Evaluating Transportation Sustainability in the U.S.A. by Developing an Innovative Approach for Comparing Counties in the U.S.A.

2021 CTECH REU Intern: Micah Chen

Intern Affiliation: Engineering, Cornell University

CTECH REU Principal Investigator: H. Oliver Gao, Civil and Environmental Engineering, Cornell University
CTECH REU Mentor: Razieh Nadafianshahamabadi, Civil and Environmental Engineering, Cornell University
Primary Source of Research Funding: Center for Transportation, Environment, and Community Health (CTECH)
Contact: mc2284@cornell.edu, hg55@cornell.edu, rn366@cornell.edu

Abstract:

As the repercussions of climate change become more severe, efforts to study the impacts and human causes of climate change increase. In particular, the link between fossil fuel use and climate change is apparent. Since the transportation sector is a large consumer of fossil fuels, the sector is exploring ways to reduce its negative environmental impact. In addition to emissions, other aspects of the transportation sector are unsustainable for both the environment and human health. Thus, it is important to understand the current state of transportation sustainability to aid next steps to increase sustainability. This study seeks to rank counties in the U.S.A. based on how sustainable their transportation systems are. Counties are evaluated based on their achievements towards sustainable transportation in terms of clean transportation/transit, environmental impacts, and human health. County-level data for various indicators including emissions, vehicle-miles traveled, and car mode share are collected. Then, the Eigenvector method is used to evaluate and rate counties across the U.S.A. In addition to rating and ranking the counties, several socioeconomic variables of interest were studied to see if there are any patterns between these variables and transportation sustainability in the county. This ranking system helps policymakers understand the current state of transportation sustainability in their jurisdiction compared to their peers and make policy decisions.

Literature Review:

When choosing a rating/ranking method, several desired characteristics were sought after:

1. Accessibility and ease of understanding: the method must be easy to understand and implement.
2. Final rating should be reflective of some set of standards.
3. Final rating should fall within some range so that a user can infer sustainability directly from a rating.

Rating/ranking systems that were found include systems that use fuzzy analysis, tiered averaging, additive methods, and percentile systems. When reviewing existing literature, indicators used were also noted. The three broad areas of indicators used were transportation, environment, and human health. The full list of indicators used can be found via Appendix [A].

Methodology:

The Eigenvector method uses the dominant eigenvector of a certain distance matrix as calculated from the data for all sustainability indicators [1]. For each indicator, its data is "distancized," where positive "distances" between data points are stored in a square distance matrix. Each matrix is then normalized, where each entry is divided by the sum of all entries in the matrix. Then the distance matrices are combined by an entry-wise weighted average. The dominant eigenvector of the final averaged distance matrix and entries are the ratings for their corresponding counties.

Top 25 Counties	Bottom 25 Counties
1. New York County, NY	3118. Platte County, WY
2. Kings County, NY	3119. Taliaferro County, GA
3. Bronx County, NY	3120. Torrance County, NM
4. Queens County, NY	3121. Turner County, GA
5. Hudson County, NJ	3122. Chase County, KS
6. San Francisco County, CA	3123. Carbon County, WY
7. District of Columbia, DC	3124. Cleburne County, AL
8. Suffolk County, MA	3125. Sherman County, OR
9. Richmond County, NY	3126. Warren County, GA
10. Philadelphia County, PA	3127. Quay County, NM
11. Kusilvak Census Area, AK	3128. Kimball County, NE
12. Essex County, NJ	3129. Gilliam County, OR
13. Westchester County, NY	3130. Terrell County, TX
14. North Slope Borough, AK	3131. Irion County, TX
15. Bethel Census Area, AK	3132. Holt County, MO
16. Kalawao County, HI	3133. McMullen County, TX
17. Cook County, IL	3134. Cimarron County, OK
18. Northwest Arctic Borough, AK	3135. Hudspeth County, TX
19. Aleutians East Borough, AK	3136. Deuel County, NE
20. Nassau County, NY	3137. Trego County, KS
21. Alameda County, CA	3138. Clark County, ID
22. Nome Census Area, AK	3139. Sterling County, TX
23. Prince George's County, MD	3140. Guadalupe County, NM
24. Bergen County, NJ	3141. Kenedy County, TX
25. Aleutians West Census Area, AK	3142. Loving County, TX

Table 1: Top and bottom twenty-five counties ranked based on Sustainability Score.

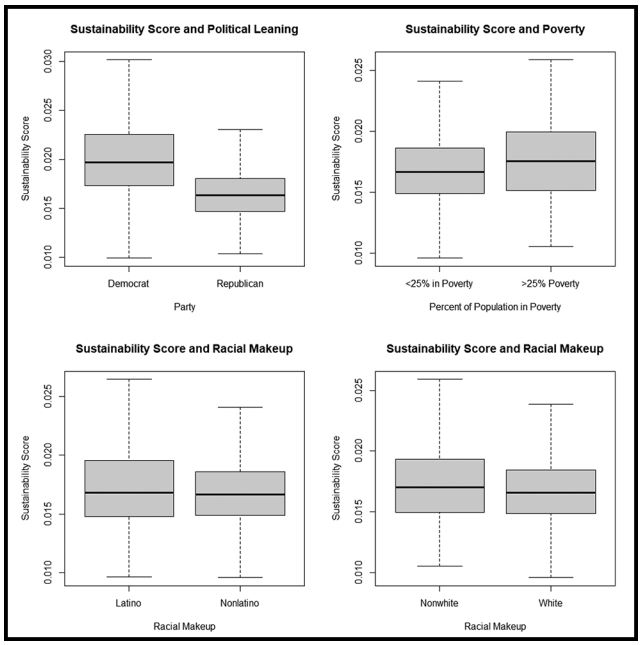

Figure 2: Boxplots comparing Sustainability Scores for different socioeconomic variables.

Results and Discussion:

Table 1 shows the top and bottom 25 counties ranked by their Sustainability Score. Full ranking can be found via Appendix [B]. Using these counties as representative samples of counties that tend to rank higher or lower, counties near cities on the coast tend to rank higher than those in the rural middle of the country. The high-ranking counties are areas where robust public transportation systems exist. The exception for those in the top 25 are counties that are rural and isolated, where travel from that county to another cannot be done by road.

Regarding the bottom 25, all are located in the center of the country or are rural connected counties. These are counties where the population is not substantial enough to have robust public transport. Figure 1 visualizes the Sustainability Score across the U.S.A.

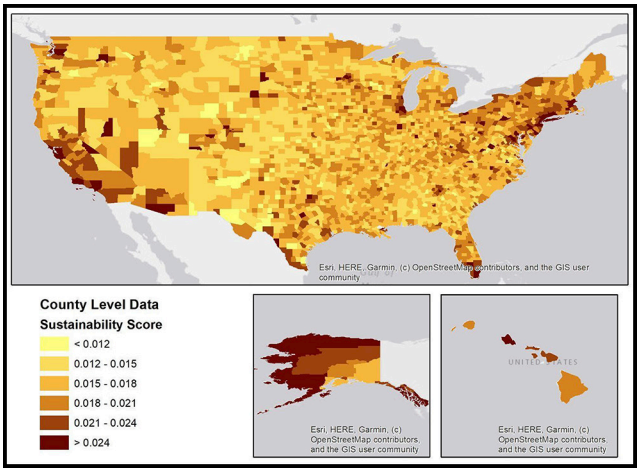

Figure 1: Sustainability Scores for all counties in the U.S.A.

Counties were categorized using socioeconomic variables, and their Sustainability Scores were compared. Summary boxplots are in Figure 2. Democratic counties tend to rate higher than Republican counties, categorized based on the 2020 presidential election, which makes sense considering the party agendas. The median score for Democratic counties is 0.019 while that of Republican counties is 0.016.

In addition, it seems that counties with a higher proportion of its population living under the poverty line do slightly better than those with a lower proportion (using 25% as the cutoff between high and low). The median Sustainability Score is 0.017 for counties with more than 25% of its population living under the poverty line, compared to 0.016 for counties with less than 25%. Wealthier areas tend to be able to afford more transportation projects, which may suggest that wealthier counties can be more sustainable. However, these wealthier areas with higher household incomes also tend to have more vehicles and households are able to afford to travel more by private car. In contrast, people who live in low household income areas may not be able to afford a car, and therefore depend on public transportation. This leads to a realization that higher income counties are not necessarily more sustainable in transportation than lower income counties.

The Sustainability Score is not significantly different between counties of different race/ethnicity categorization. Non-White counties have a median of 0.017 while White counties have a median of 0.016. Latino counties have a median of 0.017 while non-Latino counties have a median of 0.016.

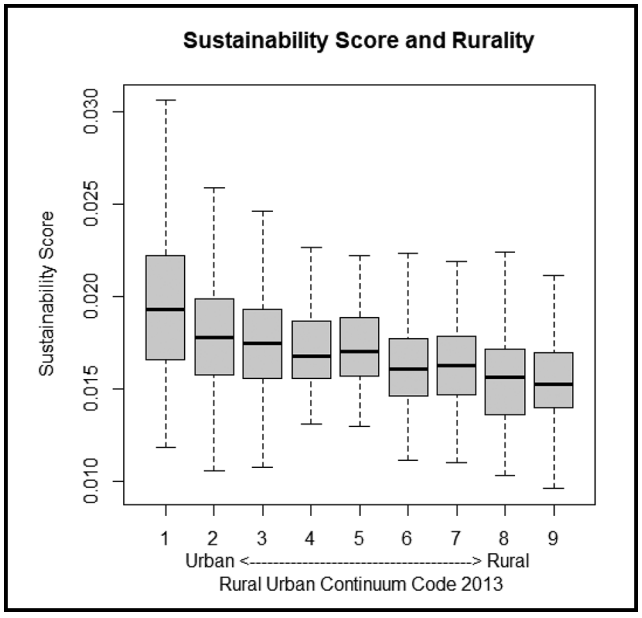

Figure 3: Sustainability Score versus Rurality.

Lastly, there is a correlation between rurality and transportation sustainability since cities tend to have the most robust transportation systems. This trend can be visualized using the Rural-Urban Continuum Code developed by the U.S. Department of Agriculture Economic Research Service in Figure 3.

Conclusions:

Counties in metropolitan areas tend to be sustainable in transportation. In addition, there are trends between transportation sustainability and socioeconomic variables. They may warrant further study, perhaps at a higher resolution, such as a neighborhood level to see if there are improvements that can be made to better serve people in need.

While counties are used, the same rating/ranking method can be used for other types of political jurisdictions such as states and cities. Corporations with large transportation operations can also use this to understand how to be more sustainable.

Other areas of improvement are to refine the weighting system, refine the list of indicators, and quantify equity and how sustainability differs among populations of different socioeconomic statuses. In terms of policy, more resources and attention may have to be given to rural counties, where increasing transportation sustainability is difficult due to the nature of their land use. While metropolitan areas are ahead in sustainability, rural counties should make improvements suitable for them to avoid a growing rift between urban and rural America.

References:

[1] Amy N. Langville and Carl D. Meyer. (2012). Who's #1? The Science of Rating and Ranking. Princeton University Press.

Appendix:

[A] Indicators, https://docs.google.com/spreadsheets/d/1DAfDkiqGVapGx6J0KQOVbAqbv0gomQBNk4E1ReRbi9g/edit#gid=0

[B] Ranking, https://docs.google.com/spreadsheets/d/1LEAkyA94YsukMp1zl7iASWU5hej2COxy/edit#gid=936508060