Economic impacts of climate change's effect on Boulder County infrastructure

The impact of climate change on Boulder County extends to the County infrastructure. Roads, buildings, and bridges are all susceptible to changes in operating conditions including temperature and precipitation. The following analysis provides a projected cost of this impact on Boulder County infrastructure through 2050. The cost projections reflect a comparison of the operating environment in which the infrastructure was built (temperature, precipitation, and flooding) with the projected future operating environment. In cases where the future operating environment exceeds the conditions in which it was intended to operate, damage estimates are estimated. In these cases, cost estimates to repair the damages are calculated. This is done under 42 different IPCC (Intergovernmental Panel on Climate Change) approved climate scenarios plus a historic baseline to get a range of potential cost scenarios. The analysis is completed for each infrastructure element on an annual basis to get an annual and cumulative total.

It's important to note that the biggest impacts to increasing infrastructure costs in Boulder County are related to increases in heat. Increased water flows will have an effect, but more focused on the bridges and a few extreme events which will cause wider road damage.

In addition, all costs discussed below are above what would be expected under historic conditions.

- **Roads –** The analysis of road impacts was based on a County-wide inventory of over 1,500 miles of roads within the County's geography boundaries. The inventory included three categories of roads including primary roads such as Highway 287 or Foothills Parkway, secondary roads such as Arapahoe Ave and McCaslin Blvd, and tertiary roads which are neighborhood roads. The analysis also distinguished between paved, gravel, and unpaved roads, each of which have unique damage considerations.
    - Total increase in maintenance costs by 2030 above historic costs are projected at $81 million for a median model and up to $183 million for a high-end model.
    - The cumulative increase in maintenance costs by 2050 is projected to be $215 million for a median projection and $765 million for a high-end projection.
    - The average required increase in annual maintenance budget using a 2050 cumulative total is $6.3 million over historic (a 60% increase over the current budget) for a median total and $22.5 million over historic for a high end model.
    - The increase in projected cost per mile of road per year using the average annual cost from the 2050 projections is $4,200 for a median projection and $15,000 for a high-end projection.
    - The primary cause of increase in road maintenance will be damages resulting from increased temperatures.

- **Bridges** – The inventory of bridges included bridges throughout Boulder County. After eliminating culverts from the list, which are analyzed separately in the roads analysis, 84 distinct bridges were analyzed for climate change vulnerability.
    - 75% of the climate scenarios project that increased flow will result in a required $14 million in improvements to Boulder County bridges, not counting culverts.

- **Buildings** - The current analysis includes about 6,000 non-residential buildings located across Boulder County. The analysis covers 16 different categories of commercial, industrial, and multi-family structures. Single family residences are not included in this analysis. Additionally, the analysis does not include the cost of installing air conditioning in the buildings studied. The additional cost of installing cooling systems would be significant in both residential and non-residential buildings. It is also important to note that the cooling demand for electricity may not be able to be met by current energy production capacity.

    - Buildings in Boulder County will experience a cumulative increase in cooling costs of 23% by 2030 ($23 million). Similarly, the buildings will experience a cumulative increase in cooling costs of 32% by 2050 ($72 million).
    - Savings of 10% - 12% on heating costs are possible by 2050 due to reduced heating demand in winter months.
    - Buildings will experience a slight increase in damage ($1.6 million by 2030 and $3.2 million by 2050 cumulative for all buildings) from increased precipitation according to 40% of the model projections.

- **Total Impact** - The total cumulative impact of projected climate change on asset maintenance could reach $464 million by 2050 according to the average RCP 8.5 projection. A stabilized scenario of 4.5 indicates this number could reach $376 million by 2050. Please note: The RCP 4.5 is considered a stabilized climate, where some mitigation is put in place, but not enough to reverse what is happening.
    - The total cumulative impact of climate on additional asset maintenance is projected by higher end models to exceed $750 million. Increased cooling demands could increase this number to over $800 million (Not including potential savings from reduced heating).
    - Increases in cooling demands may require buildings that currently do not have appropriate cooling infrastructure to install or expand cooling systems which would increase the total impact above the projected costs.

Study Methodology

The climate impact results reported in this study were generated in conjunction with Resilient Analytics, Inc utilizing an engineering-based approach to determining damage and costs resulting from changes in infrastructure operating conditions. The study focused on the infrastructure inventory provided by Boulder County through GIS maps of buildings, roads, and bridges throughout Boulder County. The final inventory included over 1,500 miles of roads, over 6,000 buildings, and 84 bridges covering the breadth of Boulder County.

For each infrastructure type, a comparison was completed between the historic operating environment and the range of projected climate futures from 42 climate scenarios through 2050. The annual change in projected temperature, precipitation, and flooding was examined in terms of the potential impact these changes may have on the individual infrastructure elements. Where damage was projected to occur above historic maintenance levels, the cost of repairing that damage was calculated to create a vulnerability for each infrastructure element on an annual basis. Energy demand changes were similarly calculated based on changes to heating and cooling demands for each building on an annual basis. The individual damage and energy demand costs were combined into infrastructure categories to obtain an overall cost impact for roads, buildings, and roads. The result of this analysis was a set of 42 possible cost impact scenarios for each infrastructure type on an annual basis.

The final results presented above are a summary of the results generated from the overall study for the individual infrastructure categories. In particular, the median and 95th percentile results from the 42 generated scenarios present a midpoint and higher end projection of vulnerabilities. Similarly, the results from 2030 and 2050 provide a snapshot of near-term and long-term impacts for planning purposes. This range of projections reflect the differences in the climate scenario projections and provide a starting point for discussions on the level of risk associated with projected climate change.

Adaptation Considerations

The determination of vulnerability in Boulder County to climate change from an infrastructure repair perspective is only a small part of the overall impact that infrastructure damages can have to the economy. Social and business impacts must be considered in addition to the direct impacts. Mitigating these impacts requires a consideration of how Boulder County may implement proactive adaptation strategies to increase the resiliency of its infrastructure to the projected climate changes. Initial indications of adaptation benefits include:

- Proactive investments in changes to road design can reduce the cumulative impact of temperature through 2050 from a median value of $160 million to less than $100 million.
- Focusing building energy mitigation on hospitals, office buildings, and large hotels will have the greatest potential benefit in terms of reducing increased energy demand.
- Initiating early bridge and culvert modifications will significantly reduce potential vulnerability to increased flooding events projected by 2030.