# Resilient Analytics
# California Statewide Assessment Summary
# Case Study 2014 - 7

## Study Summary

Quantitative assessment of the vulnerability, adaptation options, and economic impacts of climate change on road infrastructure is essential to building a more robust and resilient transportation network. To date, most research has focused on qualitative statements or broad findings. This paper details a quantitative, engineering-based analysis of the impacts of specific climate stressors on different types of road infrastructure. The results are designed to be utilized by transportation planners to understand the vulnerability, risk, and adaptation options for creating a climate-resilient road network by providing specific design changes and fiscal cost analysis. Results are presented for the State of California and include the vulnerability of the road network and specific costs of adaptation options. A more detailed analysis is provided for the City of Sacramento, including a criticality analysis of key road networks connecting other assets of the built environment, including hospitals, schools, and libraries. The contribution of this research is to move beyond the identification of vulnerabilities to a quantitative assessment of specific adaptation options that reduce a community or regions vulnerability to climate change. The findings indicate that the economic costs of adaptation vary across regions but the vulnerability analysis shows a substantial need to incorporate the costs of climate change into current and future designs. Findings for California show a savings of over $1.9 billion for the 95$^{th}$ percentile climate model projection when a proactive adaptation policy is taken, compared with a no adaptation scenario

## Background

***California Statewide Assessment (Case Study 2014-7)*** is one of a series of case study examples highlighting the application of the Infrastructure Planning Support System (IPSS) software system for vulnerability and resiliency analysis. The IPSS system integrates expertise from researchers in civil and environmental engineering, water resources, architecture, international development, economics, and more. IPSS provides decision makers with quantitative information about the impacts of a changing future climate on existing and planned infrastructure. Based on IPCC-approved climate models, IPSS provides easy-to-understand and applicable results to decision-makers. Existing vulnerabilities, specific adaptation options to reduce risk, responsible future design, and cost-benefit analysis are part of the standard IPSS analysis.

## SUMMARY OF FINDINGS

Figure 1 below shows the changes in precipitation and temperature for the 2050 decade projected by the 95th percentile GCM model. These changes cause stress to the road system and cause specific degradation and cost impacts.

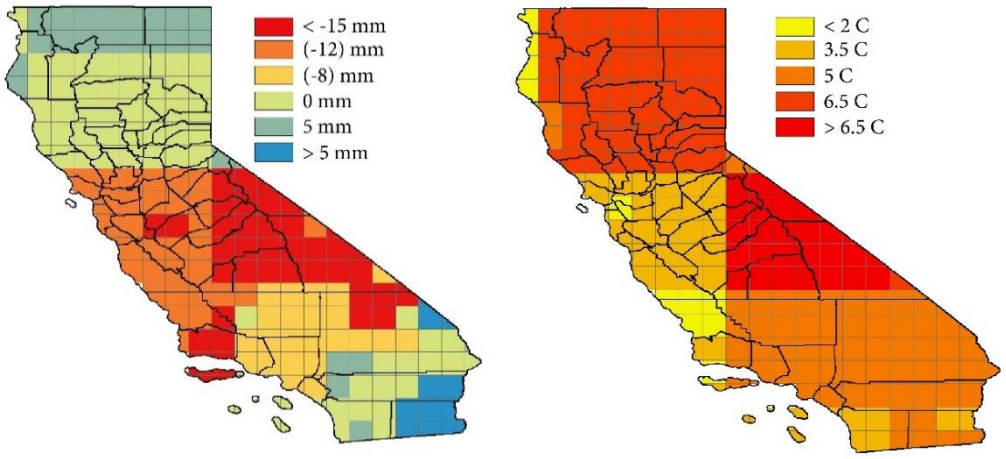


***FIGURE 1**: Projected changes in precipitation (left, in millimeters) and temperature (right, in Celsius) based on 95th percentile GCM in the year 2050 as compared to historical baseline averages. Results presented at CRU level*

The cost of climate change to existing road infrastructure in the State of California is shown in Table 1. For each of the climate change models analyzed, a proactive adaptation strategy saves money through 2050. The 5th, 50th, and 95th percentiles show the range of costs from the full set of AR4 General Circulation Models approved by the Intergovernmental Panel on Climate Change (see: http://www.ipcc-data.org/sim/gcm_monthly/SRES_AR4/index.html)

| | 95th | 50th | 5th | OPTIMAL |
|---|---|---|---|---|
| **No Adapt** | $ 3,693 | $ 627 | $ 593 | $ 792 |
| **Adapt** | $ 1,758 | $ 584 | $ 405 | $ 709 |
| **Adapt No CC** | $ 430 | $ 338 | $ 326 | $ 358 |

These costs are based on three factors: The existing road inventory for California, the projected changes in precipitation and temperature, and the engineering analysis performed by the IPSS system developed by Resilient Analytics.

## STATEWIDE COST IMPACT PROJECTIONS

Figure 2 shows the full range of costs predicted by 2050 for the State of California. From a risk perspective, the No Adapt Scenario poses the greatest range of cumulative costs. A proactive adaptation strategy shows a maximum cost range from $0.4 billion to $2.1 billion.

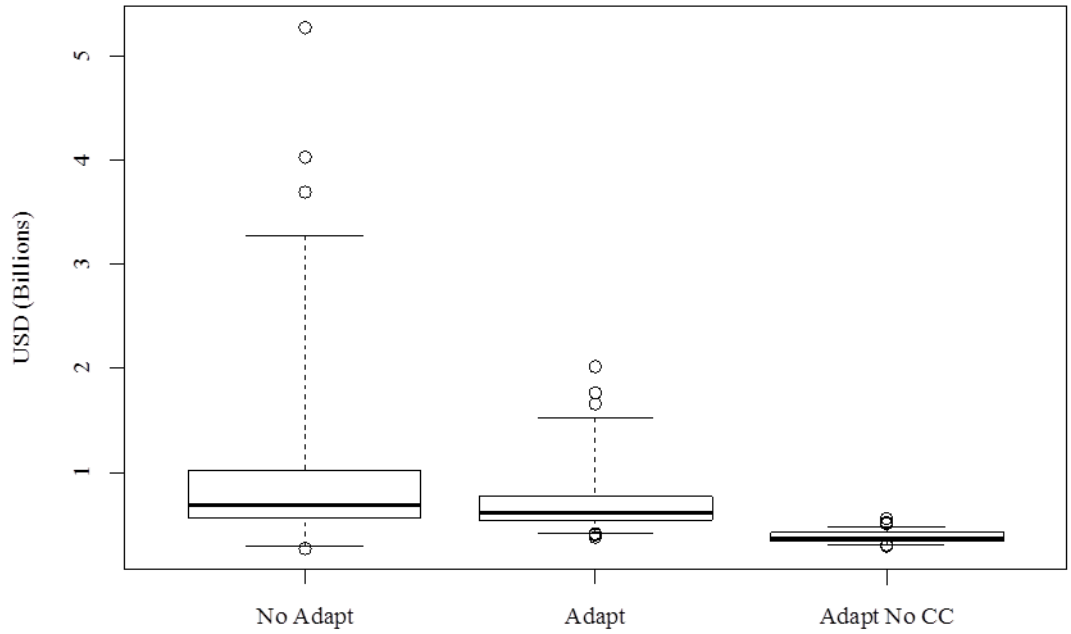


***FIGURE 2:*** *Box and whisker plot detailing the total range of costs from 54 GCM models utilized for the State of California. Results represent three policy choices: no adaptation, proactive adaptation, and adaptation where no climate change occurs. Costs are total cumulative costs for 2015-2050 based on existing road infrastructure.*

Figure 3 shows the cost impacts for the Adapt and No Adapt scenario for 2050 based upon the 95th percentile model at the County Level. Findings show that by 2050, all counties see a cost advantage in proactive adaptation strategy. The northern and central counties see higher overall costs from climate change, particularly with a no adapt strategy. Most states are below $40 million annually with a proactive adaptation strategy, whereas with a no adapt approach, nearly 2/3 of counties see costs above $55 million annually on average from 2015-2050.

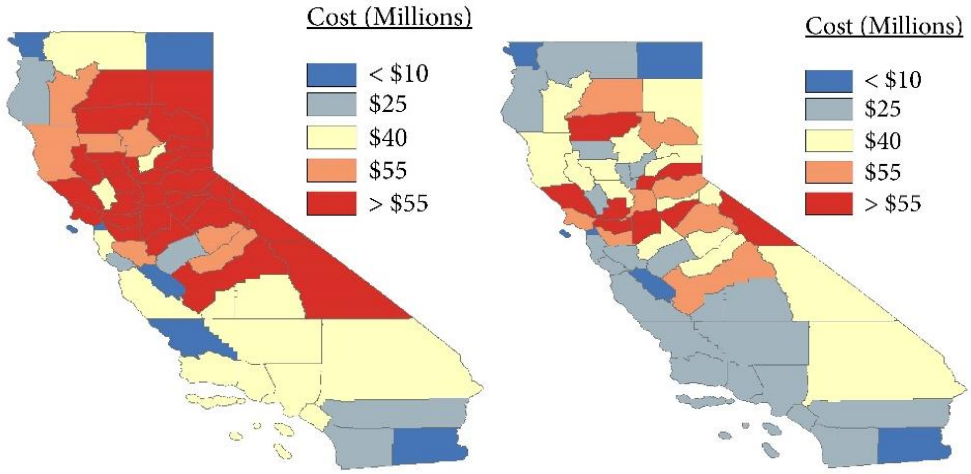


***FIGURE 3:*** *County level vulnerability to climate change in 2050, based on average annual cost 2015-2050 for 95th percentile GCM results. Left graphic shows cost based on "No Adapt" Policy; Right graphic shows costs for proactive "adapt" policy. Costs overall are reduced by approximately $1.7 billion with proactive adaptation policy.*

## PROJECT APPLICATION

These findings can inform a policy strategy when combined with existing plans to identify critical assets in need of upgrading to withstand climate impacts. Among other factors, a climate change vulnerability and adaptation analysis can reduce risk to critical road corridors and reduce the overall cost of climate change to road network maintenance, construction, and life-cycle considerations.