Results

Our aim was to analyze how FEMA allocates funding aid to states, based on the type of natural disaster that occurs. Though there are many other factors that may come into play regarding funding allocation, natural disaster type clearly plays a significant role and it's important to dissect these allocations. Figure 1 represents the correlation between disaster type and allocated funding. For example, in this linear regression model, coefficients represent the relationship between natural disasters (under "Feature") and the funding amount (represented by the "Coefficient") as follows: If the coefficient for Earthquake is is 6.78 x 106, it means that for each additional earthquake in a state during a given year (all else being equal), the model predicts an additional $6,580,000 in disaster relief funding. A negative coefficient is associated with a decrease in predicted disaster relief funding (this could occur due to prioritization or other complex funding dynamics). It's important to note that these coefficients do not imply causation, only statistical association. It's also important to note that if disaster types are highly correlated (e.g., hurricanes often cause floods), the coefficients might not reliably isolate the effect of each variable.

To further analyze how state funding is allocated and understand how natural disasters play a role in funding, we conducted a k-cluster analysis. Figure 5 demonstrates 3 clusters pulled from the 50 states based on disaster type, frequencies, and allocated funding. As seen in Cluster 0, there are a high average number of disasters, and this represents areas with frequently occurring disasters. Cluster 1 has fewer disasters than Cluster 0, and moderate funding levels which probably represents regions with moderate disaster frequency. Cluster 3 has high values for specific disasters (such as Freezing), which suggests a focus on areas prone to specific but impactful disasters.

This data provides crucial insights into patterns of disaster frequency, severity, and associated funding, allowing for a more strategic approach to resource allocation (reference Figure 6 for a visualization of the disaster clustering). By clustering disasters into groups based on their characteristics, decision-makers can identify regions or disaster types that require the most attention. For instance, Cluster 0, with the highest total number of disasters and significant funding allocation, likely represents areas with frequent and severe events, such as floods or fires, necessitating sustained investment. Conversely, Cluster 1, with fewer disasters and lower funding, may highlight regions where resources can be allocated more efficiently. The funding discrepancies across clusters suggest opportunities to reassess how resources are distributed, ensuring that high-impact but less frequent disasters (e.g., tsunamis in Cluster 2) are not underfunded. Overall, this analysis enables targeted disaster preparedness and relief strategies, ensuring funding aligns with the unique needs of each cluster to maximize resilience and minimize long-term recovery costs.

Appendix

```
Mean Squared Error: 75236351229713.56
R-squared: -1.6420160847190273
              Feature   Coefficient
13              Other  7.458012e+06
5          Earthquake  6.578130e+06
19   Toxic Substances  3.527077e+06
3     Dam/Levee Break  2.175235e+06
6                Fire  2.714233e+05
18            Tornado  6.178786e+04
8               Flood  4.682506e+04
14   Severe Ice Storm  3.367254e+04
11          Hurricane  2.696142e+04
0          Biological  8.313693e+03
15       Severe Storm  1.473953e+03
1            Chemical  2.997695e-09
10        Human Cause  9.313226e-10
9            Freezing  1.164153e-10
22            Typhoon  0.000000e+00
17          Terrorist  0.000000e+00
23  Volcanic Eruption  0.000000e+00
20     Tropical Storm  0.000000e+00
21            Tsunami  0.000000e+00
7      Fishing Losses -4.656613e-10
4             Drought -2.153683e-09
16          Snowstorm -4.004818e+04
24       Winter Storm -1.177787e+05
2       Coastal Storm -1.715085e+05
12      Mud/Landslide -3.614730e+05
```

Figure 1. A linear regression demonstrating the correlation between natural disaster occurrence within a state and the expected change in funding allocated to that state as a result.

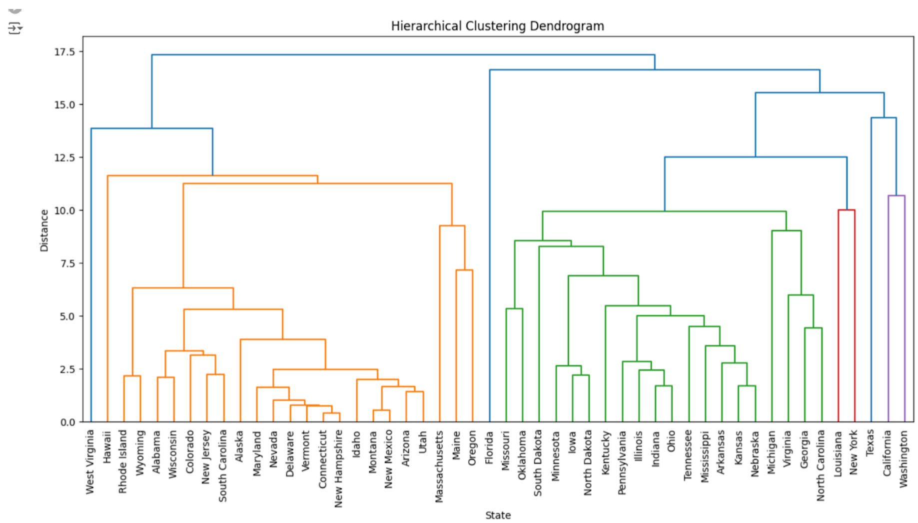

Figure 2. Hierarchical clustering of states based on natural disaster type, occurrence, and FEMA Funding allocation.

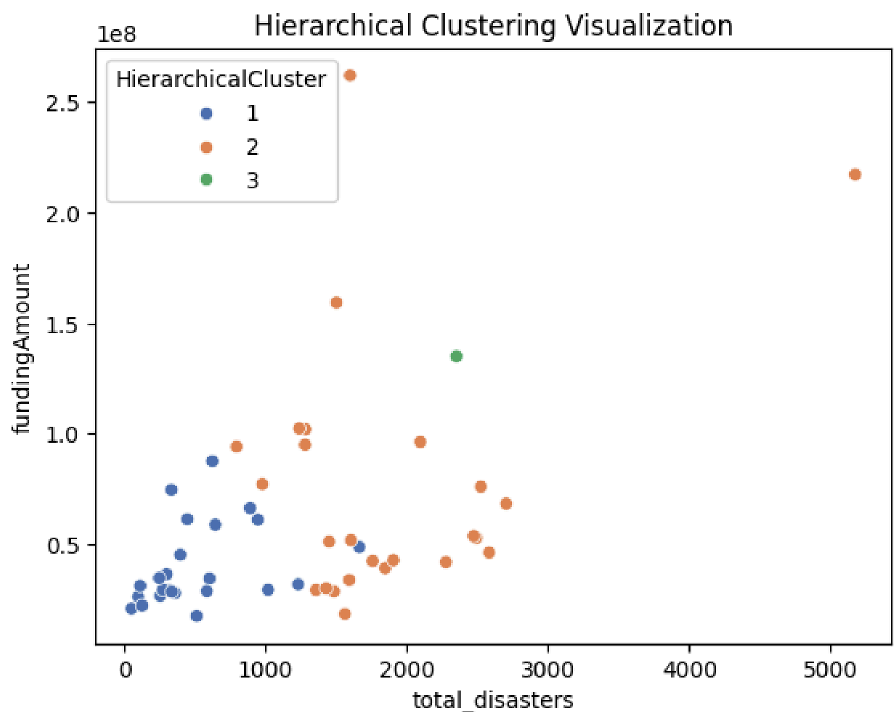

Figure 3. Correlations within the cluster between funding amount and total number of disasters.

```
            Biological  Chemical  Coastal Storm  Dam/Levee Break  Drought  \
state
Alabama            139         0              0                0       67
Alaska             121         0              2                0        0
Arizona             73         0              0                0        8
Arkansas           152         0              0                0       32
California         116         0             43                5       47

            Earthquake  Fire  Fishing Losses  Flood  Freezing  ...  Terrorist  \
state                                                          ...
Alabama              0    11               0    104         0  ...          0
Alaska              13    30               0     50        14  ...          0
Arizona              0    88               0     82         1  ...          0
Arkansas             0     0               0    271         0  ...          0
California          32   460               4    448        57  ...          0

            Tornado  Toxic Substances  Tropical Storm  Tsunami  Typhoon  \
state
Alabama          62                 0               0        0        0
Alaska            0                 0               0        0        0
Arizona           0                 0               0        0        0
Arkansas        113                 0               0        0        0
California        0                 0               0        3        0

            Volcanic Eruption  Winter Storm  total_disasters  fundingAmount
state
Alabama                     0             0             1665   4.887564e+07
Alaska                      0             0              318   2.934264e+07
Arizona                     0             0              335   7.473417e+07
Arkansas                    0             0             1593   3.395693e+07
California                  0             0             1599   2.618396e+08

[5 rows x 27 columns]
```

Figure 4. Example of State mapping of natural disasters, total disaster occurrence, and funding allocated to each state

```
         Biological  Chemical  Coastal Storm  Dam/Levee Break    Drought  \
Cluster
0        569.000000  0.000000      25.500000         0.000000  74.500000
1        135.829787  0.191489      11.914894         0.276596  22.893617
2        150.000000  0.000000      25.000000         0.000000   0.000000

         Earthquake        Fire  Fishing Losses       Flood    Freezing  ...  \
Cluster                                                                  ...
0          0.000000  613.500000        8.000000  299.500000   13.500000  ...
1          2.319149   44.744681        0.553191  205.085106    2.702128  ...
2          0.000000  277.000000        0.000000   73.000000  147.000000  ...

           Tornado  Toxic Substances  Tropical Storm   Tsunami   Typhoon  \
Cluster
0        25.000000          0.000000             0.0  0.000000  0.000000
1        31.510638          0.191489             0.0  0.191489  0.042553
2        38.000000          0.000000            54.0  0.000000  0.000000

         Volcanic Eruption  Winter Storm  total_disasters  fundingAmount  \
Cluster
0                 0.000000      0.000000      3096.000000   1.233323e+08
1                 1.085106      0.914894      1132.234043   5.596522e+07
2                 0.000000      0.000000      2352.000000   1.350564e+08

         HierarchicalCluster
Cluster
0                   1.500000
1                   1.510638
2                   3.000000

[3 rows x 28 columns]
```

Figure 5. Mapping of unique natural disasters, total disaster occurrence, and allocated funding per 3 clusters of the 50 states (reference Figure 2)

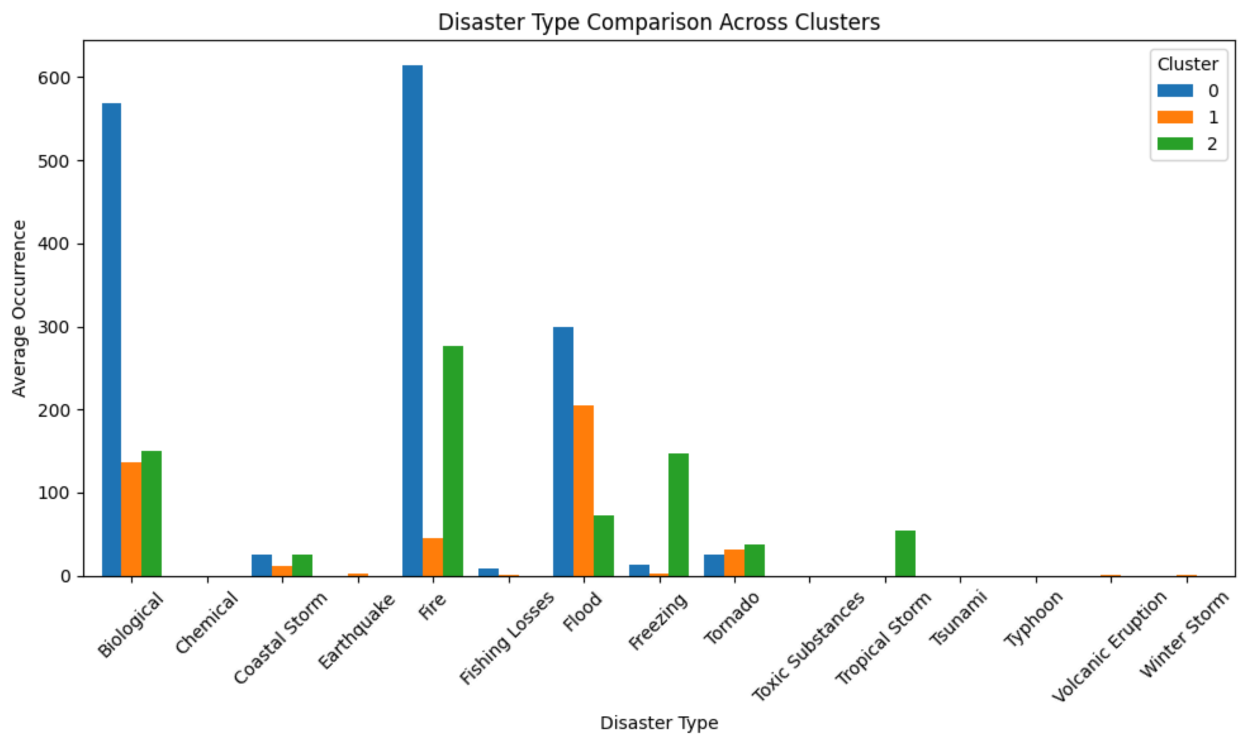

Figure 6. Bar chart visualization of Figure 5

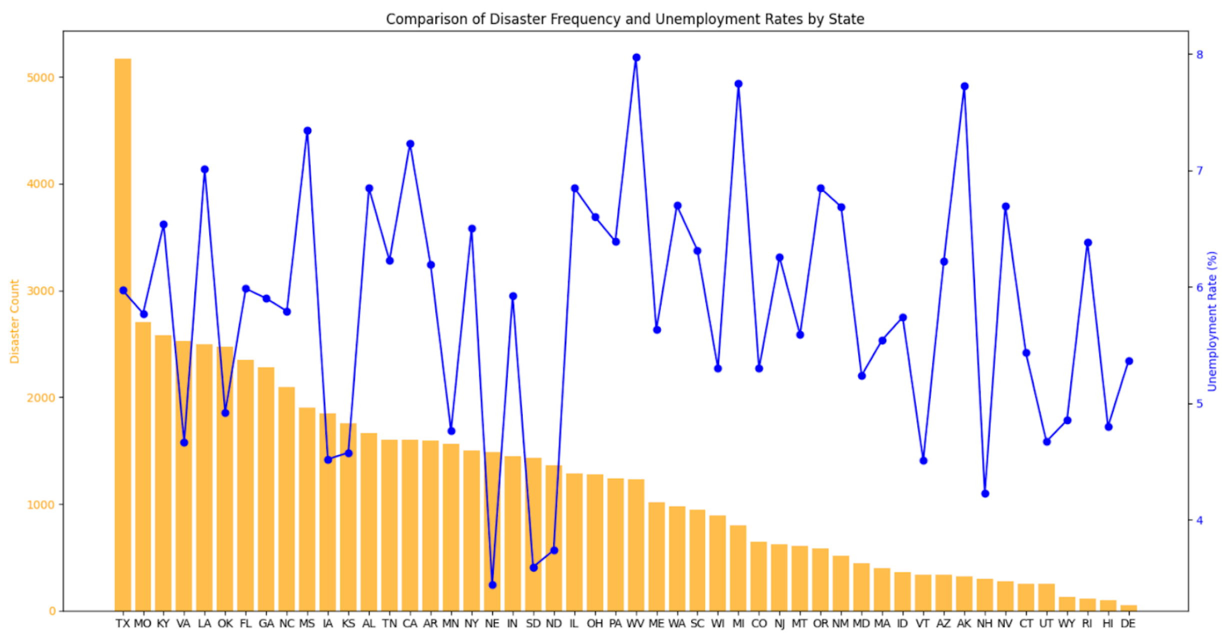

Figure 7. Comparison of disaster frequency and unemployment per state