Introduction

Bike-sharing systems play an important role in sustainable urban transportation. Accurately understanding and predicting bike-sharing demands can help cities allocate bikes efficiently and encourage low-carbon mobility. Biking in Vancouver has risen exponentially in the past decade, and bike rentals are at the forefront of the rise. This is due to the convenience of Mobi Bike stations, where you can pick up a bike and drop it off at different locations. The changes in roadways to include bike lanes also contribute to the rise in bike trips in Vancouver. The number of Mobi bike station around Vancouver and the cost being quite low makes it easily accessible to everyone. This study examines how weather conditions like precipitation and temperature influence bike-sharing usage.

Research Question

The research question that this study will answer is which temporal and weather-related factors most strongly influence bike-sharing demand, and how accurately demand can be predicted using these variables. This analysis will examine how ridership varies across seasons, days of the week, and weather conditions such as temperature and precipitation. The analysis will be looking at the spatial and non-spatial sides of the problem.

Methods

The data used for the analysis was collected from the Mobi Bike Sharing website. The website is updated to provide monthly rider data from 2017 to 2026. The study used 2025 data because it was the most recent complete year. Temperature and precipitation data were gathered from the Government of Canada, where four stations closest to the Mobi Bike stations were used: Vancouver Sea Island CCG, Vancouver Intl Airport, Vancouver Harbour, and Vancouver

Harbour CS. To generate a city-wide weather signal, climate observations were averaged across all four stations for each date. For data processing, both bike rental and weather datasets were first cleaned by removing outliers and incomplete records to ensure data quality. The datasets were then merged in R by matching the date fields aligning daily rental counts with their corresponding temperature and precipitation values for each day. After merging, summary statistics were calculated such as the date with the highest number of bike rentals (July 1st) and the most common rental hour (5 pm). Combined data were then visualized in R for analysis shown in Table 1. Station location data was obtained from the General Bikeshare Feed Specification database and joined to the rental dataset using station IDs which allowed for spatial aggregation and mapping. However, the dataset only contains location data for the Mobi stations near downtown. To assess the overall relationship between weather and bike-sharing usage, a baseline linear regression model (Figure 1) was estimated relating total daily bike rentals to mean daily temperature and total daily precipitation. This model quantified the average marginal effect of weather on bike-share demand at the city scale.

	Date	bikes_rented	mean_temp	min_temp	max_temp	total_precip
1	2025-01-01	983	4.100000	2.100000	6.075000	0.00000000
2	2025-01-02	1177	3.600000	2.175000	5.025000	4.23333333
3	2025-01-03	1158	4.200000	2.475000	5.925000	5.40000000
4	2025-01-04	1102	6.350000	5.175000	7.550000	7.63333333
5	2025-01-05	1194	5.875000	3.400000	8.350000	1.70000000

Table 1. Combined data from Bike Rental Data and Precipitation and Temperature data. (365 rows)

```
Call:
lm(formula = bikes_rented ~ mean_temp + total_precip, data = bike_weather)

Residuals:
    Min      1Q  Median      3Q     Max 
-2356.0  -507.4    -0.5   464.8  3288.3 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept)   967.980     91.451   10.59   <2e-16 ***
mean_temp     224.277      6.699   33.48   <2e-16 ***
total_precip  -80.152      6.874  -11.66   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 756.2 on 362 degrees of freedom
Multiple R-squared:  0.7939,	Adjusted R-squared:  0.7928 
F-statistic: 697.3 on 2 and 362 DF,  p-value: < 2.2e-16
```

Figure 1. Linear Regression Model

To examine how weather effects vary across space, daily bike rentals were aggregated at the station-day level. Separate regression models were then estimated for each station with daily bike rentals as the dependent variable and mean temperature and total precipitation as independent variables. Stations with insufficient observations were excluded because smaller stations would crowd the map and not provide any good results. From each station-level model, estimated coefficients for temperature and precipitation were extracted and interpreted as measures of station-specific weather sensitivity. These coefficients represent how strongly bike-sharing demand at each station responds to changes in temperature or precipitation. Station-level weather sensitivity estimates were then converted into spatial point features using latitude and longitude coordinates, as shown in Figure 4. The redder a station is, the greater the change in bike rentals with the effects of precipitation or temperature. Vancouver’s boundary shapefile was used as a basemap to provide geographic context, shown in Figure 5.

Results

Bike-sharing demand exhibited a clear day-to-day variation. Higher ridership generally occurred on days with warmer temperatures and little or no precipitation, while cooler and wetter days were associated with reduced usage. These patterns indicate a strong sensitivity of bike-share demand to short-term weather conditions. Shown in Figure 2 is how temperature relates to the number of bikes rented. The linear regression line is showing a positive slope, which means that higher temperature correlates to higher ridership.

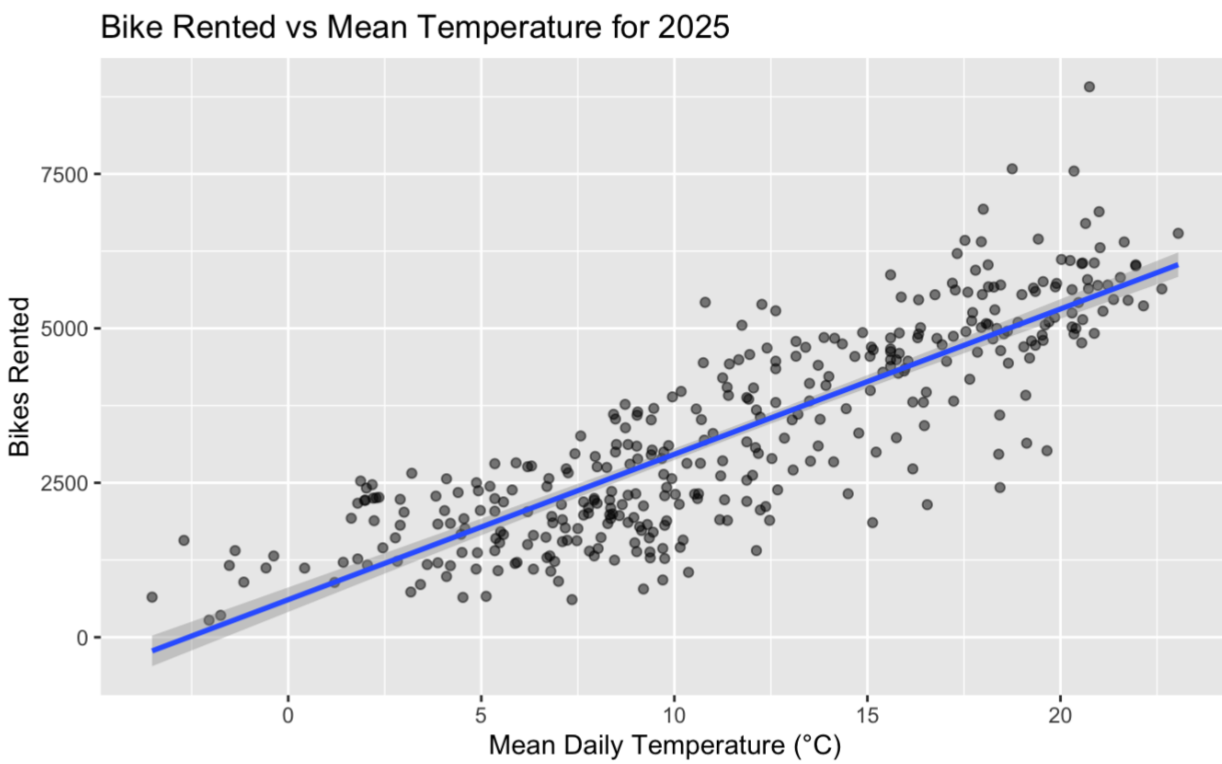

Figure 2. Bikes Rented vs Temperature

Figure 3 is the relationship between bikes rented and precipitation. The linear regression line is negative, which means that higher precipitation correlates with fewer riders. Together, these results demonstrate that weather conditions play an important role in shaping overall bike-sharing demand.

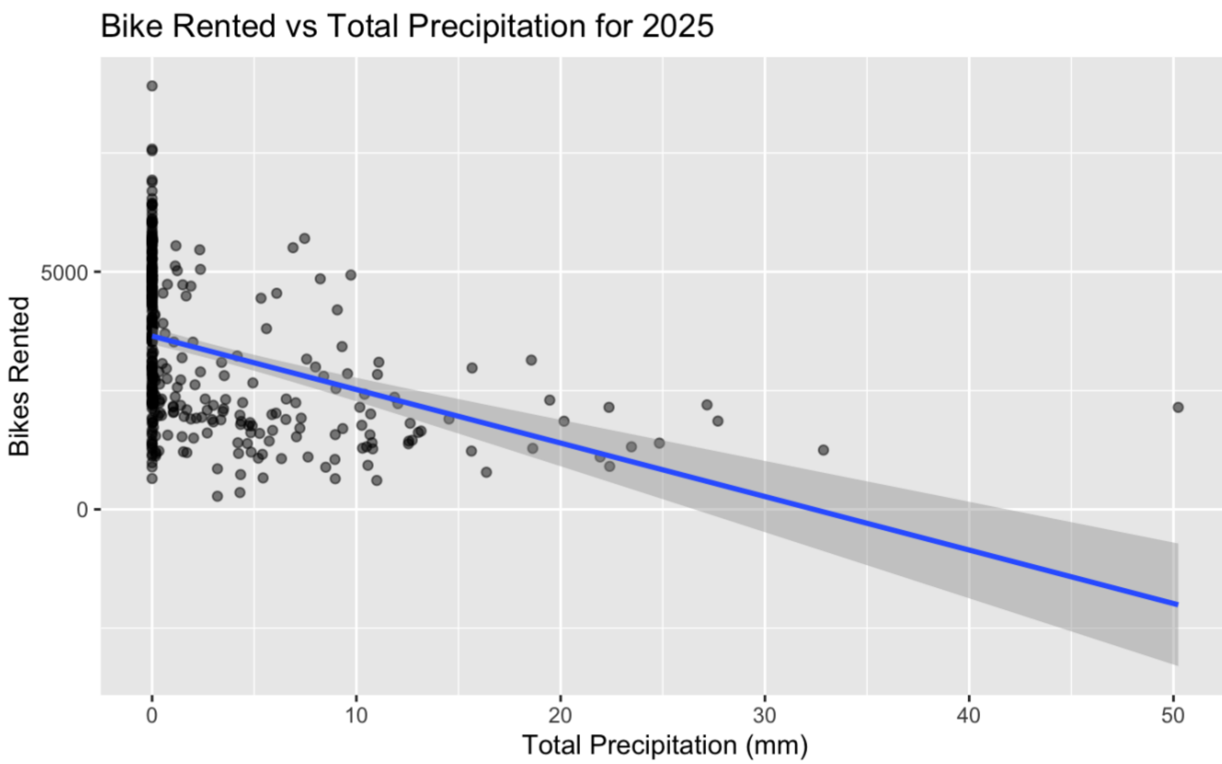

Figure 3. Bike rented vs Precipitation

Spatial analysis indicates that precipitation and temperature had a limited effect on bike-sharing across most stations in the study area. Apart from a few stations in Stanley Park, which displayed noticeable sensitivity to weather variables, the majority of downtown stations demonstrated minimal variability in ridership in response to changes in temperature or precipitation. This uniformity could be attributed to the spatial constraint of the dataset, as it only includes stations within the downtown core and excludes those in surrounding neighborhoods where weather sensitivity might differ. The stations outlined in black in Figure 5 represent those with the most significant increase in bike rentals per degree Celsius, indicating localized weather responsiveness possibly due to their proximity to recreational routes or tourist destinations. These findings suggest that spatial heterogeneity in weather effects may exist beyond the downtown area and that broader spatial coverage would be necessary to fully capture how weather conditions influence bike-sharing demand across the city.

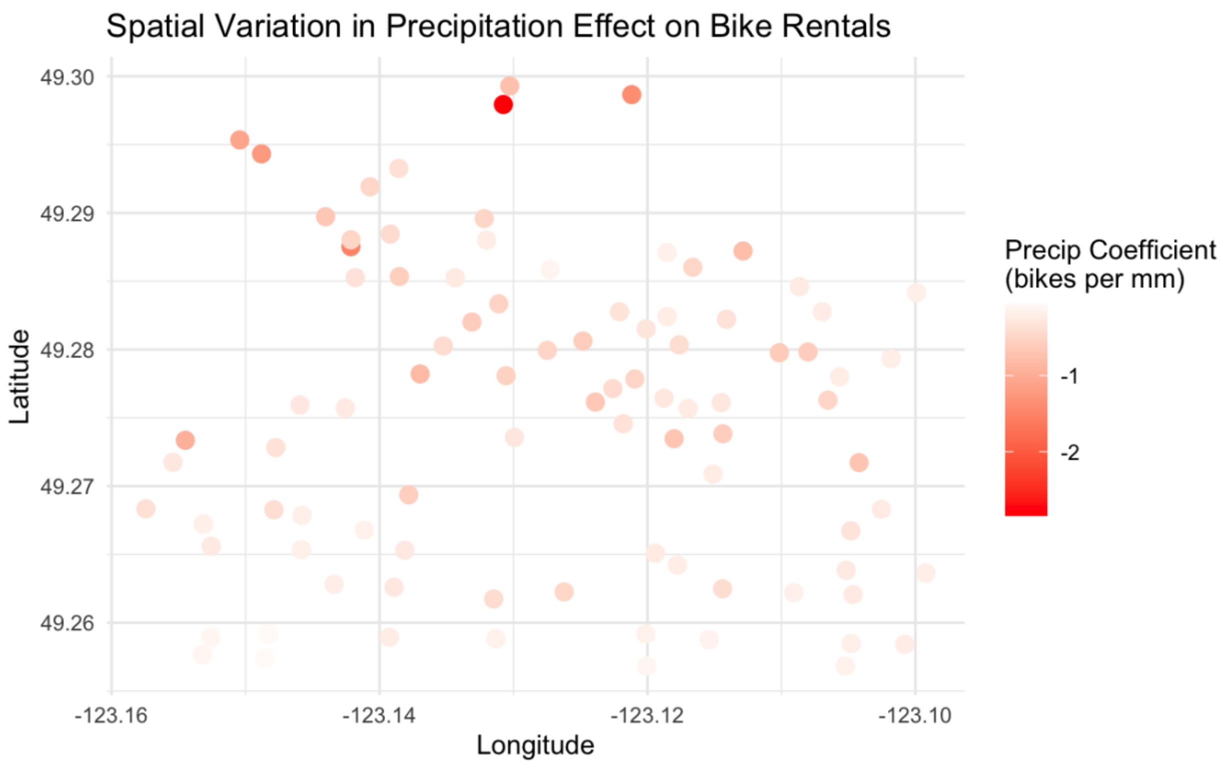

Figure 4. Spatial Variation of Precipitation on Bike-Sharing

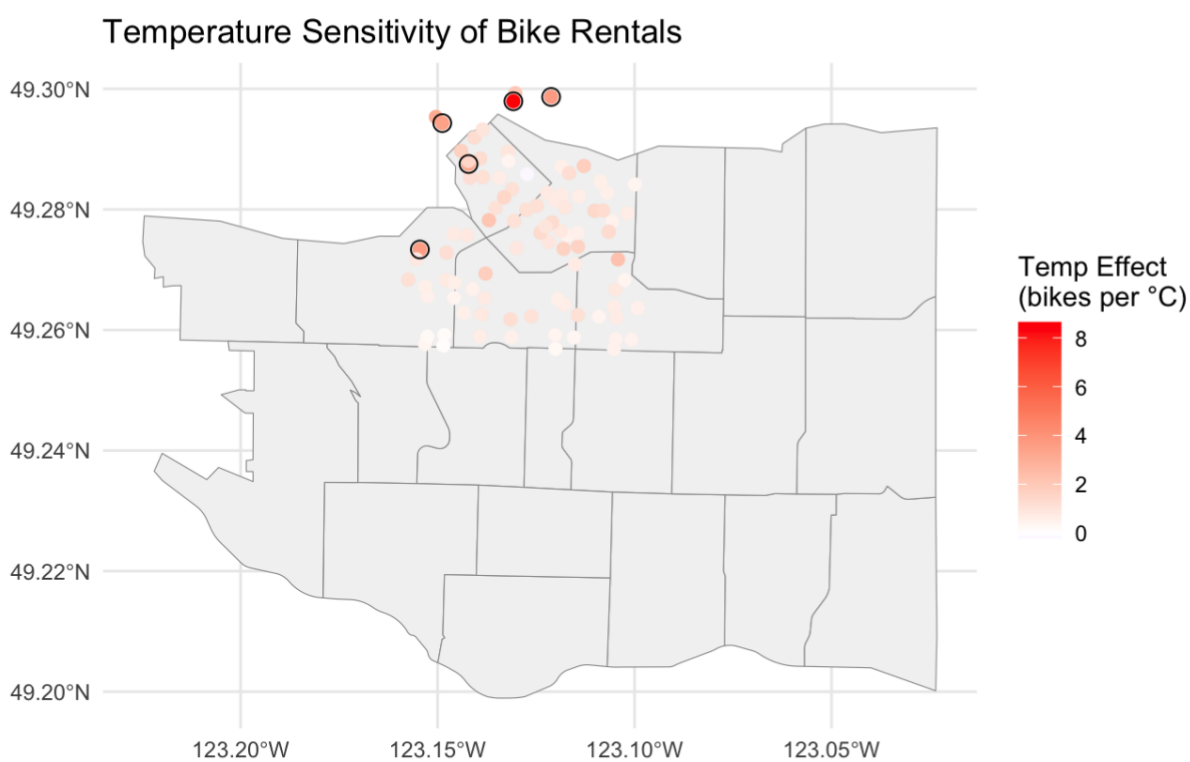

Figure 5. Spatial Variation of Temperature on Bike-Sharing

Conclusion and Future Research

This study examined how weather conditions influence bike-sharing demand and how these effects vary across space. Results show that temperature and precipitation are important determinants of bike-share usage, with warmer temperatures associated with increased demand and precipitation linked to reduced ridership. There wasn't a definite spatial aspect, as the results showed little to no change amongst all the downtown stations. To answer my research question, the most impactful weather-related factor is temperature. The linear regression line gives a very clear relationship between temperature and bike ridership. Bike-sharing demand could potentially be predicted using the study, but there needs to be further research is needed. Incorporating built environment variables such as land use, population density, and proximity to bike infrastructure could explain more about the spatial impacts that weather has on bike-sharing. Spatial clustering analyses, such as the K-function, could explain how weather redistributes bike-share activity across urban space.

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