Mainstreaming Sea Level Rise Preparedness in Local Planning and Policy on Maryland's Eastern Shore

A report by the Eastern Shore Land Conservancy on behalf of the Eastern Shore Climate Adaptation

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[1] This report was commissioned by the Eastern Shore Land Conservancy on behalf of the Eastern Shore Climate Adaptation Partnership (ESCAP). The main body of the report was written by Eastern Shore Land Conservancy coastal resilience specialist James Bass. Flood vulnerability studies were written by Eastern Shore Regional GIS Cooperative director Dr. Michael Scott. The Higher Standards report was written by Jessica Grannis et al. with the Georgetown Climate Center. The Capital Improvement Planning report was written by Brandy Espinola and Kristel Sheesley with the University of Maryland Environmental Finance Center.

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Cover photo: David Harp, Chesapeake Photos

I - Executive Summary

Coastal flooding is not a new phenomenon on the Eastern Shore of Maryland. However, current modeling by the U.S. Geologic Survey (USGS) indicates that sea level is rising in the Chesapeake Bay nearly twice as fast as the global rate. The risk of flood damage from coastal storms is growing as sea levels rise and development encroaches on shorelines. While the region's historical vulnerability to flood events is understood and accounted for by planners, the coastal floodplain of the 21st century will look and behave very differently than it used to. The goal of this report is to clarify these new flood risks by assessing several scenarios that consider rising sea levels in the Chesapeake Bay and its tributaries.

This report is intended: 1) to inform decision makers and residents about local risks associated with the combination of sea level rise and coastal storm flooding; and 2) to guide communities towards policies and practices that will reduce flood and sea level rise risk. The report provides local government leaders and staff with data, analyses, policy options, and implementation guidance.

Partners in the development of this report include the Eastern Shore Regional GIS Cooperative (ESRGC), the Georgetown Climate Center, and the University of Maryland Environmental Finance Center. This report is the result of a yearlong planning process aimed at assisting ESCAP communities in preparing for sea level rise impacts. Using a "science to solutions" process, the project team combined geospatial data and economic information to assess risk and vulnerability to flood and sea level rise (SLR) impacts. These findings were the foundation of community adaptation workshops, which informed the recommendations and model language, provided herein.

The rates of sea level rise used in this report – approximately 2 feet by the year 2050 and 6 feet by the year 2100 – are based on extensive research by the U.S. Army Corps of Engineers and closely match projections included in the Maryland Climate Commission's "Sea Level Rise: Projections for Maryland 2018." Specific sea level rise rates used for each jurisdiction in this study are listed in Section VI.

A series of community adaptation workshops for local elected leaders and planning staff were held to ground truth the analyses performed by the Eastern Shore Regional GIS Cooperative. Local concerns about flooding were discussed, including:

1. A need for expanded freeboard requirements
2. Recognition that 1% chance storms seem to be occurring more frequently and extreme weather events are increasing in severity
3. Acknowledgement that sea level rise is reducing the margin of safety afforded by existing floodplain management practices (ordinances, building codes, policies, etc.). Stronger practices are needed to maintain and improve the margin of safety in the region's housing stock.

The workshops also gathered potential strategies for local jurisdictions to reduce sea level rise and flood risks. The Georgetown Climate Center and UMD Environmental Finance Center responded to the comments from the workshop participants and compiled specific policy options and practices that will help local officials plan for sea level rise impacts in their community. The recommendations that were prioritized by ESCAP members during the community adaptation workshops include:

1. Conduct a resilience assessment prior to undertaking new capital investment projects
2. Develop a multi-year maintenance and upgrade plan for infrastructure and other assets
3. Integrate resilience into capital improvement planning

4. Expand the regulatory floodplain
5. Enact three-foot freeboard requirements in all building codes
6. Regulate Coastal A zones as V zones

Flood risk is changing across the Eastern Shore. The strategies included in this report will help communities build a greater margin of safety against coastal storms. While the 2050 and 2100 scenarios seem far off, the buildings where residents will live and work in those future years are being built today. Now is the time to build in the protections that the Eastern Shore's building stock and infrastructure need to weather new flood risks.

II - Introduction

The purpose of this report is to identify and illustrate risk associated with sea level rise on Maryland's Eastern Shore, and to provide guidance to local governments seeking to incorporate evolving flood risk into local plans and decision-making. The fundamental intent underlying all elements of this report is a "science to solutions" process, drawing on multiple disciplines to inform a broad and interconnected array of findings and recommendations based on scientific and policy-based research.

The data contained in this report is an innovative look at the impacts of flooding on Maryland's Eastern Shore in the coming years. By overlaying storm surge inundation with scenarios of anticipated sea level rise (SLR), this analysis provides critical new information to planners and decision makers by estimating the costs in dollars of several expected flood scenarios.

Upon publication of this report, jurisdictions participating in the Eastern Shore Climate Adaptation Partnership (ESCAP) should be informed and empowered to have more substantial conversations and planning initiatives that involve planning and zoning, floodplain management, economic development, emergency management, housing, public health, transportation, and more. By utilizing a science-to-solutions approach, local decision makers will be empowered by rich, complex information distilled into simple messages and tangible recommendations. These recommendations will enable change that will protect Eastern Shore communities for years to come.

ESCAP communities are the primary audience for this report. ESCAP is a network of county and municipal government staff working in collaboration with representatives of state government, academic institutions, and not-for-profit organizations to understand, plan for, and reduce the costs of impacts of climate and sea level rise impacts.

The scope of work for this project was designed to advance priorities stated by multiple ESCAP jurisdictions in their official planning documents and vulnerability assessments. By identifying and aggregating needs across the region, this project demonstrates the ESCAP's ability to provide data, analysis, and guidance products more cost-efficiently than jurisdictions could achieve individually.

III - Vulnerability Assessment for Sea Level Rise and Flood Events

Maryland's Eastern Shore is naturally vulnerable to elevated water levels and heavy rainstorms. Sitting on the Chesapeake Bay and housing numerous tributaries, the area has low-lying areas that are exposed to both coastal and riverine flooding. Climate change is exacerbating environmental conditions and increasing the risk of certain natural hazards. This section examines how climate change is altering the risk of flooding today and in the future.

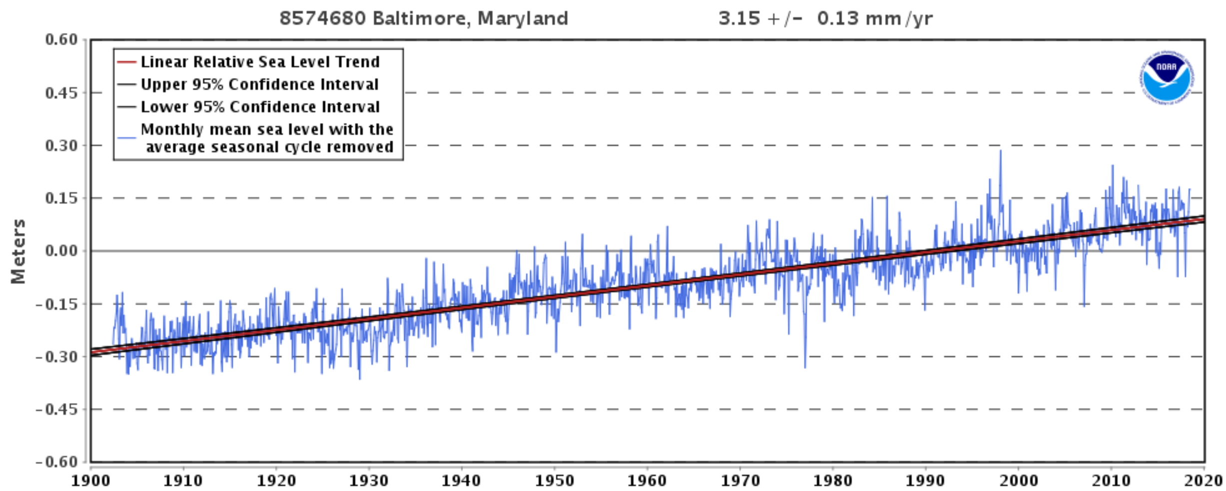
Sea level rise, observed and perceived

Water levels around the globe vary naturally on daily, monthly, annual, and multiyear scales. Locally, water levels are rising for three reasons. First, the volume of water in the ocean changes. In the past 100 years, the volume of water in the oceans is increasing due to inputs of freshwater from melting glaciers and land-based ice sheets, and due to expansion of seawater as it warms. Secondly, water levels appear to be rising because the Chesapeake region as a whole is sinking, a phenomenon known as subsidence. This subsidence is primarily an ongoing reaction of the Earth's crust to the retreat of the Laurentian Ice Sheet following the last ice age. Land subsidence accounts for approximately half of the observed sea level rise in some ESCAP jurisdictions over the last 100 years. Groundwater extraction for drinking water and agriculture has been shown to accelerate subsidence in other parts of the world, though no such studies are known to exist for Maryland's Eastern Shore. Finally, changes in ocean dynamics, such as a weakening of the Gulf Stream Current, can cause ocean water rise along the U.S. Atlantic seaboard. Climate change is expected to increase the relative effects of ice melt, thermal expansion of seawater, and ocean dynamics in coming years.

Tide gauge records

Globally, sea level has risen an average of half a foot in the past century. In the Chesapeake Bay region, relative sea level rise has been double the global average, due to the additional effect of land subsidence. Spanning more than 110 years, the NOAA tide gauge at Baltimore Harbor has one of the longest data records in North America. The chart shows a clear trend of rising water elevation, amounting to nearly 13 inches in the past 100 years.

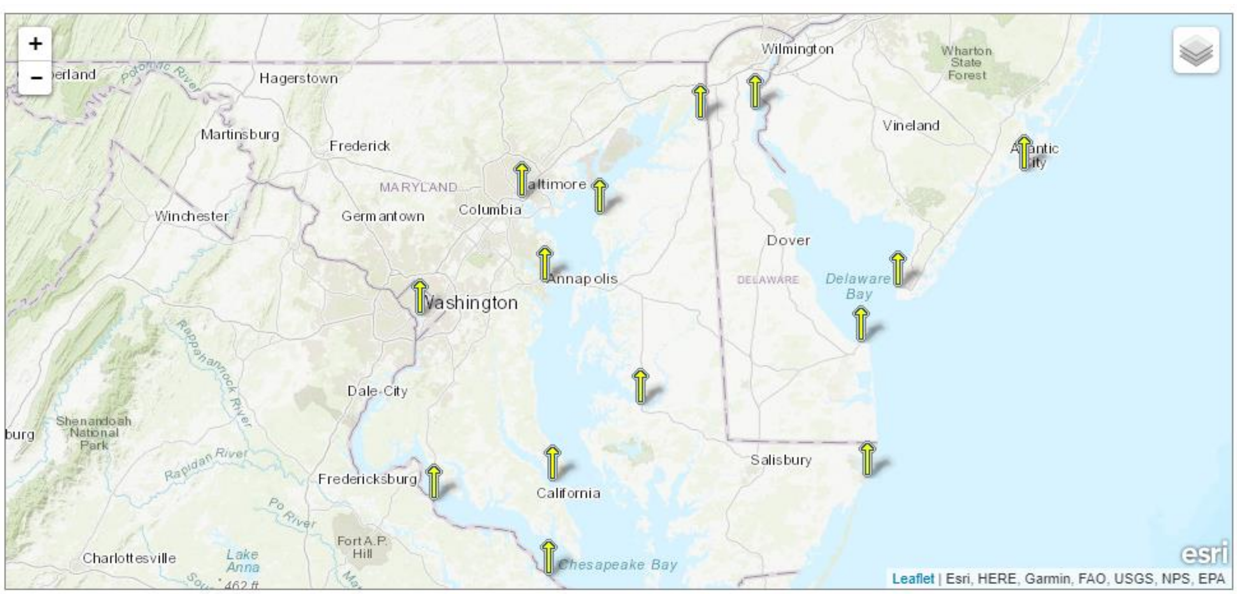
Fig. 1: Mean Sea Level Trend for Baltimore, MD



Source: NOAA. http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8574680

When looking regionally, a trend can be seen. Due to the combination of land subsidence and sea level rise mentioned above, tide gauges across the Chesapeake and mid-Atlantic indicate relative water level rise of 3 to 6 mm/year (1 to 2 feet/century). These rates are the highest of the entire Atlantic seaboard and among the highest worldwide.

Fig. 2: Chesapeake and Mid-Atlantic Relative Sea Level Trends for NOAA Tide Guages



The map above illustrates relative sea level trends , with arrows representing the direction and magnitude of change. Click on an arrow to access additional information about that station.

Source: NOAA. https://tidesandcurrents.noaa.gov/sltrends/sltrends.html

Sea level rise projections

Rates of sea level rise will vary slightly across the Eastern Shore due to the topography of the land and the Chesapeake Bay. Below is a table provided indicating SLR rates at several tide gauges in the Chesapeake and its tributaries.

Tidal Station	2050 MSL*	2050 MHHW	2100 MSL	2100 MHHW**
Annapolis	2.08	2.79	5.70	6.41
Baltimore	2.01	2.87	5.59	6.45
Solomons Island	2.10	2.82	5.76	6.48
Cambridge	2.11	3.13	5.78	6.80
Chesapeake City	1.98	3.63	5.56	7.21
Washington DC	2.21	3.83	5.78	7.40
Ocean City	2.06	3.25	5.86	7.05

Source: ESRGC *Mean Sea Level ** Mean Higher High Water

Storm surge inundation

Tropical storms and hurricanes generate a bulge of seawater known as storm surge that travels ahead of the storm. Height of the storm surge depends on the strength of the storm, with stronger storms producing larger surges. As a storm makes landfall in the Chesapeake region, the storm surge is pushed northward up the Chesapeake Bay and into its tributaries. As the upper Bay narrows, the storm surge bulge becomes more confined, squeezing the water upward and amplifying the surge height.

Storm surge is in addition to normal tidal cycles. The sum of storm surge plus tide level is known as the storm tide. Storms making landfall at or near high tide will have higher storm tides and greater flooding potential than if landfall occurred at low tide.

Storm surge is exacerbated by sea level rise. As still-water levels rise due to climate change, the starting level for storm surge becomes higher. This enables weaker storms to achieve the same flood levels that once required a stronger storm to achieve. For example, in 2003 Isabel, a tropical storm at landfall, brought 4 to 9 feet of storm surge to the Mid and Upper Eastern Shore. Despite being a weaker storm, Isabel was able to reach approximately the same flood level as the Great Chesapeake-Potomac Hurricane of 1933 because sea level rose about 8 inches during the seventy years between storms. Isabel, a weaker storm with smaller storm surge, was able to cause the same level of flooding because the starting water level had been elevated by sea level rise.

In the future, as sea level continues to rise, storm surge flooding could become more common – not because tropical storms are more frequent, but because the combination of surge and sea level rise will enable weaker storms (ones that used to pass without significant flood impacts) to cause significant flooding. Today's preparations for a Category 2 hurricane, may only offer protection against a Category 1 storm in future decades. When stronger hurricanes do occur, sea level rise will enable flood impacts that the region has not encountered in recorded history.

Damage data

The following figures are a multi-jurisdictional overview of damage estimates for each of the ESRGC planning scenarios. They are intended to graphically show the region's vulnerability in both number of buildings and cost in flood damage. Note that the numbers in figure 4 reflect actual damage cost, which is substantially lower than replacement or insurance cost.

Scenarios analyzed below include:

- Year 2015 (baseline): no flood, 1% chance storm, 0.2% chance storm
- Year 2050: no flood (accounting for approximately 2 ft. sea level rise), 1% chance storm
- Year 2100: no flood (accounting for approximately 6 ft. sea level rise), 1% chance storm

More information on ESRGC's modeling can be found in Section IV of this report. For more detail on each county, see Appendix C from the Eastern Shore Regional GIS Cooperative.

Fig. 3: Count of vulnerable buildings for sea level and flooding scenarios

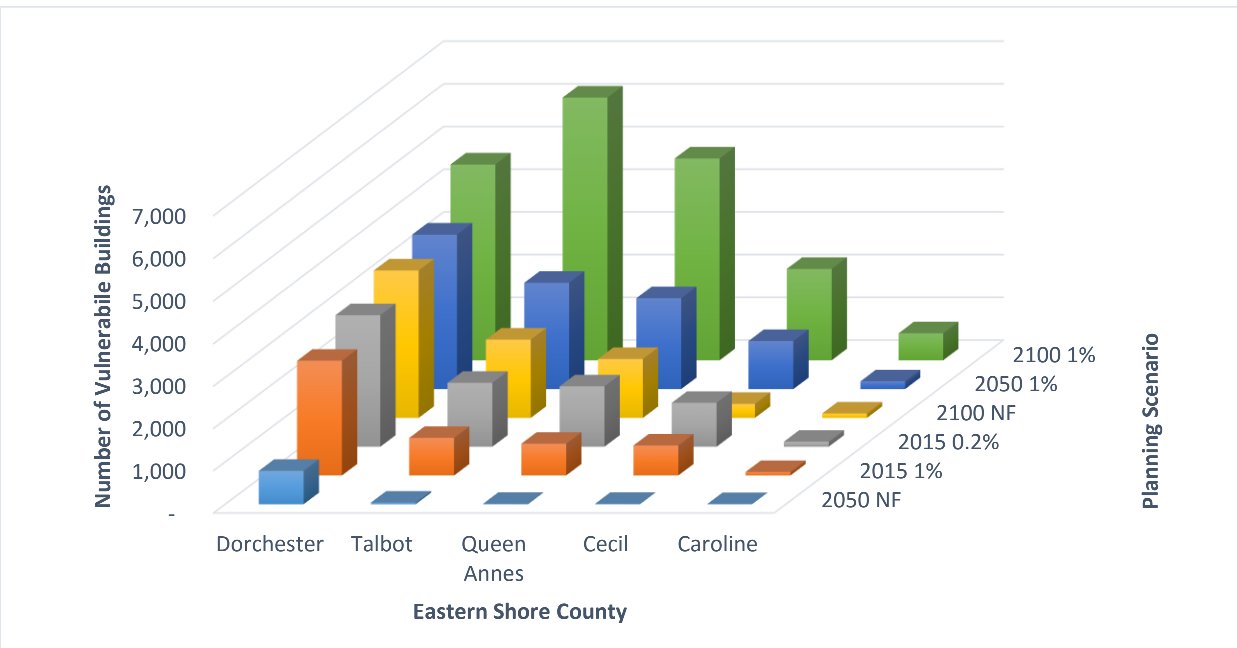
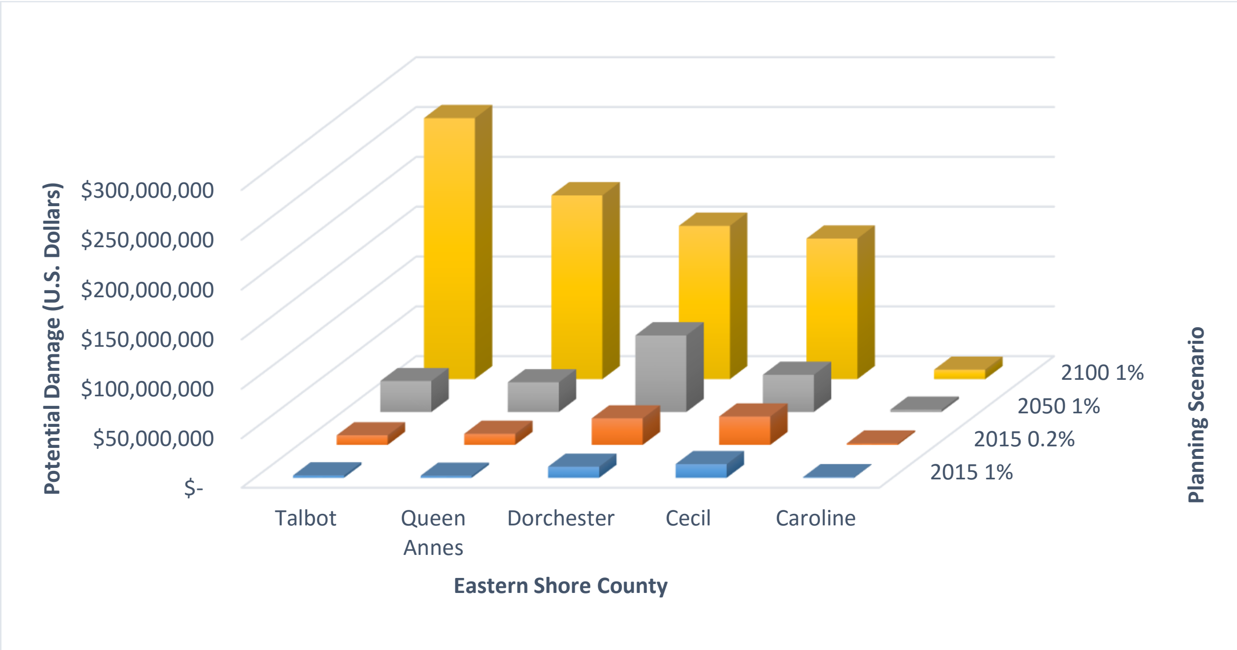


Fig. 4: Potential damage to buildings under each scenario



Key messages

Region-wide Messages:

- The window of opportunity to make policy adjustments that adapt communities to sea level rise is still open in most of the region…
    - Only 63 buildings are expected to be constantly wet by 2050, but that excludes Dorchester, which will have 790 wet buildings.
- …but the window is closing fast.
    - Today, a 1% chance storm impacts $1.2B in property/contents values and causes $30M in damage.
    - In 2050, that same storm affects $2.8B of property value and causes $178M in damage (2016 dollars).
- A tropical storm in 2100 causing damage comparable to Hurricane Isabel will fundamentally change the landscape of the Eastern Shore if we are not prepared by then.
    - More than 15% of buildings will be impacted, worth $5.8B, with expected damages of $751M.

Cecil County:

- The narrowing and shallowing that occurs in the northern Chesapeake Bay creates high vulnerability to coastal flooding.
- The window of opportunity is considerably wider in Cecil County than lower on the Eastern Shore.

Queen Anne's County

- Development pressure has the county on an edge, with damage exposure jumping starkly as storm severity increases (a 0.2% chance event has 5 times the impact on property as a 1% chance storm).
- The impact of future flood events will be felt more heavily by the commercial sector than in other counties due to commercial development patterns.

Caroline County

- Because land values in Caroline have been historically less than in neighboring counties, there will likely be increased development pressure in the coming decades – both a potential threat and an opportunity to build right the first time.

Talbot County

- Topography and past floodplain management practices built a margin of safety into the building stock.
    - Only 39 buildings are impacted by sea level rise in 2050.
- However, once the margin of safety is breached, the results are the worst in the region.
    - Nearly 30% of all buildings in Talbot could be impacted by a 1% chance event in 2100

Dorchester County

- This study does little to challenge the notion of Dorchester being the "Most Vulnerable to Flooding on the Eastern Seaboard"
- The future impact of SLR is lower than in other counties due to the extreme significance of *current* potential for harm from flooding
    - Right now, almost 17% of the buildings in the county are threatened by a 1% chance event. In 2050, that "only" rises to 22.6%.
    - The damage does increase significantly though, from $11M to $66M

Floodplain management practices

As indicated by the data above, current floodplain management practices are providing protection sufficient for today's 1% chance flood. Relatively limited damage is caused by today's 1% and 0.2% chance floods, both in terms of impacted structures and property value lost. A tipping point is being approached, however, which will fundamentally change the way local governments manage their floodplain. Sea level rise models are improving regularly. The confidence in the projections for 2050 is sufficient for planners and decision makers to take action. Projections for the year 2100 vary in magnitude but still serve important roles in guiding long-term planning for infrastructure siting and future development. It is important to note that each new study published over the last decade has revised sea level projections for 2100 upward, anticipating water levels which are higher and more intrusive than the studies that preceded them.

As sea levels approach the modeled 2050 and 2100 inundation levels, the damage and loss levels increase significantly. There is time, however, for local jurisdictions to prepare their communities for the eventual increase in inundation. By acting now upon the recommendations listed in Section 5 of this report existing codes can be updated, new standards can be developed, and communities can change the way capital planning is approached so that safety, sustainability, and resilience are characteristics of every new initiative in the future.

IV - Science to Solutions Process

Science to Solutions background

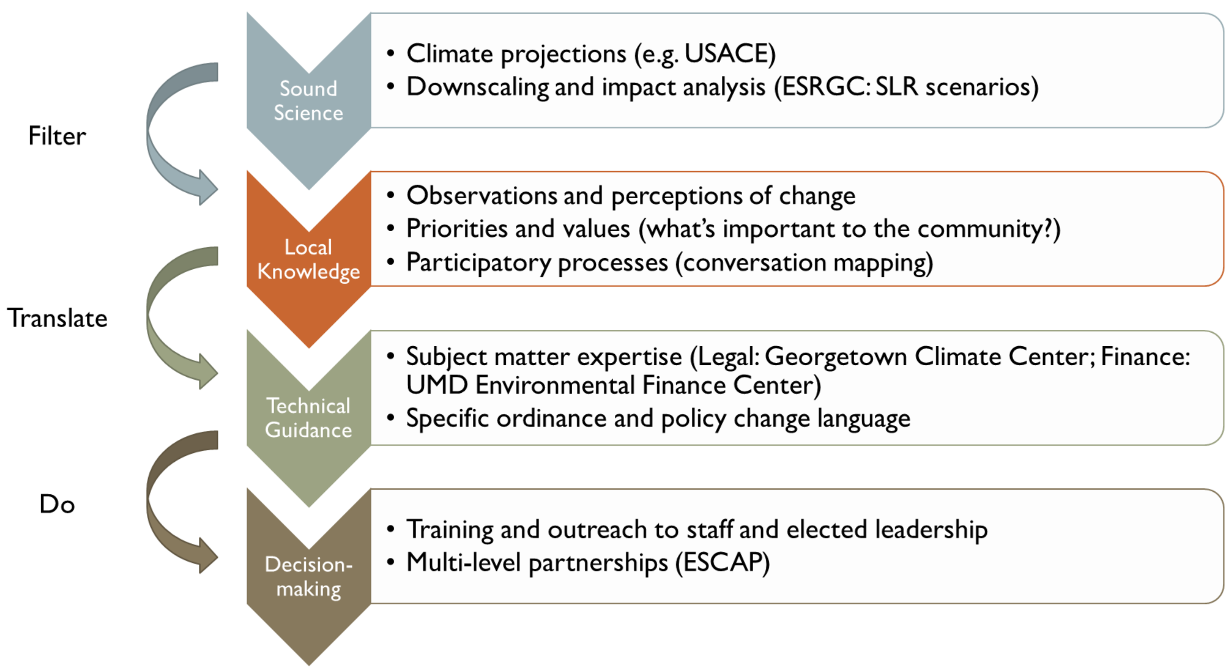
The goal of the science to solutions process is to implement decisions at the local level, which are built soundly upon scientific data via a three-step process.

Step one involves taking data from scientists and applying a local filter in order to verify or "ground truth" the data's relevance. The filtering process involves knowledgeable voices at the local level who can paint a picture of the community. The goal is to have a thorough understanding not only of the data being used, but how it will be applied in context.

Step two is to translate this filtered science into technical guidance. Subject-matter experts ensure the data is applied properly to the needs of the community. Guidance may include draft codes, specific ordinances, policy change language, implementation recommendations, and case studies.

Finally, step three is to act upon the newly developed technical guidance. By filtering and translating, communities can undertake new or expanded actions which are rooted in science and have been developed based on local context.

Fig. 5: The Science to Solutions process



Hazard mitigation alignment

The genesis of this project was rooted in a hazard mitigation planning activity undertaken by several ESCAP communities. In a "mitigation crosswalk," communities identified similar or shared priorities across their individual local hazard mitigation plans. Integrating resilience into capital investment planning and flood prevention/stormwater management were the top two items that were common among four of the six ESCAP counties. The identification of these two shared action items led the ESCAP to recognize the need for a regional project addressing both complex flood data as well as recommendations for planning and decision-making.

GIS modeling

To develop detailed geospatial information systems (GIS) data for use by its member communities, the ESCAP contracted the services of the Eastern Shore Regional GIS Cooperative (ESRGC) at Salisbury University. Analysis was conducted for five counties and included multiple scenarios, including:

- 2015 – baseline (no flooding), 1% chance, and 0.2% chance floods
    - *Note: this report refers to 1% and 0.2% chance floods, storms, or events. The more-commonly used analogs to these terms are "100-year" and "500-year" floods. ESLC believes these more commonly used terms to be increasingly misleading and dangerous in the face of changing climate and sea level; look no further than Ellicott City, MD, to see a 0.2% event occurring more frequently than every 500 years.*
- 2050 and 2100 – sea level rise projections, plus 1% chance flood

ESRGC analysis also included property and infrastructure impacts, including:

- Number of flooded structures
- Cumulative damage value (in dollars)
- Number and length of inundated road segments

Upon completion of analysis, ESRGC conducted GIS training for county and town staff. This in-depth workshop addressed project methodology, results, limitations, and key messages to communicate. The fundamental conclusion of this GIS data is that the Eastern Shore will soon reach a critical juncture for mitigating sea level rise and action is required now to address it.

Workshops

In addition to the GIS training, the ESCAP conducted additional workshops for local government staff and leaders. These workshops engaged participants in comprehensive discussions of the new GIS data and its implications for flood vulnerability and risk management. The workshops utilized the tool "Game of Floods," a public education activity developed by Marin County, California, to enable creative thinking about the local impacts of climate change and sea level rise. In the game, players must work as a team to develop adaptation strategies for their hypothetical community while working with real-world factors such as project costs, voters' concerns, equity issues, private property impacts, and environmental impacts.

The first workshop held by ESCAP used the work of ESRGC to set the stage for Game of Floods. By playing the game with ESCAP members, the group was able to think of sea level rise issues in Maryland in new and creative ways. Members were divided into three teams, with each team assigned a unique set of resources and challenges. The distribution and allocation of these resources led to the most valuable lessons in adaptation planning. For example, one group had ample funding to implement adaptation measures in their scenario community while another group with insufficient funding had to think critically about the prioritization of community assets at every turn. These differences drove home for all participating ESCAP members the complexity of the issues central to conversations about climate and sea level rise.

The second and third ESCAP workshops conducted in conjunction with the ESRGC study were community adaptation workshops geared towards understanding the vulnerabilities, key messages, and action options for each jurisdiction. These workshops were designed to allow participants in each county to react to and discuss the data presentations, key messages, and implications for floodplain management, building codes, ordinances, and capital investment planning.

Key results from the community adaptation workshops include:

- A need for expanded freeboard requirements
- Recognition that 1% chance storms seem to be occurring more frequently and extreme weather events are increasing in severity
- Acknowledgement that sea level rise is reducing the margin of safety afforded by existing floodplain management practices (ordinances, building codes, policies, etc.). Stronger practices are needed to maintain and improve the margin of safety in the region's housing stock.

More information on these key results can be found in Section V of this report.

Technical guidance

Supportive guidance documents have been produced by the Georgetown Climate Center (Georgetown University Law School) and the Environmental Finance Center (University of Maryland). The planning and policy recommendations contained in these reports are intended for use by the local government members of ESCAP and are the product of the community adaptation workshops referenced above, as well as literature reviews and research into best practices nationwide. These documents are intended to address and incorporate community concerns identified by ESCAP members as well as to highlight opportunities to elevate standards for future floodplain management and capital investment planning.

The guidance documents from the Environmental Finance Center and the Georgetown Climate Center present best practices for embedding climate risk assessment into planning processes at the municipal and county level. For capital improvement, these are cost-effective means of building community resilience to climate-related threats. For regulatory standards, these are comprehensive and innovative ways to enhance resilience to flooding due to sea level rise. Drawing on ESCAP member input, resilience literature, and case studies from other jurisdictions around the country, these documents offers a suite of planning and management options for Eastern Shore communities to consider as they seek to improve the climate-readiness of their existing assets, future capital investments, and the regulatory standards of their community.

V – Recommendations

The recommendations below are taken from the reports written by the Georgetown Climate Center and the University of Maryland Environmental Finance Center. Items listed in bold came as a direct result of input received by ESCAP members at community adaptation workshops, with the rest supporting these priority recommendations and providing planning tools for future use.

Georgetown Climate Center

Regulatory Options:

- **Expand regulatory floodplain**
- **Resilient design standards: enact three-foot freeboard requirements in all building codes; regulate Coastal A zones as V zones**
- Other resilient design standards: critical facilities, prohibitions on fill, size/height restrictions, setbacks
- Cumulative substantial improvement
- Restrictions on new subdivisions
- Critical Areas
- Transferrable Development Rights

Non-regulatory Options:

- Buyouts
- Conservation easements
- Hazard mitigation projects
- Post-disaster redevelopment plans
- Capital improvement planning and budgeting
- State standards
- Regional coordination on CRS

Environmental Finance Center

Conduct a resilience assessment for proposed capital improvement projects prior to making any major new capital investment

Develop a multi-year maintenance and upgrade plan for all capital assets which addresses future sea level projections

Address resilience in capital improvement planning by including criteria for scoring, and prioritizing projects that support local resilience goals

VI – Appendices

Appendix A – Georgetown Climate Center

Appendix B – UMD Environmental Finance Center

Appendix C – Eastern Shore Regional GIS Cooperative