

Helping Cities Manage Climate Change: Smart Surfaces, Credit Ratings and Risk Management

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Executive Summary

Climate change is increasing the frequency and severity of extreme and costly weather events such as storms, hurricanes, extreme rains, and heat waves. These are increasing costs and risks to cities, in turn threatening their credit rating and their cost of borrowing money. The U.S. government's 2018 National Climate Assessment Report recognizes that "Climate change creates new risks and exacerbates existing vulnerabilities in communities across the United States, presenting growing challenges to human health and safety, quality of life, and the rate of economic growth." Moody's Investors Service warns that climate change, "will be a growing negative credit factor for issuers without sufficient adaptation and mitigation strategies." These mitigation strategies include what we call smart surfaces – including highly reflective roofs, porous and reflective pavements, roads and parking lots, green roofs, and trees. These strategies can reshape how cities manage rain and sun, greatly reducing costs and risks of excess heat, smog and flooding, and making cities more livable, comfortable, and safe. To date, the potential impact of adopting these strategies on city credit rating has been largely overlooked. Our analysis demonstrates that cities that choose to not adopt smart surfaces will experience significantly increased climate related losses, increased risk of credit rating reductions, and associated increases in city borrowing costs. Over time, these combined threats will increase risk of insolvency for cities that do not adopt resilience strategies such as smart surfaces. This article provides the first rigorous description and quantification of the costs and benefits of city climate change mitigation strategies on their credit risk. This work is part of the Smart Surfaces Coalition, comprised of thirty partners, including the National League of Cities and the American Institute of Architects. This analysis is intended to help cities better understand and more effectively manage and reduce climate risk, and thus help cities remain livable, healthy, and financially viable.

Smart Surfaces, Credit and Risk: Background and Need

Climate change is increasing the frequency and severity of extreme and costly weather events such as storms, hurricanes, extreme rains, and heat waves. These events increase costs and risks to cities, threatening their credit rating and their ability to borrow money and finance city operations. Smart surfaces – such as reflective and porous pavements and roads, solar PV on cool or green roofs, and trees – provide very cost-effective ways for cities to manage sun and rain to reduce temperature, flooding, and risks associated with climate change. The Smart Surfaces Coalition is made up of thirty partners such as the National League of Cities and the American Institute of Architects. The Coalition is building on a half-decade of rigorous cost benefit analysis with cities researching and documenting the cost-effectiveness of smart surfaces. These cost benefit studies are available on

the Smart Surfaces Coalition website: <https://www.staycoolsavecash.com/> and reflect the Coalition's mission:

“The Coalition is committed to the rapid, cost-effective adoption of smart surfaces to enable cities to thrive despite climate threats, save cities billions of dollars, decrease heat, reduce flood risk, slow global warming, and increase city livability, health, equity and jobs.”

The World Economic Forum (WEF) every year issues its assessment of the top 5 global risks in terms of likelihood. In 2016, according to the WEF, failure of climate change mitigation and adaptation appeared for the first time (as the 3rd largest global risk). In 2019, the 3 largest global risks directly relate the climate change.¹ These include extreme weather events, major natural disasters, and failure of climate-change mitigation and adaptation. All these risks are being driven by accelerating climate change and together they create enormous risks and costs for cities. Increasing frequency and severity of severe weather events, increasing heat and rising oceans in turn are driving expanding property losses, making insurance increasingly expensive, and leading some insurance firms to withdraw from high risk areas.

World Economic Forum Annual Top 5 Global Risks in Terms of Likelihood:

2015	2016	2017	2018	2019
Interstate conflict with regional consequences	Large-scale involuntary migration	Extreme weather events	Extreme weather events	Extreme weather events
Extreme weather events	Extreme weather events	Large-scale involuntary migration	Natural disasters	Failure of climate-change mitigation and adaptation
Failure of national governance	Failure of climate-change mitigation and adaptation	Major natural disasters	Cyber-attacks	Natural disasters
State collapse or crisis	Interstate conflict with regional consequences	Large-scale terrorist attacks	Data fraud or theft	Data fraud or theft
High structural unemployment or underemployment	Major natural catastrophes	Massive incident of data fraud/theft	Failure of climate-change mitigation and adaptation	Cyber-attacks

Similarly, the United States government released the Fourth National Climate Assessment Report in November 2018.² The report's summary states:

Climate change creates new risks and exacerbates existing vulnerabilities in communities across the United States, presenting growing challenges to human health and safety, quality of life, and the rate of economic growth.

The impacts of climate change are already being felt in communities across the country. More frequent and intense extreme weather and climate-related events, as well as changes in average climate conditions, are expected to continue to damage infrastructure, ecosystems, and social systems that provide essential benefits to communities. Future climate change is expected to further disrupt many areas of life, exacerbating existing challenges to prosperity posed by aging and deteriorating infrastructure, stressed ecosystems, and economic inequality.

The American Meteorological Society's 2018 report *Explaining Extreme Events in 2017 from a Climate Perspective* identifies several extreme weather events that they said were "virtually impossible" without climate change.³ The AMS press release states that these extreme weather events "could not have happened without warming of the climate through human-induced climate change."

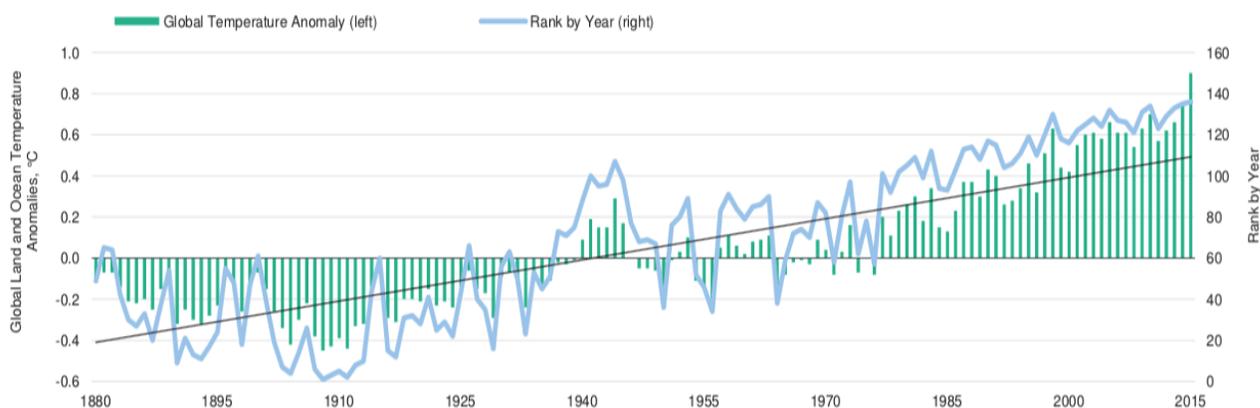
The Editor in Chief of the Bulletin of the American Meteorological Society states that, "These attribution studies are telling us that a warming Earth is continuing to send us new and more extreme weather events every year," and "The message of this science is that our civilization is increasingly out of sync with our changing climate."⁴

Moody's Investors Service, which rates the creditworthiness of government bonds, warns governments to adopt approaches to increase city resilience in order to reduce the risk and severity of future losses projected to occur as a result of accelerating climate change, saying that climate change, "will be a growing negative credit factor for issuers without sufficient adaptation and mitigation strategies." – Moody's Investors Service, November 2017

Moody's cites the rise in loss of business operations resulting from loss of power and slow recovery times. "The interplay between an issuer's exposure to climate shocks and its resilience to this vulnerability is an increasingly important part of our credit analysis, and one that will take on even greater significance as climate change continues." – Moody's Investors Service, November 2017

This report analyzes the costs and benefits of city adoption of smart surface measures that would enhance the resilience of cities. The risks/costs that these smart surface measures help mitigate include excess summer heat, flooding, smog, loss of tourism and business downtime, and recovery time.

Global Land and Ocean Temperature Anomalies 1880-2015

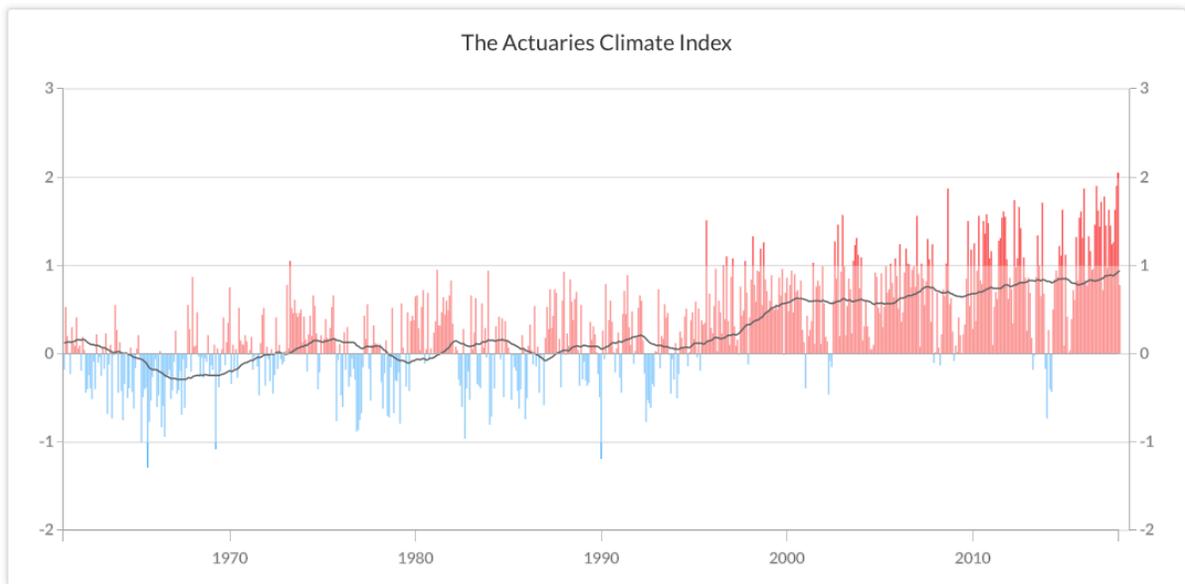


Source: National Oceanic and Atmospheric Administration, National Centers for Environmental Information

The Insurance Industry has likewise recognized the impact of climate risk and has taken steps to minimize adverse effects on its underwriting results.

The American Academy of Actuaries, the Canadian Institute of Actuaries, the Casualty Actuarial Society, and the Society of Actuaries have developed the “Actuaries Climate Index”, a five-year moving average of climate extremes across the USA and Canada. The Index reached a new high in the fall of 2017 reflecting continued deviation of climate and sea level extremes from historically expected patterns.⁵

USA and Canada Combined

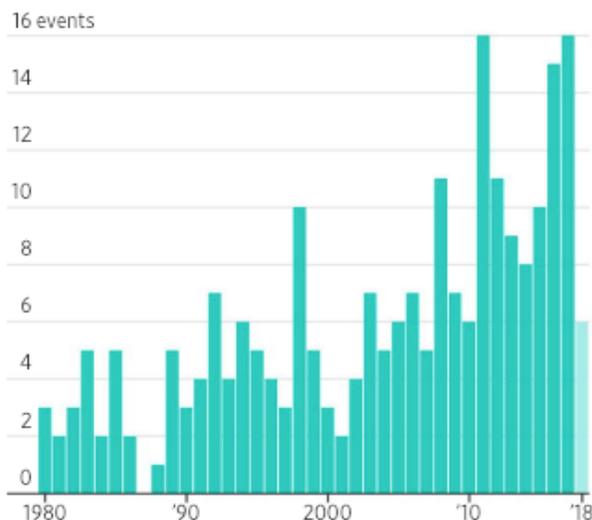


Losses from insured climate related risks continue to increase despite increasingly restrictive underwriting and pricing programs. Flooding risks of all kinds (including rising bodies of water, back up of sewers, basement flooding, and mold related costs and illness) are typically excluded from US property insurance policies. Policies issued in wind prone geographies generally have high deductibles for wind damage, even higher deductibles for named storms (sometimes excluding damage from a named storm) and lower limits — placing a greater risk burden on the policy holder.

Data reported by the Insurance Information Institute and Munich Re reveal that the insured losses due to natural disasters in the United States in 2017 totaled \$78 billion, more than triple the \$23.8 billion total for 2016. Tropical cyclones with \$49.1 billion in losses accounted for 63 percent of U.S. insured losses in 2017. Severe thunderstorms losses, at \$18.2 billion, accounted for about 23 percent of the 2017 insured losses. Wildfires, heat waves, and drought produced \$9.5 billion in insured losses in 2017, or about 12 percent of the total.⁶

Overall, losses per event have grown while number of loss events have more than doubled since the 1980s.⁷

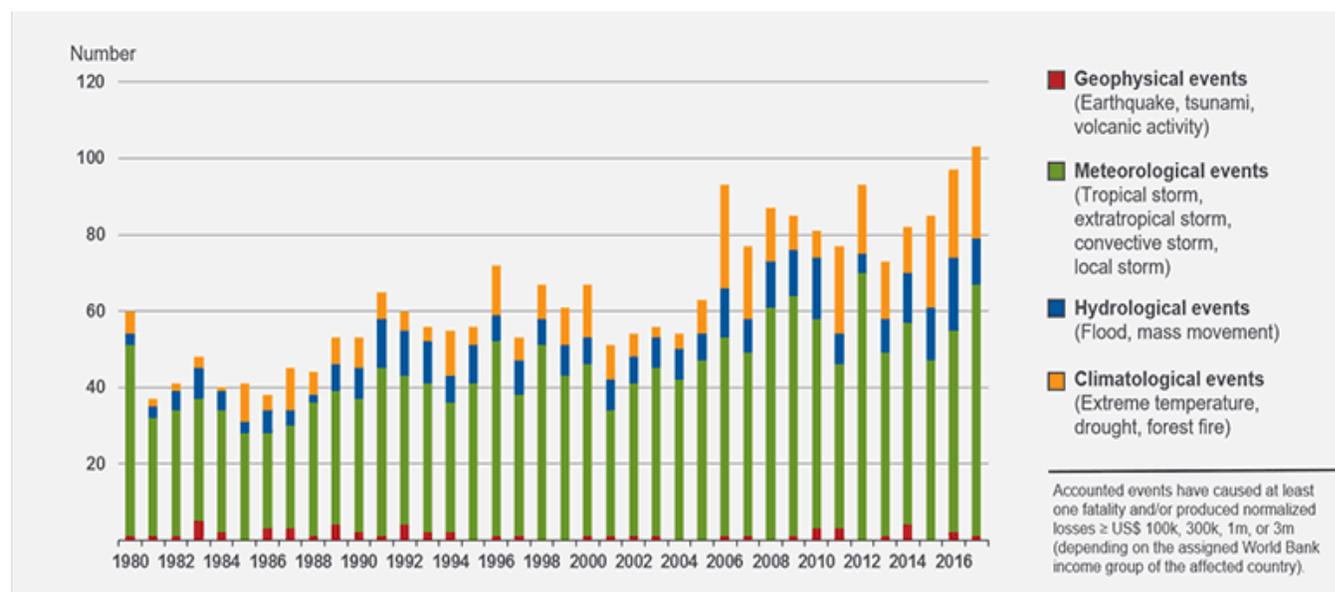
NATURAL DISASTERS CAUSING AT LEAST \$1 BILLION IN TOTAL DAMAGES



Notes: Data are inflation-adjusted to 2018 dollars; 2018 data as of July 9

Loss Events in the U.S. 1980-2017

(Number of relevant events by peril)



The threat and costs of climate change is large and expanding rapidly. Moody's finds that:

“Of the 86 global sectors that Moody's has qualitatively scored for exposure to environmental issues that may have a credit implication, a total of 11 – with approximately \$2 trillion of rated debt – are experiencing material credit impacts or are likely to start doing so over the next three to five years. For these 11 sectors, the consequence of regulatory or policy initiatives for carbon reduction and other air emissions is the most frequently cited issue impacting creditworthiness.

“A further 18 sectors – with approximately \$7 trillion of rated debt – face the potential of changes in their credit profiles that could be material due to environmental considerations, but over a longer period of 5 years or more.⁸

An increasingly large part of the economy is at risk from accelerating climate change, making the work of quantifying risk to cities and understanding how to limit these risks, increasingly urgent and necessary.

How Climate Risk Affects Credit Risk

Climate change drives increasingly severe weather events in ways that are not precisely attributable on an event by event basis. This makes it difficult to assign direct impacts of climate change for a single event since climate change may just increase severity of a weather event rather than cause it directly. In addition, climate change at this scale is a relatively new phenomenon. While there is scientific consensus that severe climate change driven losses are large and growing, assigning specific losses, and resulting city credit downgrades, to climate change events is a new and challenging area that will be increasingly important if cities are to make informed and smart design and policy decisions.

As former two-term mayor of Austin (and a co-author of this report) Will Wynn stated:

“Increasingly, the success of mayors and their cities will depend on whether cities adopt smart proactive policies like smart surfaces to make their cities less vulnerable to climate change. Those that do not heed the scientific reality of climate change will suffer while those who move quickly by adopting smart surfaces such as green and cool roofs and porous, reflective pavement will protect and enhance their city livability.”

Because cities rely on borrowing to finance operations, their ability to borrow money at a low interest rate is of great importance. Cities generally issue bonds to raise money for a range of purposes including financing important urban infrastructure, such as new wastewater treatment plants. Credit rating agencies assign each city a credit rating that determines the interest rate at which cities can borrow money – or if they can borrow money at all. Therefore, a credit rating is fundamentally important to the financial viability of cities. Credit ratings, especially by the big three – Moody’s Investors Service Inc. (Moody’s), Standard & Poor’s (S&P), and Fitch Group (Fitch), determine cities’ financial health through regular (usually annual) review of cities’ credit rating. Each agency has their own rating system; however, they all function similarly.⁹

There are tens of thousands of issuers of municipal bonds, all of which rely on credit ratings. A worsened or downgraded credit rating translates into a higher cost of borrowing. “When a bond issuer gets downgraded, the yield on the bonds from that issuer will usually go up; this is to compensate prospective buyers of the bonds for a perceived increase in risk reflective of the lowered rating.”¹⁰

When a city issues a bond, it is in effect pledging to pay lenders back from city revenue, largely from property and sales tax. The property tax is a function of overall property values. If property values decline due to severe weather events or the prospect of increasing risk due to weather catastrophes, it reduces property value and therefore the amount of taxes that the city can raise. Since much of cities’ budgets goes to fixed obligations, changes in tax base or taxes can have a large impact on repayment ability and therefore on credit risk and rating.

Mayor Will Wynn notes that “Fundamentally, mayors have to convince the credit rating agencies that they are either (1) taking active steps to mitigate future risks, or (2) are prepared to and able to raise tax rates immediately following a disastrous event. My experience is that the agencies are becoming more skeptical of the latter.”¹¹

Climate change poses a broad, profound, and fundamental risk to cities not only because of increasing storms, excess heat, and other direct costs, but also because it directly impacts the credit rating process. Major credit rating agencies are increasingly concerned about climate change impact on risk because of their exposure to increasing losses resulting from rising temperatures and more severe and costly weather events. According to Lloyds, for example, following Hurricane Andrew in 1992, the Property Claims Service reported an industry loss of \$15.5bn and the insolvency of 11 insurers.¹²

Increases in actual and projected severe weather events resulting from climate change has led credit rating agencies to issue warnings about credit risk. For example, Moody's warns cities that their credit rating is at risk because of climate change unless they plan for and invest in reducing risk exposure and improving resilience. In November 2017, Moody's issued an important report (quoted above) called "Environmental Risks – Evaluating the impact of climate change on US state and local issuers,"¹³

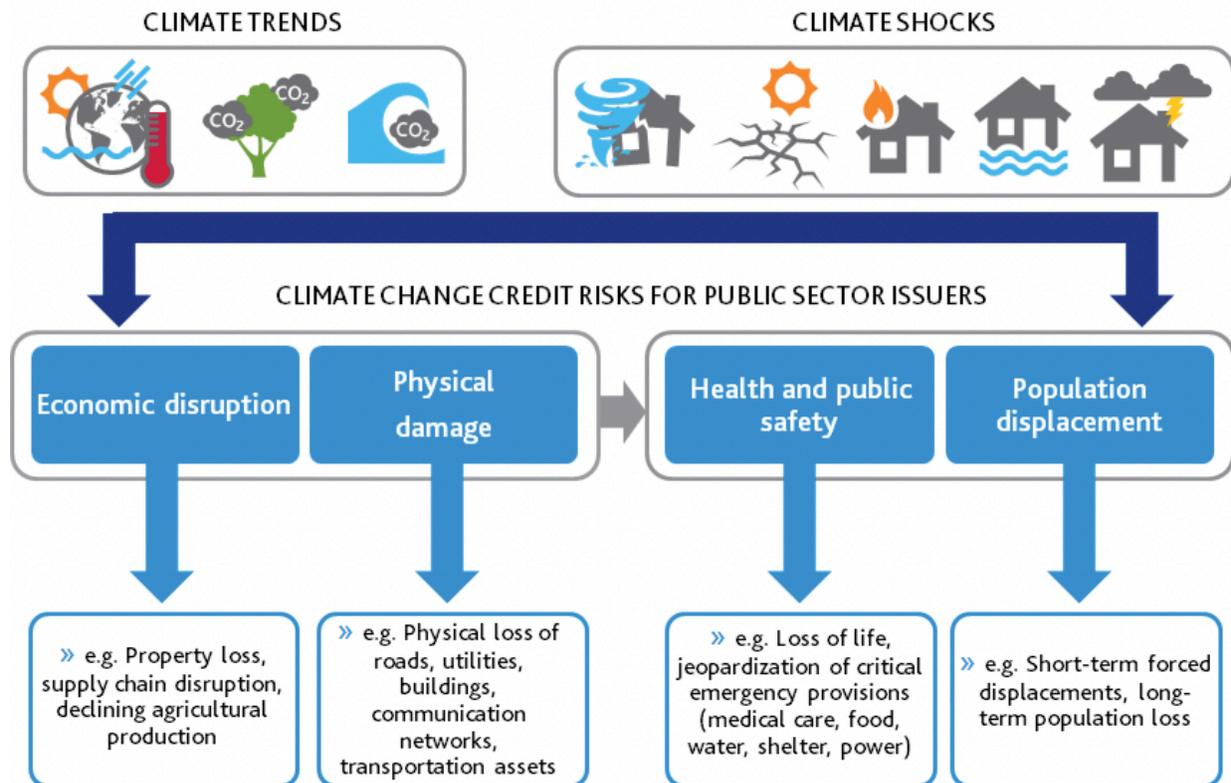
As a NYT editorial summarized: "Moody's is making it clear that there is a potential climate risk bubble in which an extreme weather event causes damages so catastrophic that taxpayers, insurers, lenders, states and municipalities suffer damages or losses of hundreds of billions of dollars and local and state government face downgrades in their credit worthiness, affecting their ability to borrow money."¹⁴

Moody's warns municipalities and states that failure to respond to climate change driven severe storm, flooding, and related events will result in increased risk of credit downgrade. Moody's notes that "analysts for municipal issuers with higher exposure to climate risks will also focus on current and future mitigation steps and how these steps will impact the issuer's overall profile when assigning ratings" and concludes that climate risk "will be a growing negative."¹⁵

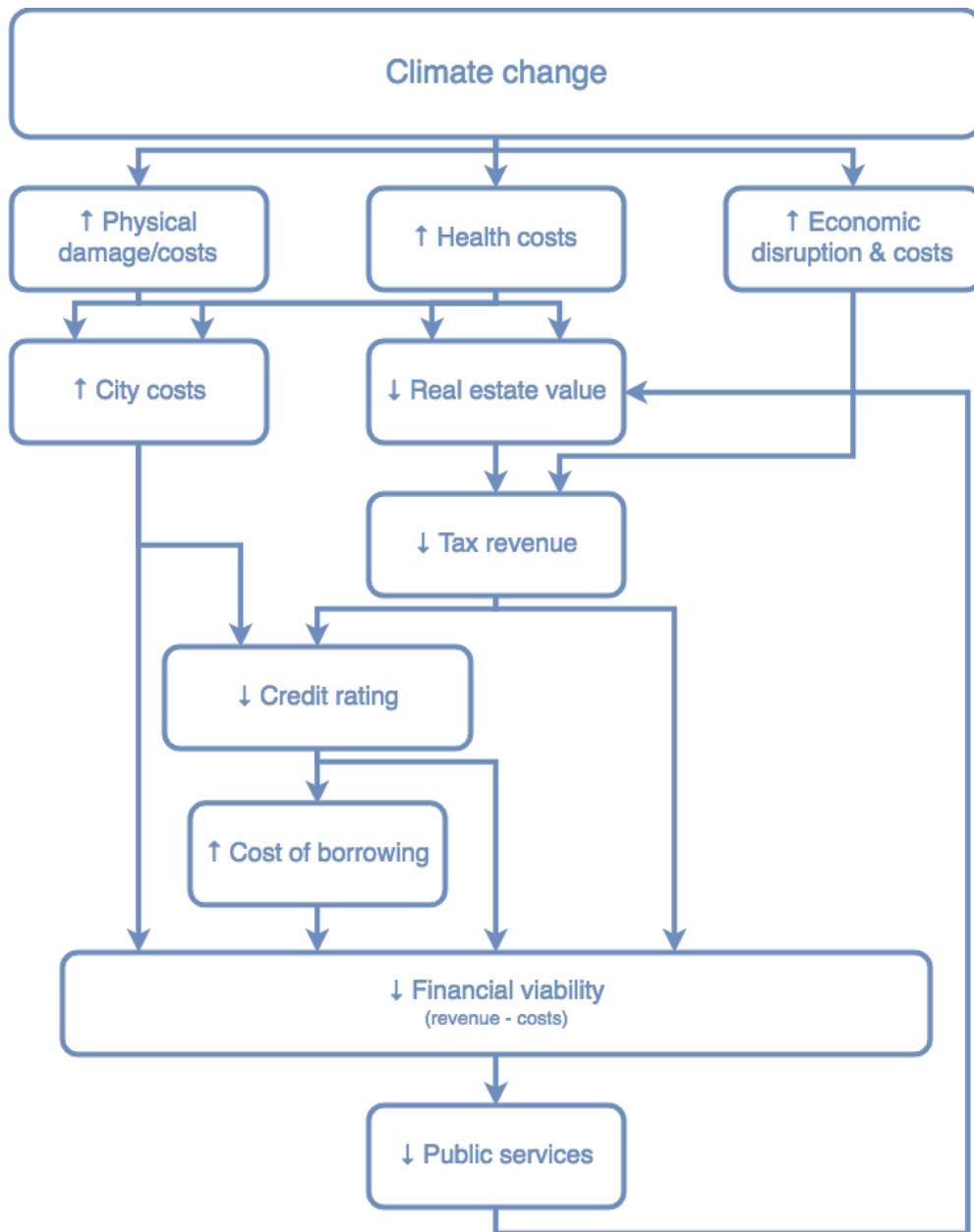
Moody's includes key credit risks associated with climate change:

1. Economic disruption (e.g., property loss/damage; lower revenues; increased debt; and higher insurance costs);
2. Physical damage (e.g., property loss/damage; loss of utilities, transportation and communication networks);
3. Health and public safety (e.g., loss of life; jeopardized critical emergency service provisions);
4. Population displacement (e.g., short term displacements and longer-term population migration).¹⁶

The smart surface strategies analyzed in this report reduce all four of these risks.



This framework from Moody's provides a valuable basis on which to build a more specific model of how climate change driven losses translates into cost increases, reduced property value, and lower revenue at the city level.¹⁷ Below we have mapped how climate change related severe weather events result in physical damages, increased health costs, increased city costs (including from property damage and greater need for city services), reduced real estate value and then reduced credit rating and higher cost of borrowing.



Source: Capital E

This chart maps out many of the main pathways by which climate change imposes costs and risks on cities, including loss of value to real estate and resulting decline in tax basis and city revenue. With increased climate change driven losses, city costs and need for expanded public services also increases, creating financial and budgetary challenges for cities that can hurt credit rating, in turn increasing the cost of borrowing and worsening city budgetary challenges.

Rating agencies, such as Moody's, issue a credit rating that constitutes a professional, highly considered judgment of the likelihood that a city will be able to pay back lenders (bondholders).

If the credit rating drops, cities have to increase the amount of interest paid to bondholders in order to compensate for the excess risk the bondholder takes on. Cost of borrowing is determined by the city credit rating – and an improved credit rating reduces the cost of borrowing. For example:

- In 2014 when Baltimore’s credit rating improved, the Baltimore Sun noted, “The new credit rating is expected to allow the city to borrow money at lower interest rates for projects such as infrastructure upgrades, new schools and improved recreation centers. That in turn would save taxpayers cash on interest payments.”¹⁸
- In July 2015, Detroit, in a remarkable turnaround after struggling out of insolvency, received an investment-grade bond rating from Standards & Poor’s on \$245 million in bonds tied to the city’s bankruptcy exit financing. The city reported that the favorable rating should allow it to save \$2.5 million annually and \$20 million in interest costs over the life of just that small portion of the city debt.¹⁹
- In May 2016, Seattle received high credit ratings, leading Mayor Ed Murray to note that “High ratings allow the city to borrow money for projects at a lower cost to taxpayers. Every dollar that we save through lower borrowing costs helps us to stretch limited public dollars and reinvest those savings in providing better service to residents.”²⁰

City Debt Burden/Exposure

There is a large range of city indebtedness, although the overall level of city indebtedness is generally rising.²¹ For example, Cincinnati owes nearly \$1.25 billion, triple what it was 25 years ago when adjusted for inflation.²²

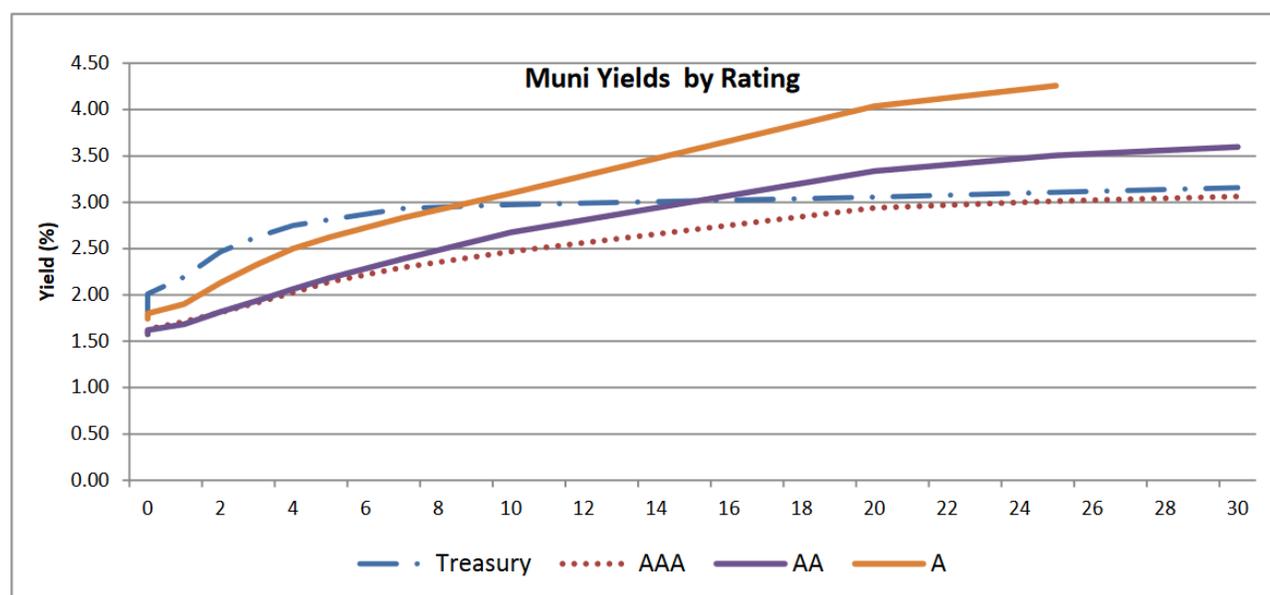
City debt represents a large portion of spending for many US cities. An extreme example is Milwaukee, where debt service alone took up 34 percent of fiscal 2015 governmental fund spending, according to the city’s comprehensive annual financial report.²³ A recent analysis of fiscal year 2016 expenditures in cities with populations over 500,000 found that “the largest legacy line item for many localities is debt.”²⁴

The US urban population estimate as of 2016 is 265 million.²⁵ ²⁶ The total amount of outstanding municipal debt at year end 2015 was \$1.8 trillion²⁷ and rising, so the per citizen city indebtedness is \$6792, conservatively assumed as \$6800 for current calculation purposes. In 2015, \$218 billion of new debt was issued, or \$822 per person. In 2015, local governments spent \$75 billion on debt interest, or \$283 per urban dweller each year.

Credit Rating and Interest Rate

Various studies show a strong correlation between credit rating and interest rate.²⁸ This is illustrated in the graphic below which shows that lower credit ratings have higher associated yield across the range of bond terms from 1-30 years.

Muni Index Yield Curve by Credit Rating – Data Source: Bloomberg



The difference in interest rate between rating grades, for bonds rated AA and lower, are now approximately 40 basis points (0.40%) as of spring 2018. That is, each reduction in rating level is associated with an increase in interest rate of 0.4 %.²⁹ This analysis assumes that each bond rating reduction is associated with a slightly lower increase of 0.35% in interest rate per reduction in rating. (Assuming 0.35% is conservative because it is a somewhat lower benefit from avoiding a credit rating reduction). The exception to this is the single step rating reduction between investment grade and junk grade.

Bonds are generally classed as either “investment grade” or not, based on their credit rating, with some using the term “junk bond” for bonds below investment grade. The term “junk bond” is a pejorative term and reflects an industry-wide historic view that bonds issued by organizations with credit ratings below BBB, are considerably riskier than investment grade bonds. As noted above, the interest rate impact of a single credit rating decrease is around 0.35 (e.g. 35 basis points increase in cost of borrowing). However, a one credit rating decrease from investment grade (BBB-) to a junk bond (BB+) is larger due to the psychological impact of investing in a bond classified as “junk” or “non-investment grade.” A broad literature review did not provide a rigorous recent estimate of the interest impact of a one level reduction in bond rating that moves a bond below the range of investment grade.

In order to determine the average interest cost increase for a reduction in bond rating we undertook a quantitative analysis of available bond data. To do so, we looked at every non-state, non-zero-coupon, municipal bond available through BondDeskGroup and with a credit rating of either BBB- (S&P, Fitch) or Baa3 (Moody’s) and BB+ or Ba1 (as of 5/24/2018). We omitted all bonds that either did not have sufficient data, or where the data was distinctly separate from the rest of the data. The yields for all BBB- or Baa3 were then averaged and the median was found. The same method was used for all BB+ or Ba1 bonds to find the numbers summarized in the chart titled “Municipal Bond Yields”.³⁰

Our analysis of over 300 municipal bonds available for purchase as of May 24, 2018 showed that the average yield for BBB- or Baa3 bonds is 4.08%, whereas BB+ or Ba1 bonds have an average yield of 4.72%. This equates to an average increase of 0.65%, and a median increase of 0.73% (65 basis points (BP) and 73BP, respectively). This study assumes a cost of borrowing increase of 0.65% when city bonds drop one rating level from investment grade to junk status. For a city like Cincinnati, with \$1.25 billion dollars in debt, the effect of a single step credit rating decrease into ‘junk bond’ territory could cost the city over \$8 million dollars annually.

Municipal Bond Yields		
Bond Rating	Mean (%)	Median (%)
BBB- / Baa3	4.08	3.98
BB+ / Ba1	4.72	4.71
Difference (Δ)	0.65	0.73

Yield % reflects current yield of n=314 non-state municipal bonds available as of May 24, 2018 (individual bond data from BondDeskGroup, LLC)

Source: Capital E

A city of 100,000 with \$900 million dollars of debt that experienced a one-step downgrade in credit rating would, as those bonds get issued, experience an increased borrowing cost of \$2 million per year, or \$40 million over the life of a 20-year bond. This translates into an extra \$300 in interest per person. If Moody’s or S&P reduces its credit rating by three levels it would increase the interest rate by 1.2 percent and increase the interest cost per person over the 40-year period by \$1,224. Each billion dollars borrowed would increase costs on interest by \$5.1 million dollars per year, or \$204 million over 40 years. Higher interest costs increase a cities risk of not being able to repay, thus increasing the risk of default, and in turn increasing the likelihood of further cuts in credit rating.

Smart Surfaces and Risk Mitigation

Cities are faced with the prospect of rating agency credit downgrades if they do not act to mitigate their climate risks. Moody’s Investors Service states; “The growing effects of climate change, including climbing global temperatures, and rising sea levels, are forecast to have an increasing economic impact on US state and local issuers. This will be a growing negative credit factor for issuers without sufficient adaptation and mitigation strategies.”³¹

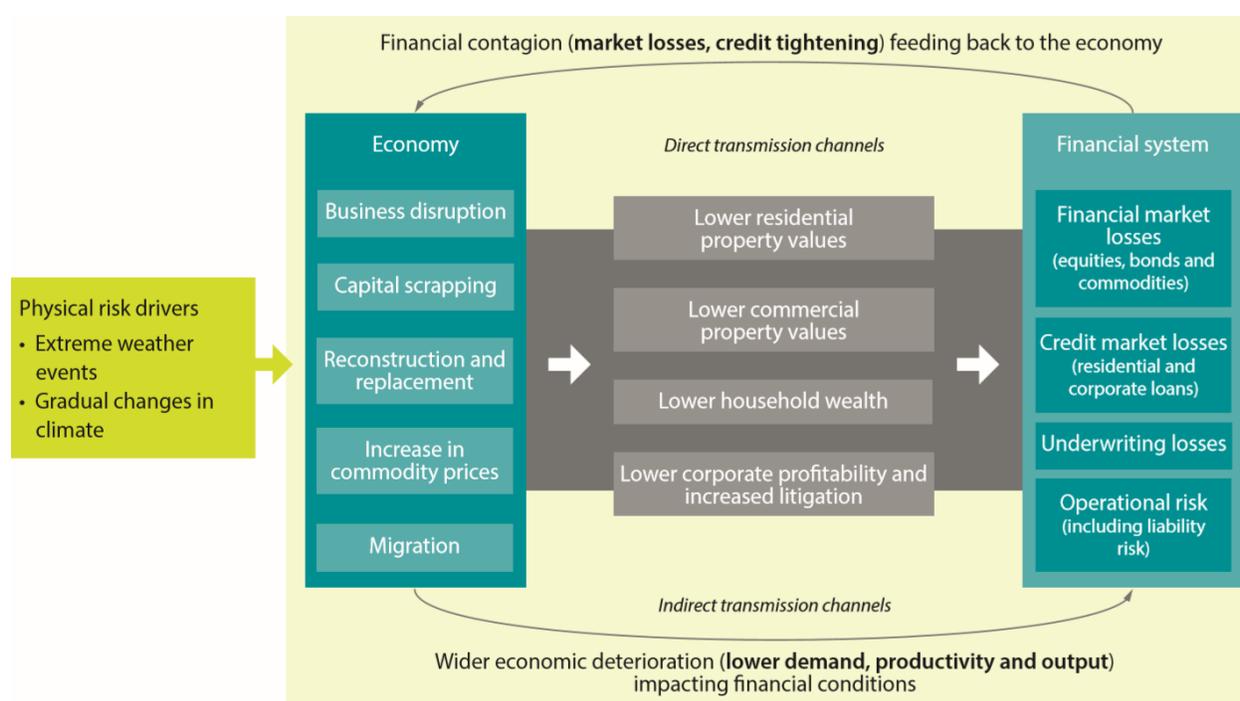
Mayor Will Wynn notes that “Historically, credit rating agencies handicapped a city’s likelihood to respond to a downturn. These agencies now seem to be far more interested in cities’ policies and investments in advance of an inevitable downturn, including those that are climate-related.”

Increasingly credit rating agencies are under pressure from investors and policy makers who see significant gaps between climate risk and city’s mitigation actions. The rating agencies are already factoring into their muni credit rating whether or not cities are taking actions to protect their residents.³² Smart surface strategies give cities a strong set of risk mitigation tools. (For detailed discussion see the 300-page report: [Delivering Urban Resilience](#) on the Smart Surfaces website.)

Adoption of citywide programs like green and reflective roofs and porous pavements can make them far more resilient. Smart surfaces directly mitigate the urban heat island effect, urban flooding from surface water accumulation, and sewer back up.

In 2019 a group called Network for Greening the Financial System, representing many of the world's major national banks, released a review mapping how climate change impacts financial risk, including for municipalities. As illustrated below, the key intermediaries between physical risk and financial stability risk are changes in residential and commercial property value, lower household wealth, reduction in corporate earnings, and increased liability.³³

From physical risk to financial stability risk:



Source: Central Banks and Supervisors Network for Greening the Financial System, 2019

Impact of Climate Risk on Cities, Businesses, and Residents

As discussed earlier, accelerating climate change directly exposes cities, their residents and businesses to an increasing range of weather risks. These include prolonged heat waves; flooding from severe rainfall events and from sea level rise; hurricanes, tornadoes; wildfire; prolonged droughts, all of which are occurring with greater than historic frequency and with increased severity. As Moody's notes, smart cities will choose to manage these risks in a prudent and proactive manner. Smart surfaces mitigate and reduce the risks and costs of floods, heat waves, and other risks that can have a disruptive, even deadly, impact on residents of cities.

Heat Islands

Among all the climate-related disasters that are confronting cities, heat waves are the deadliest. According to the Centers for Disease Control and Prevention, extreme heat now causes more deaths in U.S. cities than all other weather events combined.³⁴ Extreme heat causes a large range of illness and sickness, up to and including death. Longer, more frequent heat waves – like the one affecting most of the nation in summer 2018 – are expected in the future, meaning summer’s death toll will rise.³⁵

In Europe in 2003 an extended heat wave killed over 70,000 people, mostly in southern Europe.³⁶

The summer of 2018 was challenging for many North American cities. In late June 2018, dozens of people were killed across the U.S. and in Canada³⁷ – including 28 people in Montreal – after much of the country experienced multiple days that were 100 degrees Fahrenheit and higher.³⁸ The following week, much of California experienced a heat wave with all-time record-setting temperatures, and another deadly heat wave swept through the Southwest later in July.^{39 40} At one point, a heat dome of hot air pushed temperatures above 90 degrees in 44 of 50 states.⁴¹ More than 155 people died from heat-related causes in Phoenix area in 2017. Former Phoenix Mayor Greg Stanton deemed it a public health crisis.⁴²

Elsewhere in the Northern Hemisphere, other cities have seen high death tolls. In 2018, Japan recorded an all-time high of 106 degrees as a total of 96 people were killed across the country.⁴³ In Seoul, 29 people died during a two-week stretch of 95-degree days.⁴⁴ Two separate deadly heat waves have struck Europe in 2018.^{45 46}

Excess heat reduces productivity, especially for workers working outside on roads, in building and facility maintenance, on power lines, electrical maintenance, etc. A 2013 NOAA study projects that heat-stress related labor capacity losses will double globally by 2050 with a warming climate. The impact will be felt the most by those who work outside or in hot environments, such as firefighters, bakery workers, farmers, construction workers, factory workers, and others who will be forced to slow down due to increases in heat and humidity.⁴⁷

The Fourth National Climate Assessment documents that extreme weather and climate-related events can have lasting mental health consequences in affected communities, particularly if they result in degradation of livelihoods or community relocation. Adaptation and mitigation policies and programs that help individuals, communities, and states prepare for the risks of a changing climate would reduce the number of injuries, illnesses, and deaths from climate-related health outcomes.

In addition, heat waves place a significant strain on aging electrical grids. Summer brown outs and blackouts are common. Heat related power outages and rolling blackouts were common in the US during the summer of 2018. See, for example:

- Heat Waves Leaves Thousands of Edison Customers Without Power. – Long Beach Post.⁴⁸ lbpost.com
- Massachusetts Hit With Power Outages as Heat Sets In.⁴⁹ – [Boston Herald](http://BostonHerald.com)

- Officials Managing State’s Electrical Grid Warn of Possible Rolling Blackouts.⁵⁰ [CBS Sacramento](#)

Below is a table summarizing how smart surface adoption can help cities avoid and mitigate these climate changes risks.

Impact of Heat Related Events	
Cities without smart surfaces	Cities with smart surfaces
Climate change brings prolonged periods of high temperatures. Cities without smart surfaces bear the full impact of high temperatures.	Cities that have adopted the smart surface strategies can mitigate extreme temperatures by several degrees, including at night.
Increased heat related sickness and death puts greater strain on city emergency and medical services	Reduced resident sickness and death. Emergency and medical services better able to deal with crisis
Productivity of businesses and cities decrease as employees face with higher temperatures.	Buildings with green and cool roofs cost less to cool and allow adequate cooling in extreme heat, enabling businesses and apartments to maintain comfortable temperatures for employees
Greater strain placed on city’s electrical infrastructure increasing probability of blackouts and brown outs.	Less strain placed on electrical infrastructure reducing probability of black outs and brown outs.
Cost of increased power consumption	Lower energy costs cost due to lower air condition load
Cities with extreme heat face a reduction in tourism.	City avoids suffering reputation damage due to prolonged heat events. Smart surface cooling and shading enhances livability and walkability of cities in summer
Businesses and residents may relocate to “cooler” cities reducing tax base and straining city finances. Credit rating could be jeopardized.	Cities that successfully manage the heat island effect could become attractive relocating destinations for businesses and new residents driven out by climate change in more affected, risky areas.

Flooding

Increased costs due to climate change is particularly apparent in coastal cities where real estate insurance costs are rising due to increased flooding risk and hurricanes. A recent Freddie Mac publication identifies climate change related flooding as a major threat to many cities, one which will get larger and costlier with increasing severity of climate change related flooding. The report states, “While technical solutions may stave off some of the worst effects of climate change, rising sea levels and spreading flood plains nonetheless appear likely to destroy billions of dollars in property and to displace millions of people.”⁵¹

Floods result in direct damage to city property, homes, and commercial businesses. Generally, only some of the damage is covered by insurance, leaving much or most of the cost to repair and rebuild on the shoulders of homeowners and businesses. As noted earlier, most US property insurance policies exclude coverage for flood damage. The National Flood Insurance Program (NFIP) was created in 1967 to fill this gap. However, only a fraction of properties damaged by flood in Hurricanes Harvey and Florence had any flood insurance.^{52 53}

Even when flood insurance is in place, homeowners and businesses must pay all out of pocket costs for living expenses or loss of business income while the flood damage is being repaired. There are also significant potential losses that are not insured, such as business income or resident's additional living expense. Cities must continue to provide services as well as manage the emergency. Further, NFIP coverage pays losses on an "actual cash value" basis which is often far less than the cost to repair or replace the property.

Following a flood, renters and businesses may be forced to relocate to other communities and many never return. If there is no flood insurance to pay for repairs, buildings may simply be abandoned, becoming a blight on the community and lowering the tax base. This downward spiral reduces revenue and threatens the city's credit rating.

Climate change has increased the frequency and severity of extreme weather events, including heavy rainfall that, unless mitigated by smart surface strategies, results in surface water accumulation, sewer back up and overflow of rivers, streams, and other bodies of water.

Cities have the capacity to move from dark impervious surfaces to reflective, porous, and green surfaces. Or as Moody's Cahill notes; "business, economic and financial factors as well as technological solutions are expected to mitigate some of these risks, especially for businesses and institutions that have longer time frames to adapt and that also possess inherent credit strengths".

Smart surface strategies lessen the impact of storms, storm water retention, and runoff. Municipalities that implement a smart surface strategy secure risk reduction and resilience benefits which accrue and expand over time, offsetting climate change and protecting cities from increasing heat and storm severity. Adopting smart surfaces can reduce city temperature faster than climate change is expected to increase it. That is, smart surfaces provide a pathway for cities to become cooler as the world warms - and to do so in a way that saves money and reduces urban global warming.

Smart surface strategies, including green space with trees, roof design, and porous pavement can significantly reduce the risks and financial losses associated with surface water and sewer backup. Cities that implement smart surface strategies will enjoy significant financial advantages over cities that do not over the coming decades. This divergence in financial performance will result in better credit ratings for forward thinking cities.

Flood Insurance

In the United States, the lion's share of flood insurance is provided by the National Flood Insurance Program (NFIP). NFIP was formed in 1967 as US private insurers had been reluctant to provide

flood coverage. Private insurance for homeowners, public entities and businesses excludes all forms of flood (surface water, waves, tidal water, overflow of a body of water, water which backs up through sewers, drains or sumps).^{*} The National Flood Insurance Program already offers discounts to communities that have taken meaningful adaptation actions.

However, the NFIP “is not designed to handle catastrophic losses like those caused by Harvey, Irma and Maria,” Mick Mulvaney, the director of the White House Office of Management and Budget, said bluntly in a letter to members of Congress after the three huge hurricanes barreled into the United States this season.⁵⁴

Mortgage lenders require flood insurance for properties in the 100-year flood plain. Otherwise flood insurance is voluntary. It is rarely purchased when not required. For example, only 20% of properties damaged in Harvey’s 2017 floods had flood insurance, while even less of the Carolinas had flood insurance when hurricane Florence struck.⁵⁵

Private insurance accounts for 15% of the total flood insurance premiums in the US. The amount of private flood insurance premiums grew by over 50% in 2017. Private insurance is not subsidized by the government and is generally much more expensive, more accurately reflecting the actual flood risk. Private insurers have three approaches to flood insurance; providing coverage excess of NFIP coverage for large property owners, providing coverage in program and group policies for clients (that can include cities) and cherry picking the best (lowest) risks through risk analysis and modeling.

Flood insurance rates will increase substantially and risk management requirements will become more stringent. In March 2019, FEMA announced that beginning in 2020 they will begin using computer modeling to price federal flood insurance. Referred to as “Risk Rating 2.0”. The new plan is expected to increase flood insurance premiums.^{* 56} Strong risk management programs would reduce losses, help avoid loss of coverage, and can alleviate rate increases – and might even lead to rate reductions. NFIP flood rating plans will continue to include discounts for cities that have taken steps to mitigate flood risks. Municipalities and their residents and businesses that implement smart surface strategies should realize the benefits of lower premiums.

Private insurers will continue to be interested to screen, identify, and insure the best risks and will continue to use sophisticated modeling and analytics to cherry pick the best risks – giving cities that have adopted smart surface strategies a distinct advantage.

* NFIP insures direct losses from flood up to limits up to \$250,000 for homes and \$500,000 for commercial and municipal structures. Personal property is covered up to \$100,000. Losses are settled on an Actual Cash Value basis (replacement cost minus depreciation), valuable papers and records are excluded, there is no coverage for additional living expenses, extra expense to run a business or a city or loss of business income. Deductibles apply. Business personal property, including stock, located in basements may not be covered. NFIP rates are based on Flood Insurance Rate Maps maintained by FEMA. Cities (including privately owned property within its boundaries) that have implemented flood risk mitigation programs can be eligible for rate discounts of up to 40%. Smart surface strategies are not specifically included in the discount program but are similar to several mitigation actions that are. NFIP rates are highly subsidized and do not reflect the true flood risk. The program owes a \$25 billion debt to the US Treasury and has underwriting losses of \$1.5 billion annually.

Cities and their residents and businesses that adopt smart surface strategies will be better positioned to manage the impact of flood risk on their finances than cities that have not. This advantage exists today and will become more pronounced over the next several decades. There will likely be a significant divergence in municipal finances and credit rating between those that adopt smart surfaces city-wide and those that do not. Some of these differences are summarized in the table below.

Flood Insurance Premiums	
Cities without smart surfaces	Cities with smart surfaces
Today	
Higher NFIP premiums.	Smart surface strategies are risk mitigation practices that can reduce the need for and cost of flood insurance for cities, residents and businesses.
Future	
City, residents and business will pay higher NFIP flood insurance premiums. Private insurance market availability will be limited.	NFIP in future will likely include stronger risk mitigation requirements, positioning smart surface cities to qualify for lower premiums – cities, residents and businesses would be relatively more attractive to private insurers, with greater availability of private insurance.

Financial Impact

The financial benefits of adopting smart surface strategies may amount to a few hundred dollars for each insured property today and could increase 5 to 10-fold over the next 10 to 20 years.

For many home buyers and owners, the cost of flood insurance is a growing burden.⁵⁷ As premiums rise, property values fall, a trend already hurting home prices in places like Atlantic City, Norfolk, Va., and St. Petersburg, Florida. According to economists, the phenomenon of rising insurance premiums making homes less affordable and less valuable will increase as the federal government shifts away from subsidizing flood insurance rates to get premiums closer to reflecting the true market cost of the risk.⁵⁸

As accelerating climate change increases the frequency of severe storms, the financial benefits of adopting smart surfaces will increase. Cities that have not implemented these mitigation strategies will be at a greater risk of credit downgrade as their tax base erodes and costs rise, as summarized below.

Financial Impact of Flood Losses	
Cities without smart surfaces	Cities with smart surfaces
Today	
NFIP settles flood losses on an actual cash value basis (replacement cost minus depreciation). Flood loss commonly exceeds NFIP limits, and some property	Smart surfaces can mitigate flooding and costs, for example losses from backed up of sewers. Avoiding these losses can significantly reduce

<p>(e.g. papers and records) is not covered. Additional city expenses would not be covered. If there is no insurance, the loss to the city is unprotected.</p> <p>Residents and businesses face similar financial risks as cities. Recovering from even a minor flood can take months, with competing local demand for contractors and construction materials. Some businesses and residents typically relocate permanently following serious flooding.</p> <p>The sales tax and real estate tax bases are eroded.</p> <p>Cities that have not adopted smart surface strategies face increased climate related risk. City budgets are strained and residents and businesses incur losses, reduced municipal capacity to provide basic services.</p> <p>Cities that have not adopted smart surface strategies face increase mold and health risks and costs Buildings that can no longer be occupied diminish in value and erode the cities' tax base.</p>	<p>direct financial losses of the cities and their businesses and residents.</p> <p>Smart surface strategies can protect residents and businesses against surface water and back up of sewers losses.</p> <p>The city can shield its tax base from financial costs of floods. Removal and disposal of flood debris presents significant costs. Much of material is toxic and disposal of debris puts an additional strain on already over-taxed landfills. Smart surface cities would experience fewer flood events, less mold and health related costs and reduce their exposure to these risks.</p> <p>Mold often follows flood losses. A serious mold problem can make a property untenable. Cities that adopt smart surface strategies will experience fewer and less costly flood, contamination and mold events, minimizing their exposure to this risk.</p>
<p>Future</p>	
<p>Multiple flood events would likely to permanently reduce a city's tax base while increasing muni costs. Some residents and businesses relocate after repeated flood events. Future tourism would also be negatively impacted.</p>	<p>Cities that have adopted smart surface strategies are better prepared to handle the increase in severe storms forecast by climate scientists.</p>

Market pricing of homes at risk from climate change are already experiencing significant losses in value in some markets. In May 2018, a Bloomberg article entitled [“Climate Change Turns Coastal Property Into a Junk Bond”](#) summarized recent research showing that climate impact is already showing up in the value of coastal real estate.⁵⁹ Houses exposed to a sea-level rise of between 0 and 6 feet sold between 2007-2016 at a 7 percent discount relative to houses a similar distance from the beach that are higher in elevation.⁶⁰ As Bloomberg notes, this price differential occurred even before the damage from hurricane Harvey. Housing areas where people report more worry about climate change experience greater price reductions. Nationally, median home prices in areas at high risk for flooding are 4.4 percent below what they were 10 years ago, while home prices in low-risk areas are up 29.7 percent over the same period, according to the housing data.⁶¹

Another recent study on Miami-Dade County found that higher-elevation locations have risen in price faster than similar locations at low elevations.⁶²

Market pricing of homes at risk from climate change are already experiencing significant losses in value in some markets. As climate change driven severe heat and weather events worsen, the value of buildings and businesses will be increasingly differentiated on the basis of risk – and whether or not they are in cities that have adopted smart surface policies.

Legal Liability

Insurance is at best a partial risk management tool for cities, their residents, and businesses. The vast majority of flood losses are not insured and when insurance is in place coverage only partial. Smart surface strategies significantly mitigate flood risk arising from surface water accumulation and sewer back up. Cities that avoid these losses through smart surface strategies suffer much lower direct loss and to protect their tax base (residents and businesses) as well.

As accelerating climate change increases the frequency of severe localized storms this financial advantage will increase. Cities that have not implemented these mitigation strategies face the increased risk of a credit downgrade as their tax base erodes.

Cities may also be potentially liable for damages suffered by residents for negligence as a result of not adopting smart surface strategies. Such damages could be large. This is complex subject, given the laws and court precedents of all 50 states and in some cases, a city’s ability to claim sovereign immunity. Requirements in California (California Civil Code Section 1714) for meeting the test of legal negligence, include, for example:

- the foreseeability of harm to the injured party;
- the degree of certainty he or she suffered injury;
- the closeness of the connection between the defendant’s conduct and the injury suffered;
- the moral blame attached to the defendant’s conduct;
- the policy of preventing future harm;
- the extent of the burden to the defendant and the consequences to the community of imposing a duty of care with resulting liability for breach;
- the availability, cost, and prevalence of insurance for the risk involved.

As smart surfaces become more widely adopted mitigation measures for climate risk, cities that choose not to implement smart surface strategies risk falling under this definition of negligence. This risk to cities would likely increase if uninsured disasters lead claimants to search for deep pockets.⁶³

Legal action is pending against private firms that have negligently failed to act during a climate crisis. For example, a Texas grand jury recently indicted chemicals manufacturer Arkema North America Inc. and two of its executives for releasing emissions that allegedly endangered the public after a 2017 hurricane.⁶⁴ Air quality problems also pose a very common urban risk that can be reduced cost effectively through adoption of smart surface strategies. As extensively document by the Smart Surface Coalition, smart surfaces adoption city-wide would both reduce liability risk and deliver net present savings of billions of dollars to mid and large size cities such as Washington DC and Philadelphia. (See analysis on the Smart Surfaces Coalition website.)

As noted in the Fourth National Climate Assessment 2018; “More than 100 million people in the United States live in communities where air pollution exceeds health-based air quality standards. Unless counteracting efforts to improve air quality are implemented, climate change will worsen existing air pollution levels. This worsened air pollution would increase the incidence of adverse respiratory and cardiovascular health effects, including premature death.”⁶⁵

Cities that invest in smart surfaces will reduce their exposure to legal liability around health property and other dimensions of risk. Conversely, cities that continue to specify dark, impervious surfaces, thus exposing their citizens to greater risks and illness can expect to face more costly legal action and lawsuits.

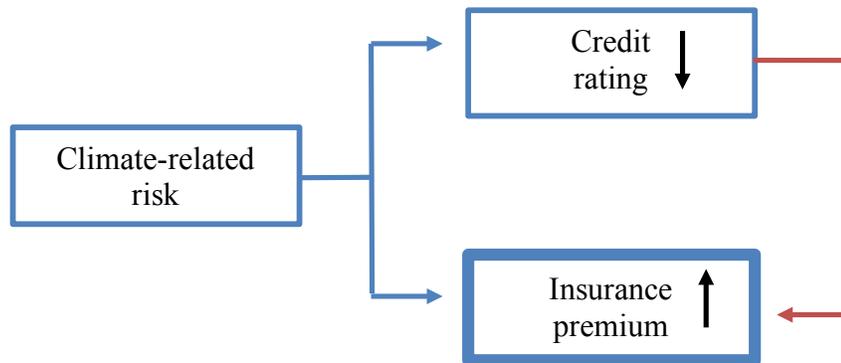
How Smart Surface Strategies Can Reduce Risk for a City

Future risks from climate change depend substantially on decisions made now. The Fourth National Climate Assessment observes that the integration of climate risk into decision-making and the implementation of adaptation activities have significantly increased since 2014, including in areas of financial risk reporting, capital investment planning, development of engineering standards, and disaster risk management.

Over a single year, differences in whether or not cities adopt smart surface resilient strategies is unlikely to measurably affect the risk or cost of severe weather events. Additionally, it is unlikely to result in changes to credit rating over a few year period; however, over the period of one or several decades, these strategies would cumulatively increase the resilience of cities while lowering the risk, cost, and severity of these extreme events.

As Moody’s makes clear, future credit rating will depend not only on actual investment in resilience, but on city policies that show commitment to addressing resilience and climate change related needs. This is illustrated below – cities that do not adopt mitigation and resilience strategies tend over time to experience reduced credit rating. The same conditions also tend to increase insurance premiums, placing further financing burden on the city, and in turn adversely affecting credit.

Credit Rating Insurance Effect



There are a several thresholds of credit risk that cities could experience, depending on how they respond to worsening climate change risks and severe weather events. Enhanced city resilience and lower risk would result from adoption of high albedo (e.g. highly reflective) surfaces such as green roofs and porous, reflective pavements.

Over time, cities that invest in smart surfaces enhance their resilience by reducing risk of flooding and extreme heat, becoming less vulnerable to climate change and improving air quality and livability. This investment in resilience would both lower experienced losses/costs. It would demonstrate to credit rating agencies acknowledgement of the scientific reality of climate change risks and the responsible engagement of cities in addressing climate change risks. As Moody's has spelled out, investment in resilience enhances city credit risk, contributing to a higher credit rating and a lower cost of borrowing. Over the period of a decade or more, that is likely to result in lower actual costs and relatively better credit rating and lower cost of borrowing - as well as lower direct losses.

Adopting smart surfaces strategies city-wide will lower the vulnerability of cities to flooding and lower excess summer heat, and would enhance air quality and make cities less vulnerable to worsening weather events driven by climate change. As discussed at some length above, credit rating agencies already view cities that fail to invest in resilience as increasingly at risk of losses and are now clear that this will contribute to determining their credit rating. Against this background, city delay in adoption of city-wide smart surface strategies will increase insured and uninsured losses and hurt city credit rating in several ways. In contrast, cities that adopt city-wide smart surfaces strategies will better manage their physical risks, help stabilize the cost of flood insurance, reduce losses, enhance credit risk and protect their credit rating.

Quantifying the Financial Impact of Credit Rating Reduction

As discussed, failure to invest in smart surfaces and resilience over time will result in increased losses and damage from severe weather events, as well as increased insurance costs and a reduction in credit rating - with a corresponding increase in the cost of borrowing. This process would be marked by a gradual step by step downgrade in credit rating e.g. from double A to single A rating. As discussed above, each rating level reduction is associated with a 0.35% increase in borrowing costs. Borrowing costs jump more when credit rating drops below investment grade (for S&P and Fitch this occurs when bonds drop from BBB- to BB+) and into what is widely and pejoratively described as “junk” status.

Although it is only one step, as noted above the drop into the category of being a junk bond is a perceived as an important risk threshold and is associated with a larger increase in cost of borrowing of 0.65%.

A recent World Bank study on cost of country credit downgrade to junk bond status is telling. The World Bank examined 20 countries that have been rated by the three major credit rating agencies (Fitch, Moody’s and S&P) between 1998-2015 to evaluate impact of credit rating downgrade or borrowing cost. As the World Bank notes, “The study found that a downgrade to sub-investment or ‘junk status’ by one major rating agency increased treasury bill rates by 138 basis points [1.38 percent] on average.”⁶⁶

Unlike recessions which are cyclical and come to an end, climate change-driven higher temperature, rising oceans or increased hurricanes are long term worsening trends, and so offer no reprieve – no prospective bounce back in property values.

Credit risk benefits for cities that choose to become smart surface cities will strengthen relative to business as usual cities (e.g. cities that persist in installing dark impervious surfaces). As climate change risks and direct costs grow, e.g. from flooding and more extreme heat and rainstorms, declining property and business taxes would also over time contribute to and/or trigger lowered credit ratings that increase borrowing cost and reduce borrowing capacity. In turn, this will limit the capacity of city services to respond to costlier clean up, repair, and maintenance needs after increasingly frequent climate change-driven costly weather events.

How rapidly will changes in city surfaces affect credit rating?

Moody’s in 2017 warned that; "The interplay between an issuer's exposure to climate shocks and its resilience to this vulnerability is an increasingly important part of our credit analysis, and one that will take on even greater significance as climate change continues." – Moody’s Investors Service, November 2017

In April 2019, the multi-trillion-dollar asset manager Blackrock warns that: “Within a decade, more than 15% of the current S&P National Municipal Bond Index (by market value) would be issued by MSAs suffering likely average annualized economic losses of up to ...1% of GDP... This would have big implications for the creditworthiness of MSAs – and their ability to fund adaptation projects.”⁶⁷ As Bloomberg summarizes it; “BlackRock Inc., the world’s largest asset manager,

says that within a decade, more than 15 percent of debt in the S&P National Municipal Bond Index will come from regions that could suffer losses from climate change adding up to as much as 1 percent of gross domestic product annually.”⁶⁸

Moody’s provides guidance on expected time to impact in two recent reports. Moody’s reports address the time to impact question for specific industries. These reports are titled “Cross Sector — Global: Moody’s Approach to Assessing the Credit Impacts of Environmental Risks” and “Environmental Risks: Heat Map Shows Wide Variations in Credit Impact Across Sectors” and were authored by Brian Cahill, a Managing Director at Moody’s, William Hunter, a senior vice president, and other senior Moody’s analysts.⁶⁹

Moody’s found that:

“Global sectors ... with approximately \$2 trillion of rated debt – are experiencing material credit impacts or are likely to start doing so over the next three to five years. For these 11 sectors, the consequence of regulatory or policy initiatives for carbon reduction and other air emissions is the most frequently cited issue impacting creditworthiness.”

“A further 18 sectors—with approximately \$7 trillion of rated debt—face the potential of changes in their credit profiles that could be material due to environmental considerations, but over a longer period of 5 years or more.”⁷⁰

Cities are generally more diverse and at less structural risk than these sectors so we can expect the period over which cities without smart surfaces to experience a change in credit profile will be longer than 3-5 years.

For the purpose of developing a reasonable estimate for credit risk impact at an individual city level we are estimating likelihood of credit rating erosion across a large number of cities. Thus, we deal with probabilities, rather than a prediction about a specific city. Based on the accelerating climate trends and rising market rate changes to low lying properties, increasing losses and other factors discussed in the paper above, we address the credit rating risk as follows. We estimate that, on average, over one decade there would be a difference on average of one credit rating level between Business as Usual (BAU) cities (predominantly installing dark impervious surfaces) vs smart surface cities (e.g. cities that adopt smart surfaces as baseline city-wide policy). That is, over a period of four decades and across a large number of cities we estimate that the average change in credit rating to smart surface city vs BAU would be expected on average to result in a difference of one credit rating per decade (e.g. the difference between AAA and AA).

As climate change accelerates and city capacity to respond is stressed, and the gap between revenue and costs widens, this will compress the period of credit rating risk reduction, perhaps compressing toward the length of 5 years.

It is impossible to predict what event will trigger a city credit crisis. Referencing climate change impact on home values in Florida, the chief economist of Freddie Mac, Sean Beckett hypothesized that the catalyst for a city credit crisis might be a bank refusing to issue a mortgage, an insurer refusing to issue a policy, or, he asked, “Will the trigger be one or two homeowners who decide to

sell defensively?” and, “Will the value of the house decline gradually as the expected life of the house becomes shorter?... Or, alternatively, will the value of the house — and all the houses around it — plunge the first time a lender refuses to make a mortgage on a nearby house or an insurer refuses to issue a homeowner’s policy?”

Over the period of four decades covered in this analysis, we estimate that each decade a city waits to switch from dark impervious surfaces to smart surfaces would, on average, expose a city to one reduction in credit rating. As noted above, on average this increases cost of borrowing by 0.35 %, or 35 basis points. If a one-step credit rate reduction drops a city from “investment grade” to junk” status the average increase in borrowing cost is 0.65% or 65 basis points.

For a city borrowing a billion dollars through the bond market, a reduction of a single level of credit rating from investment grade to junk status would add \$3.5 million in additional interest costs a year or \$70 million over 20 Years. Two credit rating reductions that include dropping city bonds from investment grade to junk grade would add \$10 million a year to borrowing costs, or \$200 million over 20 years for a 1-billion-dollar bond. For a \$100 million bond a 1% increase in cost of borrowing would add \$20 million over 20 years.

Increased city borrowing and higher interest obligations further erode city credit. And many institutions limit or cap how much of their investments are in junk bonds. Given the reality of economic cycles this creates another risk for cities that are not prudent in managing their climate change risk and associated credit risk. As the Financial Times, the world leading business newspaper, noted recently, an economic “downturn could trigger downgrades on the large number of bonds that just scrape into the investment-grade ratings, leading to wave of forced selling by funds that cannot hold below BBB”

For cities experiencing declining real estate values and associated lower tax base, lower tax revenue would happen at a time of greater need for and cost of city services. This is a prescription for declining credit rating and higher borrowing costs.

The most serious potential outcome would be cities going into a credit death spiral resulting from rising climate change related costs driving down property values and city tax revenue and increasing the cost of borrowing, making cities less able to invest in capacity or fund climate damage repairs, in turn hurting property values, and reducing taxes revenue further. City revenue is substantially based on real estate taxes which are largely driven by property value. Value of real estate is determined by market supply and demand, and the irreversible nature of climate change and the feedback loop discussed above (e.g. lower credit ratings drive higher costs of capital, in turn increasing borrowing and driving further erosion of credit risk) making city revenue, cost and credit risk systematically very vulnerable to climate change.

As [Coral Gables](#) Mayor Jim Cason puts it, if property values start to fall, banks could stop writing 30-year mortgages for coastal homes, shrinking the pool of able buyers and sending prices lower still. Those properties make up a quarter of the city’s tax base; if that revenue fell, the city would struggle to provide the services that make it a desirable place to live, causing more sales and another drop in revenue.⁷¹

Increasing losses and costs to cities, combined with declining revenues from business interruptions and lowered real estate tax base combined with a credit rating agency's negative assessment of cities that fail to respond to climate change will put cities at growing risk of lowered credit ratings. This delay will be very costly because the process of changing out surfaces such as roads, parking lots and roofs will take several decades. Ripping up new roads and replacing new roofs is very expensive, so surface changes are generally made at the surface's end of life. Maintaining a stupid surfaces strategy locks in a worsening heat, flooding, and risk profile for cities that fail to adopt smart surfaces. Cities that move slowly to address climate change increasingly risk of a future cycle of higher costs, declining housing value and revenue, and exposure to legal liabilities and damages. The adverse impact on credit rating and rising cost of borrowing will exacerbate risks and costs to cities that fail to adopt smart surfaces and other available resilience measures.

Conclusion

There are large and growing risks and costs for cities that ignore climate change and fail to adopt available, cost-effective solutions for enhancing city resilience and managing sun and rain. Over time, city investment in resilience strategies such as smart surfaces will increasingly determine whether city credit ratings improve, stabilize, or decline. As Moody's warns, climate change "will be a growing negative credit factor for issuers without sufficient adaptation and mitigation strategies."

As extensively documented by the [Smart Surfaces Coalition](#), cities now have highly cost-effective strategies and technologies for lowering climate risks and costs and for enhancing city resilience and livability. In the longer term, e.g. over a decade or more, cities that fail to invest in resilience measures such as smart surfaces will be increasingly at risk of one or more credit downgrades. These risk dimensions of climate change for cities has to date been largely overlooked but is of fundamental importance to the medium and long term financial viability of cities.

City managers do not have the luxury of pretending science is not true— they are judged on results and their decision must be based on facts – including science – to make informed and responsible city management decisions. How cities manage their sun and rain will largely determine how they manage – or fail to manage – extreme heat events, extreme rainfalls, flooding, and other increasingly common and severe climate change driven events. It will also have a large impact on city livability because it directly affects quality of life issues such as heat, air quality and walkability. Austin Mayor Will Wynn notes:

“Cities that commit to climate mitigation policies – including smart surfaces strategy adoption - clearly will save their taxpayers money and reduce risk. Cities that fail to adopt smart surfaces will experience rising climate related losses, eroded confidence of residents, businesses and credit agencies, and worsening heat, flooding, and air quality that will inevitably degrade their credit rating and capacity to borrow money to finance essential city services.”

Changing out dark, impervious surfaces such as a roads or roofs for highly reflective, porous, or green surfaces is far more expensive before end of life e.g. 10 years into a roof with a 25-year life. In contrast, changing from dark impervious surfaces at end of life of surfaces e.g. as a replacement

is very cost effective, so cities that delay adopting smart surfaces are locking themselves into long term unnecessary risks and costs. These risks include increasing heat and energy costs, worsening air quality and eroded city livability as well as declining credit rating and rising costs of borrowing - both increasing the costs of climate change and limiting cities ability to respond.

Cities that fail to act promptly to protect their populations from climate change are, in effect, making the decision to expose their citizens to worsening air quality, higher temperatures, greater risk of flooding and another adverse conditions. And this in turn would impose a growing risk of credit rating reductions and legal liabilities for cities due to increasing risks to health, property and other costs that could have been mitigated or avoided through cost-effective, available smart surface and other resilience strategies. Cities that fail to shift promptly from stupid surfaces to smart surfaces do so at their own peril.

This report provides the first rigorous and extensive analysis of these risk issues for cities and is intended to allow cities to make better informed, more prudent choices that enable them to not only survive, but thrive, in a climate changing world.

¹ “World Economic Forum Annual Top 5 Global Risks in Terms of Impact.” *World Economic Forum*, 2017. <https://www.weforum.org/reports/the-global-risks-report-2017>

² Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.). “Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.” *U.S. Global Change Research Program*, 2018.

³ “Explaining Extreme Events in 2017 from a Climate Perspective.” *Bulletin of the American Meteorological Society*, Vol 99, No 12, Dec. 2018 <https://www.ametsoc.org/ams/index.cfm/publications/bulletin-of-the-american-meteorological-society-bams/explaining-extreme-events-from-a-climate-perspective/>

⁴ “Heatwaves, Droughts and Floods Among Recent Weather Extremes Linked to Climate Change: New Studies Reveal Clear Ties between Today’s Extremes and Human Causes.” *American Meteorological Society*, 10 Dec. 2018. <https://www.ametsoc.org/index.cfm/ams/about-ams/news/news-releases/heatwaves-droughts-and-floods-among-recent-weather-extremes-linked-to-climate-change/>

⁵ American Academy of Actuaries, Canadian Institute of Actuaries, Casualty Actuarial Society and Society of Actuaries. Actuaries Climate Index. <http://actuariesclimateindex.org> (accessed July 2018). <http://actuariesclimateindex.org/explore/component-graphs/>

⁶ “Loss Events in the U.S. 1980-2017.” *Insurance Information Institute*, January 2018. Munich Re, Geo Risks Research, *NatCatSERVICE*. www.iii.org/fact-statistic/facts-statistics-us-catastrophes

⁷ Hope, Bradley, Friedman, Nicole. “Climate Change is Forcing the insurance Industry to Recalculate.” *The Wall Street Journal*, 2 Oct. 2018. <https://www.wsj.com/graphics/climate-change-forcing-insurance-industry-recalculate/>

⁸ “Credit Impact from Environmental Issues Varies Widely Across Sectors Globally.” *Moody’s Investors Service*, 2015. https://www.moodys.com/research/Moodys-Credit-impact-from-environmental-issues-varies-widely-across-sectors--PR_339980

⁹ “How Credit Ratings Affect Bond Valuations.” *American Association of Individual Investors*, n.d. <http://www.aaii.com/investing/article/how-credit-ratings-affect-bond-valuations>

-
- ¹⁰ Bojinov, Stoyan. "Understanding Bond Ratings." *Municipal Bonds.com*, 20 Aug. 2011. <http://www.municipalbonds.com/education/read/67/understanding-bond-ratings/>
- ¹¹ Will Wynn, personal communication. January 2019
- ¹² "Catastrophe Modeling and Climate Change." *Lloyd's Bank*, 2014. <https://biotech.law.lsu.edu/blog/lloyds-catastrophic-reports2014.pdf>
- ¹³ "Environmental Risks -- Evaluating the impact of climate change on US state and local issuers." *Moody's investors Service*. 2017. http://www.moodys.com/researchdocumentcontentpage.aspx?docid=PBM_1071949
- ¹⁴ Nesbit, Jeff. "When Climate Change Risk Becomes a Problem." *New York Times*, 13 Dec. 2017. <https://www.nytimes.com/2017/12/13/opinion/climate-change-credit.html>
- ¹⁵ IBID
- ¹⁶ Original content: "Environmental Risks -- Evaluating the impact of climate change on US state and local issuers." *Moody's investors Service*. Summary: "Climate Change and Credit Risk." *Canadian Investment Review*, 7 Dec. 2017 <http://www.investmentreview.com/analysis-research/climate-change-and-credit-risk-8023>
- ¹⁷ Moody's Investors Service, IBID
- ¹⁸ Wenger, Yvonne. "Baltimore's bond rating raised to highest level in years, signaling city's improved fiscal health." *Baltimore Sun*, 21 July 2014. <http://www.baltimoresun.com/news/maryland/baltimore-city/bs-md-ci-bond-rating-20140721-story.html>
- ¹⁹ Feretti, Christine & O'Connor, Brian. "Duggan touts rating of new city bond issue." *The Detroit News*, 29 July 2015. <https://www.detroitnews.com/story/news/local/detroit-city/2015/07/29/detroit-bond-rating/30835941/>
- ²⁰ "City of Seattle's AAA Bond Rating reaffirmed." *Seattle.gov Office of the Mayor*, 2 May 2016. <http://murray.seattle.gov/city-of-seattles-aaa-bond-rating-reaffirmed/>
- ²¹ "The ARC and the Covenants 3.0." *J.P. Morgan Private Bank*, 20 Sept. 2017. <https://www.jpmorgan.com/jpmpdf/1320743902699.pdf>
- ²² James, Pilcher. "Cincinnati now pays nearly \$50M in interest on its debt. Is that a problem? City says no." *Cincinnati.com*, 7 March 2018. <https://www.cincinnati.com/story/news/politics/2018/03/07/cincinnati-now-pays-50-m-interest-its-debt-problem-city-says-no/398991002/>
- ²³ "Comprehensive Annual Financial Report: City of Milwaukee, Wisconsin for the Year Ended December 31, 2015." *Milwaukee Office of the Comptroller, Martin Matson*, 2016. <https://city.milwaukee.gov/ImageLibrary/Groups/cityComptroller/Reports/CAFR/2015CAFRFinalPrintVer.pdf>
- ²⁴ Maciag, Mike. "What Are Cities Spending Big On? Increasingly, It's Debt." *Governing.com*, Sept. 2017. <http://www.governing.com/topics/finance/gov-legacy-cities-bills-debt.html#data>
- ²⁵ American Fact Finder: Population 1-Year Estimates. *U.S. Census Bureau*, 2017. https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_16_1YR_B01003&prodType=table
- ²⁶ Urban Population. *World Bank Group*. <https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS>
- ²⁷ American Fact Finder: State and Local Government Finances by Level of Government and by State. *United States Census Bureau*. https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=SLF_2015_00A1&prodType=table
- ²⁸ "Credit Ratings and the Cost of Municipal Financing." *USC FBE*. http://fbe.usc.edu/seminars/papers/F_4-28-17_CORNAGGIA.pdf
- ²⁹ "Rates Over Time – Interest Rate Trends." *WM Financial Strategies*, 2018. <http://www.munibondadvisor.com/market.htm>

³⁰ Analysis of raw municipal bond data available here:

<https://drive.google.com/open?id=1NaZRwAstRcEabJEoGe5TxC8oop2inN6s>

³¹ IBID

³² Flavelle, Christopher. “Cities Threatened by Climate Risk are Still Getting AAA Bond Ratings.” *Bloomberg.com*, 2 Nov. 2018. <https://www.bloomberg.com/news/articles/2018-11-02/cities-threatened-by-climate-risk-still-getting-aaa-bond-ratings>

³³ “A call for action: Climate change as a source of financial risk.” *Central Banks and Supervisors Network for Greening the Financial System*, April 2019. https://www.banque-france.fr/sites/default/files/media/2019/04/17/ngfs_first_comprehensive_report_-_17042019_0.pdf

³⁴ “Extreme Heat.” *Ready.gov*. <https://www.ready.gov/heat>

³⁵ Samenow, Jason. “Red-hot planet: All-time heat records have been set all over the world during the past week.” *The Washington Post*, 5 July 2018. https://www.washingtonpost.com/news/capital-weather-gang/wp/2018/07/03/hot-planet-all-time-heat-records-have-been-set-all-over-the-world-in-last-week/?noredirect=on&utm_campaign=upd_dmt&utm_medium=social-media&utm_source=twitter&utm_term=.b9e8b5f5cc0d

³⁶ Alissa Rubin. “Scorching Summer in Europe Signals Long-Term Climate Changes.” *New York Times*, 4 Aug. 2018. <https://www.nytimes.com/2018/08/04/world/europe/europe-heat-wave.html>

³⁷ Breslin, Sean. “The Record-Breaking Heat Isn't Just Uncomfortable – It's Killing People.” *Weather.com*, 6 July 2018. <https://weather.com/safety/heat/news/2018-07-05-deadly-heat-wave-impacts-us-canada-europe-asia>

³⁸ Peritz, Ingrid. “After 54 heat wave deaths, Quebec shifts focus to learning lessons for next time.” *The Globe and Mail*, 6 July 2018. https://www.theglobeandmail.com/canada/article-after-54-heat-wave-deaths-quebec-shifts-focus-to-learning-lessons-for/?utm_medium=Referrer:+Social+Network++Media&utm_campaign=Shared+Web+Article+Links

³⁹ Chiland, Elijah. “Unprecedented' Heat Wave Expected to Break Records with Triple-Digit Temperatures.” *Curbed LA*, 7 July 2018. la.curbed.com/2018/7/2/17519854/los-angeles-heat-wave-weather-july-record

⁴⁰ Widner, Cindy. “Austin Sets Heat Records as Things Continue to Burst into Flames.” *Curbed Austin*, 24 July 2018. austin.curbed.com/2018/7/24/17606112/austin-heat-records-fires-dust

⁴¹ Porter, Greg. “Oppressive Heat Dome Engulfs the Northeast - and It Will Spread West This Weekend.” *The Washington Post*, 3 July 2018. www.washingtonpost.com/news/capital-weather-gang/wp/2018/07/03/oppressive-heat-engulfs-the-northeast-and-it-spreads-west-this-weekend/?utm_term=.59f22d20b6b7

⁴² Stone, Will. “Phoenix Tries to Reverse Its 'Silent Storm' Of Heat Deaths.” *NPR*, 9 July 2018. www.npr.org/2018/07/09/624643780/phoenix-tries-to-reverse-its-silent-storm-of-heat-deaths

⁴³ “Heat Wave Deaths in Japan Could Jump 170 Percent by 2080, Spike Far Higher in Other Countries: Study.” *The Japan Times*, 1 Aug. 2018. www.japantimes.co.jp/life/2018/08/01/environment/study-sees-dramatic-rise-heat-wave-deaths-2080-mitigating-steps-not-taken/

⁴⁴ McKirdy, Euan. “Record-Breaking Temperatures Leave 29 Dead in South Korean Heatwave.” *CNN*, 3 Aug. 2018. www.cnn.com/2018/08/02/asia/south-korea-heatwave-deaths-intl/index.html

⁴⁵ Rubin, Alissa. “Scorching Summer in Europe Signals Long Term Climate Changes.” *New York Times*, 4 Aug 2018. <https://www.nytimes.com/2018/08/04/world/europe/europe-heat-wave.html>

⁴⁶ Walker, Alissa. “Our Cities are Getting Hotter, and it's Killing People.” *Curbed.com*, August 3, 2018. <https://www.curbed.com/2018/7/6/17539904/heat-wave-extreme-heat-cities-deadly>

⁴⁷ “New NOAA Study Estimates Future Loss of Labor Capacity as Climate Warms.” *National Oceanic and Atmospheric Administration*, 25 Feb. 2013. www.noaa.gov/new-noaa-study-estimates-future-loss-labor-capacity-climate-warms

-
- ⁴⁸ Rivera, Stephanie. "Heat Waves Leaves Thousands of Edison Customers Without Power." *Long Beach Post*, 7 July, 2018. <https://lbpost.com/news/socal-heat-wave-leaves-thousands-of-edison-customers-without-power/>
- ⁴⁹ Sweet, Laurel. "Massachusetts Hit with Power Outages as Heat Sets In." *Boston Herald*, 30 Aug. 2018. <https://www.bostonherald.com/2018/08/30/massachusetts-hit-with-power-outages-as-heat-sets-in/>
- ⁵⁰ Lemor, Abrams. "Officials Managing State's Electrical Grid Warn of Possible Rolling Blackouts." *CBS 13 Sacramento*, 23 July 2018. <https://sacramento.cbslocal.com/2018/07/23/blackouts-electrical-cal-iso/>
- ⁵¹ "Life's a Beach." *Freddie Mac*, 26 April 2016. http://www.freddiemac.com/research/insight/20160426_lifes_a_beach.html
- ⁵² Condon, Bernard, and Ken Sweet. "About 80% of Hurricane Harvey Victims Do Not Have Flood Insurance, Face Big Bills." *USA Today*, 30 Aug. 2017. www.usatoday.com/story/money/2017/08/29/hurricane-harvey-houston-flood-insurance-damages-claims/611910001/
- ⁵³ "Kennedy: Fewer than 10 Percent Flooded from Florence Had Flood Insurance." *WWL*, 25 Sept. 2018. www.wwtv.com/article/news/local/kennedy-fewer-than-10-percent-flooded-from-florence-had-flood-insurance/289-597919709
- ⁵⁴ Walsh, Mary. "A broke and broken flood insurance program." *New York Times*, 4 Nov. 2017. <https://www.nytimes.com/2017/11/04/business/a-broke-and-broken-flood-insurance-program.html>
- ⁵⁵ IBID
- ⁵⁶ Flavelle, Christopher. "Climate Advocates Cheer Trump Policy Shift on Flood Insurance." *Bloomberg*, 18 March 2019. <https://www.bloomberg.com/news/articles/2019-03-18/climate-advocates-cheer-trump-policy-shift-on-flood-insurance>
- ⁵⁷ Lieber, Ron. "You're Buying a Home, Have You Considered Climate Change." *New York Times*, 2 Dec. 2016. <https://www.nytimes.com/2016/12/02/your-money/youre-buying-a-home-have-you-considered-climate-change.html>
- ⁵⁸ Carrns, Ann. "Federal Flood Insurance Premiums for Homeowners Rise." *The New York Times*, 2 April 2015. <http://www.nytimes.com/2015/04/03/your-money/federal-flood-insurance-premiums-for-homeowners-rise-as-much-as-25-percent.html>
- ⁵⁹ "Climate Change Turns Coastal Property Into a Junk Bond." *Bloomberg.com* <https://www.bloomberg.com/view/articles/2018-05-03/flood-risk-makes-coastal-real-estate-look-like-a-junk-bond>
- ⁶⁰ "Disaster on the Horizon: The Price Effect of Sea Level Rise." *Journal of Financial Economics*, 21 Nov. 2017. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3073842
- ⁶¹ Urbina, Ina. "Perils of Climate Change Could Swamp Coastal Real Estate." *New York Times*, 24 Nov. 2016. <https://www.nytimes.com/2016/11/24/science/global-warming-coastal-real-estate.html>
- ⁶² Keenan, Jessie, Hill, Thomas, Gumber, Anurag. "Climate gentrification: from theory to empiricism in Miami-Dade County, Florida." 23 April 2018. <https://iopscience.iop.org/article/10.1088/1748-9326/aabb32>
- ⁶³ Horning, Alex. "Overview of a City's Tort Liability Duties to Maintain and Protect Local Government Services from Sea Level Rise: Poquoson Case Study." *Virginia Coastal Policy Clinic at William & Mary Law School*, March 2014. <https://law.wm.edu/academics/programs/jd/electives/clinics/vacoastal/documents/march2014reports/citytortliability.pdf>
- ⁶⁴ "Texas Jury Indicts Arkema, Two Execs Over Chemical Releases." *Business Insurance.com*, 6 Aug. 2018 https://www.businessinsurance.com/article/20180806/NEWS06/912323166/Texas-jury-indicts-Arkema-North-America-two-execs-over-chemical-releases?utm_campaign=BI20180806BreakingNewsAlert&utm_medium=email&utm_source=ActiveCampaign&utm_campaign=BI20180806BreakingNewsAlert&utm_medium=email&utm_source=ActiveCampaign

⁶⁵ Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart. “Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II.” *U.S. Global Change Research Program*, 2018, pp. 519.

https://nca2018.globalchange.gov/downloads/NCA4_2018_FullReport.pdf

⁶⁶ Hanusch, Marek, Hassan, Shakill, et al. “The Ghost of a Rating Downgrade: What Happens to Borrowing Costs When a Government Loses its Investment Grade Credit Rating.” *World Bank*, June 2016.

<http://documents.worldbank.org/curated/en/241491467703596379/pdf/106667-NWP-MFM-Discussion-Paper-13-SARB-CreditRating-28-Jun-2016-PUBLIC.pdf>

⁶⁷ “Getting physical: Scenario analysis for assessing climate-related risks.” *BlackRock Investment Institute, BlackRock, Inc.*, April 2019. <https://www.blackrock.com/us/individual/literature/whitepaper/bii-physical-climate-risks-april-2019.pdf>

⁶⁸ Moran, Danielle. “Climate Change: The Next Great Risk to Munis Is Already Here.” *Bloomberg.com*, 18 April 2019. <https://www.bloomberg.com/news/articles/2019-04-18/climate-change-the-already-present-next-great-risk-to-munis>

⁶⁹ “Moody's: Credit impact from environmental issues varies widely across sectors globally.” *Business Standard*, 1 Dec. 2015. https://www.business-standard.com/article/news-cm/moody-s-credit-impact-from-environmental-issues-varies-widely-across-sectors-globally-115113000490_1.html

⁷⁰ “Credit Impact from Environmental Issues Varies Widely Across Sectors Globally.” *Moody's Investors Service*, 2015. https://www.moody.com/research/Moodys-Credit-impact-from-environmental-issues-varies-widely-across-sectors--PR_339980

⁷¹ Flavelle, Christopher. “The Nightmare Scenario for Florida’s Coastal Homeowners.” *Bloomberg News*, 19 April 2017.