/). This tool, developed by the Virginia Tech team based on registration and pre-workshop planning, shows participants the existing relationships among local government departments/agencies and/or community organizations and how each links to different focus areas. The tool is designed to help participants think about the connections and partnerships that can support Salisbury in implementing adaptation solutions developed in the workshop as well as moving forward on community collaboration for climate change adaptation.

Overview of Climate Projections

The following summaries provided foundational information for the workshops about current and projected future climate changes. A table of observed and projected climatic changes can be found in Appendix B. Appendix B also provides a summary of a range of impacts that may be associated with each of the focus areas, but participants also identified their own set of impacts of importance for the transportation and open space focus areas (see Vulnerability Assessment section below).

Air Temperature and Extreme Heat

By the 2050s, average annual daily minimum temperature in Salisbury is projected to increase to 50.5°F, 4.3°F above the historical average of 46.2°F (from 1961 to 1990). By 2100, the average daily minimum temperature is expected to increase by 9.7°F to 55.9°F. Average maximum daily temperatures are projected to increase to 71.4°F, 4.5°F above the historical average of 66.9°F by the 2050s and to 76.5°F by 2100, an increase of 9.6°F[5].

Extreme heat events are also likely to increase significantly. From 1980 to 2009, the average number of days each year with maximum temperatures over 90°F was 20.2; this is projected to increase to 59.6 days per year by the 2050s and to 105.6 days per year by 2100 (representing a 195% and 423% increase, respectively).[5]

Precipitation

Annual precipitation in Salisbury is expected to increase by mid-century, with model projections suggesting an increase from 43 inches per year in 1961–1990 to 45.8 inches per year by the 2050s and 48.5 inches by 2100, an increase of 6.5% and 12.9%, respectively[5]. Seasonal shifts in precipitation distribution are expected, with substantive increases in winter (+13.6%) and spring (+8.1%) precipitation by 2100. Rainfall is also likely to increase slightly (+1.8%) in summer and fall (+3.8%)[6].

Extreme Precipitation and Flooding

Extreme precipitation is likely to increase in terms of both frequency and amount over the coming century. The number of days each year when at least 2 inches of rain falls within 24 hours is expected to increase from a historical average of 0.9 day per year to 1.2 days (+33%) by the 2050s and to 1.7 days (+89%) by 2100[5]. An increase is also projected in the amount of rain

[5] U.S. Climate Resilience Toolkit Climate Explorer (https://crt-climate-explorer.nemac.org/) generated using the high-emissions (RCP 8.5) scenario for the average of 2040–2049 and 2090–2099 time periods compared to historical conditions (average of 1961–1990).

[6] Alder, J. R. and S. W. Hostetler, 2013. USGS National Climate Change Viewer. US Geological Survey (https://doi.org/10.5066/F7W9575T), generated using the high-emissions scenario (RCP 8.5) for a late-century (avg. of 2075–2099) time period compared to recent conditions (1981–2010).

falling in a given extreme precipitation event, with rainfall totals within a 20-year storm event expected to increase 13% by 2050 and 22% by 2100.[7]

Hurricanes, which bring both strong winds and severe risk of flooding, are expected to increase in intensity and frequency with climate change. Hurricane intensity increased by 8% per decade between 1979 and 2017[8]. Hurricanes also slowed down by 16% between 1949 and 2016, significantly increasing local rainfall totals.[9] Over the past several decades (1982–2020), the probability of any given year being an active hurricane season has doubled.[10] By 2100, model projections suggest an increase in the frequency of Category 4-5 hurricanes making landfall.

Sea Level Rise and Coastal Flooding

Sea level rise projections for the Salisbury region find a 50% probability of 1.3 ft sea level rise by 2050; there is a 5% probability sea level rise will exceed 2.1 ft in that timeframe. By 2100, there is a 50% probability of 3.0 ft of sea level rise, and a 5% probability of exceeding 5.4 feet.[11]

The combination of sea level rise and increases in precipitation and storm events also make it likely that coastal flooding will increase. The return period of a present-day 100-year flood is expected to decrease to just over 7 years in Norfolk, Virginia, by 2100.[12]

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[7] D. R. Easterling et al., in Climate Science Special Report: Fourth National Climate Assessment, Volume I, D. J. Wuebbles et al., Eds. (U.S. Global Change Research Program, Washington, DC, 2017; https://science2017.globalchange.gov/chapter/7/), pp. 207–230.

[8] 5 J. P. Kossin, K. R. Knapp, T. L. Olander, C. S. Velden, PNAS. 117, 11975–11980 (2020).

[9] -16% in rate of forward motion for North Atlantic hurricanes from 1949– 2016. 6 J. P. Kossin, Nature. 558, 104–107 (2018).

[10] 7 P. Pfleiderer, S. Nath, C.-F. Schleussner, Weather and Climate Dynamics. 3, 471–482 (2022).

[11] 4 D. F. Boesch et al., "Sea-level Rise: Projections for Maryland 2018" (University of Maryland Center for Environmental Science, Cambridge, MD, 2018). Both the central estimate (50% probability SLR meets or exceeds) and the upper limit of the very likely range (5% probability SLR meets or exceeds) are presented here, for the high-emissions scenario (RCP 8.5).

[12] 9 T. L. Mayo, N. Lin, Weather and Climate Extremes. 36, 100453 (2022).

Vulnerability Assessment and Adaptation Strategies

The following sections summarize the vulnerability and adaptation information for the focus areas of Transportation and Open Space. The information presented is based on the discussions and input of workshop participants during breakout group activities.

Transportation

The transportation breakout group addressed a full range of transportation modalities in Salisbury that contribute to health, livability, and connectivity to community resources, including employment, services, health care, and recreation, in the context of expected impacts of climate change on transportation connectivity and function. The group considered a timeframe of 30 years, with a 5-year timeframe for many planning cycles.

VULNERABILITY ASSESSMENT

Summary of observed and/or anticipated effects of pre-existing conditions and climate stressors

Pre-existing Conditions

Aging and inadequate infrastructure; population growth and challenges in accessing transit; and **lack of funding,** were identified by group participants as the primary pre-existing conditions that have the most significant impacts on transportation.

Aging and inadequate infrastructure affects transportation because of increased maintenance costs, old roadway designs limiting use and function, and lack of adequate and updated transit.

Population growth is a concern for transportation because there are growing disconnects between where development is located and accessing work and services like healthcare. A large number of people commute to Salisbury for work. This places additional stress on both transportation infrastructure and road function, and it also means the City's tax base may be increasingly disproportionate to service and infrastructure demands.

Funding is a significant challenge for transportation as costs continue to rise. There is limited capacity within the City to apply for and in particular manage grants, and matching requirements for some grants can be cost prohibitive. Often, grants provide income for special or one-time projects, but they rarely provide the types of ongoing operational support for staff and maintenance that is needed.

Climate Stressors

Extreme heat and increases in freeze/thaw cycles, sea level rise and **hurricanes and extreme precipitation events** were identified by participants as the primary climate stressors that affect transportation.

Extreme heat and fluctuating temperatures are likely to have impacts on transportation, including increasing risk of damage to asphalt, increasing reliance on automobiles to escape the heat, and damage to street trees.

Sea level rise is likely to impact transportation because access to some neighborhoods will become compromised or impassible, and tidal flooding and roadway inundation will increase, leading to increased damage to roads and infrastructure. Port activities may need to be shifted or may not continue to function as sea level rises. Sunny day flooding and coastal flooding are both growing issues, with Fitzwater Street noted as a particular area of concern.

Hurricanes and storm events are likely to cause impacts, including increased road runoff and pollution and flooding of roadways that can lead to temporary shutdowns in access or transit service.

Combined Impacts of Pre-existing Conditions and Climate Stressors

Climate change is likely to exacerbate the impacts of or be exacerbated by all three pre-existing conditions. Breakout group participants identified the following challenges:

Extreme heat and fluctuating temperatures is likely to intersect with pre-existing conditions to exacerbate impacts in several ways, including the following:

- Extreme heat and freeze/thaw cycles will further distress already aging infrastructure, increase the rate of road damage and failures, and shorten times between maintenance cycles.
- Extreme heat may lower use of non-motorized transportation as people try to reduce their exposure to heat, which may in turn compromise residents' ability to get to work or needed services.
- Extreme heat can exacerbate heat island effects in neighborhoods, particularly those with low tree canopy covers damaged by heat, thus exposing more vulnerable populations to public health impacts.

Sea level rise is likely to intersect with pre-existing conditions to exacerbate impacts:

- Aging infrastructure is likely to be further compromised by sea level rise and intrusion of estuarine water onto roads and associated infrastructure.
- Increasing rates of tidal inundation could further stress a transit system that already struggles to meet the demands of residents to connect to work and needed services.

- Changes in what neighborhoods are accessible or livable may put increasing pressure on neighboring areas for development residential and commercial development and require a need to rethink transit access.

Hurricanes and extreme storm events are likely to intersect with pre-existing conditions to exacerbate impacts in several ways, including the following:

- There will be an increased need for planning evacuation routes and emergency response, particularly with a growing population.
- These events can lead to disruptions of transit services, particularly impacting vulnerable populations who rely on public transit to access work and services.
- A potential benefit for transit is that federal money tied to emergency response may be more readily available than other funding streams, but these funding streams do tend to be more reactive (after the event) than proactive, which is when such funds are needed for transit operations to prepare for change.

Overall vulnerability

Participants selected four impacts of greatest concern for transportation in Salisbury and assessed vulnerability for three of these impacts (see Table 3), as described below.

Transit access to healthcare services was ranked as having **high vulnerability** due to extreme risk and low adaptive capacity. **Aging infrastructure** and **Population growth and migration** were assigned **moderate to high vulnerability** rankings due to high to extreme risk and low to high adaptive capacity (caveated as uncertain because funding for solutions may be limited). Participants also moved forward concerns regarding old models of transportation systems, focused on single occupancy vehicles, that are especially threatened by climate change risks, but did not have enough time to assess vulnerability for this concern.

Table 1. Vulnerability Assessment Ranking Results for Effects/Impacts of Greatest Concern for Transportation

Effects/Impacts of Greatest Concern	Likelihood	Consequence	Risk	Adaptive Capacity	Vulnerability
Aging infrastructure and increases in the need for preventive and reactive maintenance	Certain	Major/ catastrophic	Extreme	High (maybe moderate because of lack of funding)	Moderate to High
Limits in transit access to healthcare services by a growing population	Almost Certain	Major	Extreme	Low	High

Population growth and migration and consequences for emergency response, changing transit needs to access work and services	Almost Certain	Moderate	High	Moderate (but could be low because of lack of funding)	Moderate to High

PROPOSED ADAPTATION STRATEGIES AND IMPLEMENTATION PLANS

Adaptation strategies for effects of greatest concern

Breakout group participants identified several possible adaptation strategies for transportation. Table 4 summarizes adaptation strategies in response to effects of greatest concern that were explored by breakout group participants.

Table 2. Identified Effects of Greatest Concern and Possible Adaptation Strategies for Transportation

Effects of Greatest Concern	Adaptation Strategies to Reduce Vulnerabilities
Aging infrastructure and increases in the need for preventive and reactive maintenance	● Re-evaluate maintenance and replacement cycles with an understanding of increasing frequency of climate change impacts, including extreme heat, sea level rise, and flooding. Identify triggers for action and retirement thresholds.** ● Increase outreach and engagement to promote awareness about emergency response and growing risk for transit areas vulnerable to flooding and sea level rise. Use social media and repetitive messaging to increase understanding that some areas will have necessarily reduced transit and service shifts with increasing climate impacts. *Co-benefits:* Increase public buy-in for transit shifts and transit funding, increase public safety by reducing exposure to risk. *Unintended consequences:* Reducing access by closures may particularly impact the vulnerable populations that need support.
Limits in transit access to healthcare services by a growing population that is further stressed by climate change impacts	● Create better connectivity between health care system, services, housing, and transit system. o Create zoning changes to facilitate more co-location of transit and health care services. o Promote physical grouping of services. o Create policy and operations change that promote neighborhood connectivity.** o Focus transit services on connectivity to health care. ● Promote telehealth were possible to reduce transit needs *Co-benefits:* Community health not only maintained but improved *Unintended consequences:* if health care services facilitated by these changes are based on having private insurance, are uninsured populations excluded from these benefits?
Population growth and migration and consequences for emergency response, changing transit needs to access work and services	● Zoning updates and planning, particularly through the comprehensive plan update, to address the needs of a growing population's multi-modal transit needs. ● Incentivize and restructure public and non-motorized transit options. ● Leverage the Maryland Smart Growth law to accomplish more compact and connected housing and services.

	● There are good examples that can be highlighted to show how better, resilient transit projects for growing populations can be done.** o Eastern Shore Drive Improvements, including upgrades to stormwater management, concentrated and centralized redevelopment, reduction of impervious surfaces and car-centric transit *Co-benefits:* Compact and denser development could increase the tax base to accomplish these priorities, particularly funding for adaptation needs. *Unintended consequences:* None identified.

Starred (**) adaptation actions were identified as high priorities for implementation.

Implementation plans for priority strategies

Participants discussed four of their highest priority adaptation strategies for transportation:

1. Highlight current and planned projects that meet goals for climate resiliency and improved multimodal transit goals.

   How to implement: Use the Eastern Shore Drive as a case study to showcase multiple goals/strengths, including 15-minute neighborhood design, increased density, urban redevelopment, green space and increased tree canopy cover to reduce heat island effects, and stormwater treatment and abatement.

   Leads and partners:

   Leads: City, especially Department of Infrastructure and Development (DID)

   Partners: Salisbury University, Planning and Zoning Committee, Developers, Shore Transit, and Mayor's office, especially communications.

   Resources and barriers identified: Property is already acquired, funding is identified, and design has begun. Barriers include the need for additional funding and the potential impacts of construction that may upset neighbors and impact traffic during the short term.

   Efficacy: High

   Feasibility: High

   Assessing efficacy: Would know if this strategy worked if there is significant redevelopment, including mixed use building; DOT valuation metrics for design; use transit metrics to quantify motorized vehicle reduction/non-motorized transit increases.

2. Improve neighborhood connectivity that is resilient to climate changes.

   How to implement: Cul-de-sacs were identified by participants as being high-cost relative to connections served, requiring high paving maintenance, and leading to disconnected housing that is poorly served by multimodal transit. Implement strategic reductions in City maintenance of cul-de-sac paving and policy changes that help the City move away from supporting extant and proposed cul-de-sac development.

Lead: City DID

Partners: HOAs, developers, field operations

Resources and Barriers identified: Significant potential cost savings make this an appealing action, but policy changes can be difficult and slow to enact.

Efficacy: Medium

Feasibility: High for both existing and future development

Assessing efficacy: Measure cost savings associated with reduced maintenance; measure increases in neighborhood connectivity.

3. Update infrastructure maintenance/repair/replacement schedule with a climate perspective
   How to implement: Add flooding risk and sea level rise more explicitly to decision matrix for repairs.

   Leads and partners:

   Leads: City DID, William White

   Partners: Field operations, State Department of Transportation, Shore Transit, residents, Salisbury University

   Resources and barriers: The processes for scheduling are already in place, and climate can be more explicitly integrated into such existing processes. No barriers were identified.

   Efficacy: High

   Feasibility: Medium

   Assessing efficacy: Reduction in the number of road problems reported; slower increase in costs; reduction, or slower increase, in amount of maintenance over time.

4. Maintain transit performance and emergency responsiveness during extreme events, including heat waves and hurricanes

   How to implement: A formal, climate-informed response plan is needed, with a clear differentiation between normal day response and hazard responses. Formalize plans for cooling centers in transit plans.

   Leads and partners:

   Leads: Shore Transit, Fire Department

   Partners: DID, Field Operations, Wicomico County

   Resources and Barriers: Resources include that a hazard mitigation plan already exists for the county, and the Transportation Development Plan is already underway. Barriers identified include considering where this work may fall in a long list of transportation planning priorities.

   Efficacy: High

   Feasibility: High

Assessing efficacy: Measuring continued performance over time relative to extreme events.

Open Space

The open space breakout group defined their goals as planning for (1) the creation and conservation of and equitable access to natural resources and (2) biodiversity and ecosystem services on private and publicly managed lands and open spaces, including state, county, and municipal parks in the Salisbury area. These goals, in the face of a changing climate, would ensure those systems remain resilient. The timeframe for this discussion was the next approximately 75 years (to 2100).

VULNERABILITY ASSESSMENT

Summary of observed and/or anticipated effects of climate stressors and pre-existing conditions

Pre-existing Conditions

Inequitable amount of, designation of, and access to natural areas; non-native, invasive species; and **disconnected green infrastructure and natural areas** were identified by group participants as the primary pre-existing conditions stressors that have the most significant impacts on the creation, conservation of, and equitable access to open space.

Inequitable amount of, designation of, and access to natural areas includes issues of unequal use of open space areas—some are underused, while others have too much pressure on them. Existing open space is not sufficiently maintained or sufficiently funded, which contributes to declining use and triggers a negative feedback loop where less use means less community support for and buy-in of funding open space acquisition and stewardship. Historical patterns of use also create barriers to connecting with natural spaces, as well as connecting natural spaces into networks.

Non-native, invasive species affect open space because these species can alter biodiversity and ecosystem services associated with open space. They can also have impacts on natural resources that are economically beneficial like fisheries. They can decrease the use of open space (e.g., poison ivy or other toxic plants) and decrease food availability for wildlife that people come to open space to view. Non-native invasive species can cause physical damage, such as increased erosion or slope instability, and they can also be vectors for, or themselves, pests and pathogens. One possible opportunity with these species is the potential for new uses of non-native species, which can in turn contribute to their control.

Fragmentation and disconnection, including lack of trees and lack of habitat heterogeneity impacts open space because of disruptions to the functioning of ecosystems, reduction of genetic diversity, and impacts to migratory pathways. Fragmented habitat is not prioritized for maintenance, and it is ignored until there is a dramatic event (e.g., trees down, storm damage, fire) and something has to be done to address the damage. Disconnected habitats also can reduce access by people and make it less desirable to visit natural areas, which can lead to the loss of recreational tourism.

Climate Stressors

Temperature and extreme heat, extreme precipitation and flooding, including storms and hurricanes, and **sea level rise and storm surge** were identified by participants as the primary climate stressors that affect open space.

Extreme heat events are likely to cause changes in the ability to access and interest in accessing open space, including access for students and education if heat events occur during planned field trips, and loss of tourism. Extreme heat can drive harmful algal blooms and fish kills, can stress plants and animals, and may cause changes in species compositions and populations, leading to decreases in ecosystem health. Extreme heat may decrease volunteer ability and the ability to conduct maintenance and stewardship activities outdoors.

Extreme precipitation, storms, and flooding can reduce access to and interest in accessing open space, including loss of tourism. Storm events can lead to erosion, inundation, and disruption of vegetation. These events may drive reductions or changes in fishing opportunities. Flooding and storms can drive increased pollution by moving chemicals from land surfaces into waterways. Infrastructure such as roads and transit used to access open space may be damaged or inaccessible.

Sea level rise and storm surge can lead to inundation and saltwater intrusion, with consequences for the amount and location of open space that is available and accessible; however, it could possibly lead to increases in availability of open space that can no longer be used for other functions. It may lead to loss or shifts in vegetation and habitats. There may be damage to or loss of water access points and associated infrastructure.

Combined Impacts of Pre-existing Conditions and Climate Stressors

Climate change is likely to exacerbate the impacts of or be exacerbated by all three pre-existing conditions. Breakout group participants identified the following challenges:

Extreme heat is likely to intersect with pre-existing conditions to exacerbate impacts in several ways, including the following:

- It will become even harder for people to get relief from the heat if there is not sufficient access to open space, and in turn it may increase pressure to build cooling centers and other infrastructure if natural spaces are insufficient.
- If extreme heat reduces access to open space even further, it will further depress use of and support for natural areas.
- Extreme heat will increase needs and demands for tree canopy cover.
- Extreme heat may favor or exacerbate some invasive species and make them more able to outcompete native species; native species may also be less able to respond to/resist invasive species due to heat stress.
- Extreme heat can lead to tree damage and loss, which can in turn increase the susceptibility of open spaces to invasive species.

- Extreme heat can contribute to or exacerbate declines in populations already impacted by habitat fragmentation.
- There may be reduced access to areas that are already limited by fragmentation.

Extreme precipitation, storms, and flooding are likely to intersect with pre-existing conditions to exacerbate impacts in several ways, including:

- Further reducing access to flood-prone areas that already underserve the local population.
- Reducing the number of places you can site a park or increase the amount of flood control that must be incorporated in order to maintain accessibility.
- Erosion and sedimentation, which can reduce transit and trail accessibility to wheelchairs and others with limited mobility.
- Flooding, which can increase invasive species spread; can disturb soils, which can facilitate invasive species; and make native species weaker and more susceptible to invasive species.
- Flooding and storms, which can further exacerbate or facilitate fragmentation by damaging and destroying soils and habitat.

Sea level rise and storm surge are likely to intersect with pre-existing conditions to exacerbate impacts in several ways, including:

- Further limiting the number of places that parks can be sited.
- Increasing the need and costs of adapting infrastructure.
- Driving inland migration of open space (as with the need for community movement).
- Vegetation loss, which may further decrease the number of sites considered attractive to visit.
- A possible benefit in terms of the increased opportunities for waterway trails and reduced cost of the land needed for access points.
- Shifts in vegetative composition, including increases in salt-tolerant invasives like phragmites, or transitions to ghost forest, which can degrade the condition of open space.
- Increased connectivity of water bodies may facilitate invasive species mobility.
- Shoreline hardening in response to sea level rise, which could lead to loss of habitat and native species.
- Sea level rise, which may cause additional habitat fragmentation and disconnection.

Overall vulnerability

Changes in patterns of use and access to open space resulting from climate risks; erosion, inundation, and loss of vegetation due to extreme precipitation and flooding; and **decreased access resulting in economic impacts, including funding declines for acquisition and maintenance of open space;** were ranked by breakout group participants as **high vulnerability** due to high extreme risk and moderate adaptive capacity. **Decreased habitat availability** was ranked as having **moderate to high vulnerability** due to high risk and low to moderate adaptive capacity. **Safety concerns** received a **moderate vulnerability ranking** due to extreme risk but high adaptive capacity. Table 5 summarizes this vulnerability assessment.

Table 3. Vulnerability Assessment Ranking Results for Effects/Impacts of Greatest Concern for Open Space

Effects/Impacts of Greatest Concern	Likelihood	Consequence	Risk	Adaptive Capacity	Vulnerability
Changes in use of, interest in, and accessibility of open space due to increasing temperature, sea level rise, and flooding	Almost Certain	Major	Extreme	Moderate	High
Erosion, inundation, and loss of vegetation due to extreme precipitation and flooding	Almost Certain	Major	Extreme	Moderate	High
Decreased access and consequent loss of revenue for maintenance and acquisition of open space	Almost Certain	Moderate to Major	High to Extreme	Moderate	High
Decreased habitat, including fragmentation and lack of connectivity due to temperature, extreme precipitation, sea level rise	Almost Certain	Moderate	High	Low-Moderate	Moderate-High
Safety concerns due to extreme heat, flooding	Almost Certain	Major (potentially catastrophic)	Extreme	High	Moderate

PROPOSED ADAPTATION STRATEGIES

Adaptation strategies for effects of greatest concern

Breakout group participants identified several possible adaptation strategies for open space. Table 4 summarizes adaptation strategies in response to effects of greatest concern that were explored by the group participants.

Table 4. Identified Effects of Greatest Concern and Possible Adaptation Strategies for Open Space

Effects of Greatest Concern	Adaptation Strategies to Reduce Vulnerabilities
Changes in use of, interest in, and accessibility of open space due to increasing temperature, sea level rise, and flooding	● Require equitable access to and amount of climate smart (meaning not vulnerable to sea level rise or flooding and well shaded) open space in the comprehensive plan.** ● Identify/map current open space areas and potential new areas for acquisition that would connect with non-motorized transit and benefit underserved areas and be out of harm's way from climate hazards.

	● Clearly mark/label open space access points in multiple languages and ensure they are physically accessible to a variety of users. ● Remove cost-related barriers for fishing, boating (e.g., reduce license fees, community boats). ● Advocate for a climate savvy state park in Wicomico County, which currently doesn't have one, that is located near Salisbury for easier access and use. *Co-benefits:* Better signage also increases public safety; improving non-motorized and transit access to open space reduces pressure on roads and need for parking infrastructure; opportunities for building more flood-adapted infrastructure associated with new acquisition. *Potential challenges/unintended consequences:* Increases in property values that can be associated with proximity to open space can exacerbate inequity.
Erosion, inundation, and loss of vegetation due to extreme precipitation and flooding	● Plant riparian buffers (with climate-ready plants), where applicable. ● Remove hardened shorelines and install living shorelines where applicable. ● Create and enforce climate-informed buffer requirements. ● Enact stricter local requirements to prioritize non-hardened shoreline/river line. ● Develop educational campaign for living shorelines with case studies. ● Create workforce to support above activities. *Co-benefits:* Increased habitat for spawning fish, invertebrates, birds, other taxa; job creation; increased public access to open space; flooding reduction. *Potential challenges/unintended consequences:* Less developable land and therefore a reduced tax base, reduced fishing access (may be correctable with raised walkways).
Decreased access and consequent loss of revenue for maintenance and acquisition of open space	● Acquire upland sites and other sites out of harm's way from sea level rise and flooding. ● Redesign to allow uninterrupted access during flood or extreme heat. ● Create community garden, "friends of" groups to support local open space. ● Use native, lower maintenance plantings better suited for a changing climate. ● Host invasives removal events that could generate revenue (e.g., fishing tournament). *Co-benefits:* Job creation, including summer jobs for students. Switching to native plantings and invasives removal can reduce nutrient runoff and pesticide use. *Potential challenges/unintended consequences:* Less developable land and therefore less housing stock; underserved parks and vulnerable populations need the most support but are less likely to have the bandwidth for "friends of" groups that can donate time or money.
Decreased habitat, including fragmentation and lack of connectivity due to	● Increase planting of climate change appropriate native species on private property.**

temperature, extreme precipitation, sea level rise	• Increase public education about Meadow Yards Program and more generally about climate benefits of increasing wildlife habitat and connectivity.** • Discuss removal of yard requirements and associated fines. • Add Certified Meadows in open spaces for demonstration; increase training for how to create meadows. • Convert impervious surface to green space. • Tree bounty and climate-adapted replacement species (species well-adapted for future site conditions). • Increase connectivity of green space (e.g., use street trees). • Update City tree list to designate climate change-adapted species. • Increase pollinator habit in dense urban areas (e.g., green roofs) • Increase understanding that range shifts and habitat migration with the goal of reducing fear/unfamiliarity. • Create invasive weed drop-off day. *Co-benefits:* Reduces food deserts if fruit trees are incorporated in planting plans. *Potential challenges/unintended consequences:* Concern that neglected yards might be considered habitat—need to encourage care and meadow creation.
Safety concerns due to extreme heat, flooding	• Increase tree canopy to reduce heat stress. • Create more connected pathways and ensure they are ADA-compliant.** • Improve flood standards to prepare for conditions over the lifetime of structures.** • Remove dangerous invasives, those that are physically risky due to potential for falling or collapsing and those that are toxic or pathogens. • Develop community alert system (e.g., Nixle) and equitable access, broadband to alert people to closed areas and/or alternate routes. • Establish cooling centers with passive cooling and renewable generation with battery backup. • Make facilities safer—longer lasting and less slippery on wet days, cooler on hot days. • Ensure adequate transit routes to provide easy access to open spaces that can offer heat relief.** *Co-benefits:* Increased overall public safety; improving flood standards could increase access to affordable insurance; passive/renewable energy ensures that infrastructure like cooling centers are not adding to greenhouse gas emissions or air pollution. *Potential challenges/unintended consequences:* Increased trees can be seen as decreased visibility and less safe (address by proper pruning and maintenance); better standards can increase costs, leading to greater barriers to implementation.

Starred (**) adaptation actions were identified as high priorities for implementation.

Implementation plans for priority strategies

Breakout group participants discussed four of their highest priority adaptation strategies for open space. A fifth adaptation solution was prioritized, but there was only time to develop ideas for leads and partners (see below).

1. Require equitable access to and amount of open space in the comprehensive plan, and map current and potential open space for climate-informed acquisition that connects with non-motorized transit and benefits underserved areas

   How to implement: Integrate into the comprehensive plan update process over the next 18 months (this is the first independent comprehensive plan for Salisbury, previously part of County comprehensive planning). Develop "equitable access" standards and verification process; inventory and map current open space and identify potential climate-informed open space for acquisition; survey users and neighbors.

   Leads and partners:

   Leads: City of Salisbury Planning Division

   Partners: Wicomico Environmental Trust (WET), Land Trust, State planning department, Maryland Department of Natural Resources (MDNR), Interfaith Partners for the Chesapeake (ICP), NAACP, Haitian Community, Fenix Youth Project, Schools, Salvation Army, Boys and Girls Club

   Resources and barriers: Existing resources include that funding exists for the comprehensive plan process; the plan is mandated; there is political will; and model comprehensive plans exist that include these kinds of priorities (e.g., e.g. County's Land Preservation, Parks and Recreation Plan (LPPRP)). Barriers include potential coordination issues between governments, lack of community participation could limit success or erode political will, and development along open space corridors.

   Efficacy: High

   Feasibility: High

   Assessing efficacy: Verification parameters for equitable access standard met; resurvey community members on open space awareness and use, how they access open space.

2. Increase native plants on private property and yards, including increased education in Meadow Yards Program and tree bounty and climate-adapted replacement plan

   How to implement: Pilot tree bounty program for 1 to 2 years. Create program administration, create and distribute information, including website and materials within a year, possibly using a summer intern. Create demonstration plots for Meadow Yards Program. Increase capacity for native plant production. Increase awareness of native plant nurseries.

   Leads and partners:

   Leads: Housing and Community Development Department and City of Salisbury Field Operations

Partners: Chesapeake Bay Foundation, Chesapeake Bay Trust, MDNR, MD Department of the Environment, congregations, One Water Partnership (Including Interfaith Power and Light, WET, and Lower Shore Land Trust), Sea Grant, Tree City, Arbor Day, local nurseries

Resources and barriers: Resources include political will; extant Meadow Yards Program; government agencies often have funding for these types of programs, already have a list of climate-ready trees, and there is a "500,000 tree" planting program where removal of non-native trees can be part of site preparation prior to planning climate-ready native trees. Barriers include the costs of trees, that local nurseries don't stock natives, and that there may be public pushback because of preferences for current vegetation and mature tree sizes.

Efficacy: Moderately High

Feasibility: Medium

Assessing efficacy: Increase in habitat and native vegetation throughout the city; assessments can be done with approaches like an annual Bioblitz.

3. Increase connected, ADA-compliant pathways and ensure adequate transit routes that provide access to and/or use open space that provides cooling services (e.g., water features, shade, buildings)

How to implement: Inventory and map open space, facilities, and transit options (including public, private, non-motorized, and motorized). Make non-motorized transit more accessible (e.g., bike library?). Include in comprehensive plan update over next 18 months. Survey ADA users on barriers and resources to paths and open space use. Conduct an urban heat map study (similar to that done by the Science Museum of Virginia[13]) , perhaps as a student project.

Lead: City of Salisbury Planning Division

Partners: Disability Advisory Committee, Salisbury University, Eastern Shore Regional GIS Co-operative, MD Department of Planning, MD Highway Administration, Congregations, Lower Shore Groups and Transit, Bicycle and Pedestrian Advisory Committee, Deaf and Dependent Living Assistance

Resources and barriers: Resources: Existing bike lanes, funds for ADA compliance and other infrastructure, public cooling spaces that already exist (library, civic center, Boys and Girls Club, Salvation Army). Barriers include political and economic will for transit routes; not all streets are wide enough for trees, bikes, and other features.

Efficacy: Medium to High

Feasibility: High

Assessing efficacy: Fewer heat-related health issues; repeat Urban Heat Assessment; remap connections and tree cover via GIS analysis; survey users about their modes of transportation to access open space

[13] https://smv.org/learn/blog/what-does-urban-heat-island-effect-mean-to-richmond/

4. Improve flood standard to prepare for lifetime of sites and structures, including access

   How to implement: Integrate into comprehensive plan, including looking forward to when FEMA maps update (last updated 2013); notify FEMA of stricter data (e.g., intent to use 30+ year projections). Expand creek watchers program to understand patterns on the ground.

   Lead: City Planning

   Partners: WET, MD Department of Emergency Management, Nanticoke Watershed Alliance, FEMA, National Oceanic and Atmospheric Administration (NOAA) IPC, developers, insurance companies

   Resources and barriers: Resources include updated data and creek watchers program. Barriers include pushback from developers, challenges with ADA access if buildings are higher, and lack of political will (reach code, not a state standard).

   Efficacy: Medium

   Feasibility: High

Assessing efficacy: Less flood-associated damage, claims, injury, etc. Continued downtown development.

5. Community alert system and equitable access to broadband to alert users to open space closures, route closures, and redirections to other options

   This idea was of interest to the group, with the thought that Housing and Community Development, Emergency Management, and the Heath Department would be important partners for this work, but there was not time to develop specifics of implementation further.

Conclusions

This workshop and the resulting report aim to improve the understanding of how transportation and open space are vulnerable to changing climate conditions in Salisbury, and to develop community ideas for addressing the identified vulnerabilities. This report summarizes possible adaptation strategies that were identified and discussed by the breakout groups as well as adaptation implementation plans designed to minimize vulnerabilities and/or increase resilience of the focus areas.

Similarities were found in both focus areas in terms of pre-existing conditions and climate stressors, and the combined impacts of these effects emerged across focus areas, including the following:

- *Pre-existing conditions* – Population growth and an inability to access services, including access to open space for recreation, heat reduction, and health as well as to work and health care services, particularly for vulnerable populations, was emphasized in both groups.
- *Climate stressors* – Rising temperatures and extreme heat, shifts in precipitation, storms and flooding, and sea level rise were all identified as major climate impacts for discussion by both groups.

Combined impacts of pre-existing conditions and climate stressors listed above were also identified across breakout groups as impacts of greatest concern, including the following:

- Impacts of extreme heat and extreme weather on the ability for people to obtain equitable access to recreational, economic, and health care services that they need was discussed in both groups.
- Extreme heat will further increase costs to both transportation and open space due to increased needs for maintenance and safe ways to transport people to services.
- Extreme storms and flooding can reduce opportunities for populations to safely access and use open space and services.
- Sea level rise will alter the nature and accessibility of open spaces and transportation connectivity in parts of Salisbury, necessitating shifts in where transit, open space, and connectivity between services is located.
- Factors such as low staff capacity make it more difficult for local agencies, organizations, and businesses to pursue and secure grant funding to assist with addressing climate vulnerabilities.

The similarities in impacts of greatest concern also resulted in overlapping and intersecting adaptation strategies, such as:

- Increasing connectivity in ways that are equitable and accessible by all residents, and support equity in accessing open space and services

- Designing transit systems that prioritize non-motorized, multimodal transit that is resilient to climate changes including extreme heat and flooding
- Highlighting extant successful projects (e.g., lower East Shore Drive multimodal transit planning; Meadow Yards Program) to increase community buy-in to and political will for climate adaptation strategies, and leverage community partnerships with a range of nonprofit organizations to disseminate information.

This report can be used as a reference for decision-makers in Salisbury as they plan for and commit resources to create a more sustainable and resilient community under climate change. The adaptation strategies that participants have identified during this workshop may present opportunities to leverage resources across multiple focus areas. In addition, there were many adaptation solutions brought forward by participants that were not developed further due to time limitations but can be a rich source of additional ideas for the community to consider.

Because climate adaptation is an iterative process and new research and modeling on projected climate changes and impacts are regularly released, it is important to revisit and/or revise the vulnerability assessments and adaptation strategies on a regular basis (e.g., every 5 to 10 years), as well as when additional topics of concern become priorities.

Appendix A. Workshop Participants and Breakout Group Assignments for Salisbury, MD

Participant Name	Affiliation
Transportation Group	
Andrew Wile	Transit Director, Tri-County Council for the Lower Eastern Shore, Maryland, Shore Transit Division
Brett Dobelstein	Data Analyst, Eastern Shore Regional GIS cooperative
Brian Soper	City Planner, City of Salisbury
Ronald Strickler, Jr.	Director, Housing and Community Development, City of Salisbury
William White	Transportation Manager, City of Salisbury
Open Space Group	
Dylan Laconich	Sustainability Specialist, City of Salisbury
Elise Trelegan	Chesapeake B-WET Program Coordinator, NOAA
Jared Parks	Land Programs Manager, Lower Shore Land Trust
Jennifer Didinger	Watershed Restoration Specialist, University of Maryland Sea Grant Extension
Madeleine Adams	President, Wicomico Environmental Trust
Mollie Rudow	Lower Eastern Shore Outreach Coordinator, Interfaith Partners for the Chesapeake

Appendix B. Climate Changes and Impacts for Salisbury, MD

Projected Trends % CHANGE BY 2100 ● Models vary

▼▼ ▼ – ▲ ▲▲

-30% -5% +5% +30%

CLIMATE CHANGES	METRIC	TREND	OBSERVED/PROJECTED CHANGES
Air temperature	Minimum temperature AVG DAILY MIN TEMP (°F)	▲	50.5°F (+4.3°F) by 2050 and 55.9°F (+9.7°F) by 2100[1] COMPARED TO HISTORICAL AVERAGE OF 46.2°F FROM 1961–1990
	Maximum temperature AVG DAILY MAX TEMP (°F)	▲	71.4°F (+4.5°F) by 2050 and 76.5°F (+9.6°F) by 2100[1] COMPARED TO HISTORICAL AVERAGE OF 66.9°F FROM 1961–1990
Extreme heat	Days over 90°F # OF DAYS WITH MAX TEMPS >90°F	▲▲	59.6 days (+195%) by 2050 and 105.6 days (+423%) by 2100[1] COMPARED TO HISTORICAL AVERAGE OF 20.2 DAYS PER YEAR FROM 1961–1990
Precipitation	Annual precipitation AVG INCHES PER YEAR	▲	45.8 in (+6.5%) by 2050 and 48.5 in (+12.9%) by 2100[1] COMPARED TO HISTORICAL AVERAGE OF 43.0 INCHES PER YEAR FROM 1961–1990
	Seasonality	▲	Significant increase in winter (+13.6% by 2100) and spring (+8.1%) rainfall, with slight increases in summer (+1.8%) and fall (+3.8%) precipitation[2]
Extreme precipitation	Amount 20-YEAR RETURN PERIOD TOTAL	▲	13% increase in amounts during 20-year events projected by 2050; 22% increase by 2100[3]
	Frequency # OF DAYS WITH 2" RAIN IN 24 HOURS	▲	1.2 days (+33%) by 2050 and 1.7 days (+89%) by 2100[1] COMPARED TO HISTORICAL AVERAGE OF 0.9 DAYS PER YEAR FROM 1961–1990
Sea level rise	Relative sea level change INCREASE FROM SEA LEVEL IN 2000	▲▲	50% probability of 1.3 ft by 2050 (5% probability of exceeding 2.1 ft); 50% probability of 3.0 ft by 2100 (5% probability of exceeding 5.4 ft)[4]
Hurricanes	Intensity MAGNITUDE OF SURFACE WINDS	▲	+8% per decade in global hurricane intensity from 1979–2017[5]
	Speed RATE OF FORWARD MOTION	▼	-16% in rate of forward motion for North Atlantic hurricanes from 1949–2016, significantly increasing local rainfall totals[6]
	Frequency	▲▲	+100% in the probability of an active hurricane season from 1982–2020[7] Likely increase in U.S. landfall frequency of Category 4-5 hurricanes[8]
Storm surge	Coastal flooding 100-YEAR FLOOD RETURN PERIOD	▲▲	Return period of present day 100-year flood decreases to 7.06 years in Norfolk, VA by 2100[9]

[1] U.S. Climate Resilience Toolkit Climate Explorer (https://crt-climate-explorer.nemac.org), generated using the high-emissions (RCP 8.5) scenario for the average of 2040–2049 and 2090–2099 time periods compared to historical conditions (average of 1961–1990).
[2] Alder, J. R. and S. W. Hostetler, 2013. USGS National Climate Change Viewer. US Geological Survey (https://doi.org/10.5066/F7W9575T), generated using the high-emissions scenario (RCP 8.5) for a late-century (avg. of 2075–2099) time period compared to recent conditions (1981–2010).
[3] D. R. Easterling et al., in Climate Science Special Report: Fourth National Climate Assessment, Volume I, D. J. Wuebbles et al., Eds. (U.S. Global Change Research Program, Washington, DC, 2017), pp. 207–230.
[4] D. F. Boesch et al., "Sea-level Rise: Projections for Maryland 2018" (University of Maryland Center for Environmental Science, Cambridge, MD, 2018). Both the central estimate (50% probability SLR meets or exceeds) and the upper limit of the very likely range (5% probability SLR meets or exceeds) are presented here, for the high-emissions scenario (RCP 8.5).
[5] J. P. Kossin, K. R. Knapp, T. L. Olander, C. S. Velden, PNAS. 117, 11975–11980 (2020).
[6] J. P. Kossin, Nature. 558, 104–107 (2018).
[7] P. Pfleiderer, S. Nath, C.-F. Schleussner, Weather and Climate Dynamics. 3, 471–482 (2022).
[8] T. R. Knutson, J. J. Sirutis, M. A. Bender, R. E. Tuleya, B. A. Schenkel, Climatic Change. 171, 28 (2022).
[9] T. L. Mayo, N. Lin, Weather and Climate Extremes. 36, 100453 (2022).

Appendix B cont. Climate Change Impacts for Salisbury, MD: examples of impacts on focus areas

LIKELY IMPACTS ASSOCIATED WITH PROJECTED CLIMATE CHANGES*	
Housing	• Increased risk of damage to housing and critical infrastructure (e.g., utilities) following storms, floods, and extreme heat • Increased heat stress in developed areas, exacerbated by large areas of impervious surfaces and lack of vegetation • Increased energy demand during heat waves, straining electrical grids and potentially resulting in power outages and increased costs • Exacerbation of existing patterns of inequity for low-income neighborhoods and other vulnerable communities who are more likely to experience heat island effects, poor drainage, etc.
Transportation	• Damage to transportation infrastructure (e.g., roads, bridges, culverts) following storms, floods, and extreme heat events • Road blockages and loss of access due to extreme events and sea level rise, impacting evacuation routes, emergency access, and other critical travel • Slower travel or road closures due to melting asphalt, overheating engines, and other impacts of extreme heat • Loss of electricity due to flooding or heat waves, limiting use of electric vehicles and impacting public transit • Decreased use of non-motorized transit due to more frequent/severe inclement weather
Open Space	• Reduced growth and productivity of native vegetation due to heat stress and increases in evapotranspiration • Expansion of non-native invasive plants, insect pests, and diseases, with associated impacts to native plants and wildlife • Increased risk of harmful algal blooms in freshwater, estuarine, and nearshore marine environments, impacting water quality and potentially causing widespread mortality of fish and other aquatic organisms • Changes in plant survival due to more frequent coastal inundation and/or saltwater intrusion into freshwater habitats, likely altering the distribution of native plant communities (e.g., salt marsh vegetation) • Increased flooding and erosion, impacting native plant communities as well as public and management access to greenspace • Increased heat stress for people and wildlife using open space areas as well as changes in patterns of recreational use (e.g., heavier use of sites with water features, increases in maintenance costs) • Altered or decreased ecosystem functioning on conservation lands due to changes in hydrology, thermal regime, and plant species composition and distribution

* All icons from the Noun Project: (1) Housing icon created by Carlos Dias; (2) Road icon created by Jorge Namos; (3) Trees icon created by David Khai

Resources:

- U.S. Climate Resilience Toolkit Climate Explorer (https://crt-climate-explorer.nemac.org)
- Maryland and the District of Columbia State Climate Summary 2022 (NOAA, https://statesummaries.ncics.org/chapter/md/)
- Sea-Level Rise: Projections for Maryland 2018 (https://www.umces.edu/sites/default/files/Sea-Level%20Rise%20Projections%20for%20Maryland%202018_0.pdf)
- Northeast Chapter of the Fourth National Climate Change Assessment (https://nca2018.globalchange.gov/chapter/18/)
- Coastal Inundation Predictions for Maryland (http://geronimo.hpl.umces.edu/mingli/)
- NOAA Sea Level Rise Viewer (https://coast.noaa.gov/slr/)