Insert title of project here

https://github.com/maggieoshea/OSheaPearceSanchez_ENV872_EDA_FinalProject.git

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#Notes to self : * Don't forget to add figure captions to exploratory analysis

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0.1 Rationale and Research Questions

Extreme weather events and natural disasters seem to be on the rise worldwide, and climate adaptation is vital to communities at risk. In the U.S., flooding is the most common natural disaster with the cost of flooding in the United States in 2020 estimated at $32.1 billion (IDMC 2019, Lindsey 2022, Wing et al. 2022). These costs, both financial as well as social, are expected to only rise as there is a predicted 24% increase in flooding by 2050 (Wing et al. 2022). Already, regions in the United States are seeing drastic increases in flooding since the 1950s - a study by the United States Environmental Protection Agency on 33 sites around the United States found flooding to be at least five times more common in over half the areas studies, with a strong concentration in sites along the eastern seaboard (EPA 2022). Given the rapid increase in flooding around the United States as well as the severe impacts this hazard can have, adaptation is becoming increasingly important and resources that already exist for these efforts are likely to become more strained.

It will be increasingly important to understand the resources that are already available to communities, the accessibility of these resources, as well as how they are being used. This analysis seeks to uncover some of this through examining the trends in flood mitigation assistance provided by the Federal Emergency Management Agency. A time series analysis helped to identify possible trends in the number of grants received for flooding over time as well as the amount paid by FEMA to understand if trends in the use of these resources are similarly increasing as flooding has been. Furthermore, due to the drastic impacts of flooding that are only increasing, we were interested to examine if individuals are relying more heavily on ex-situ adaptation measures to move away from these hazards, or if communities are attempting to stay where they are despite the flooding and thus relying on in-situ adaptation measures. The research questions that guided this work were:

1. Are there trends in the number of properties that received grants to adapt to flooding in the United States over time?
2. Are there trends in the amount FEMA paid for hazard mitigation for flooding over time?
3. How do these trends differ for in-situ vs ex-situ adaptation?

The temporal scale of the research was defined by the FEMA Mitigated Properties dataset which included information on grants from 1985 until 2020 allowing the time series analysis to cover a 35 year time-frame. The grants included those received in all states in the United States. This analysis also included a brief spatial analysis focusing on one state in particular to spatially visualize the data as well as examine potential spatial trends in ex-situ vs. in-situ adaptation funding.

0.2 Dataset Information

1 Dataset Background and Retrieval:

We used data managed by the Federal Emergency Management Agency's National Emergency Management Information Systems, downloaded directly in a CSV format through FEMA's OpenFEMA resource. The dataset includes the record of properties that received grant assistance for hazard mitigation through any of the Hazard Mitigation Assistance grant programs, programs administered by FEMA that seek to reduce losses from disasters as well as protect life and property in the face of hazards (FEMA n.d.). This includes: the Hazard Mitigation Grant Program, the Flood Mitigation Assistance Grant Program, and the Pre-Disaster Mitigation Grant Program (ibid.). Entries prior to 2012 also include grants received through the Repetitive Flood Claims Grant program and Severe Repetitive Loss Grant Program which both were eliminated through the Biggert Water Flood Insurance Reform Act of 2012 (ibid.). Each entry includes data such as the total amount paid, the number of properties receiving support, the hazard that the grant is adapting against, the program year, and others.

For the spatial analysis, the county boundaries for North Carolina were downloaded from the OpenESRI platform which had the State of North Carolina's Emergency Management Agency's best current available data as of 2020. These boundaries were identified through sources including the North Carolina Geodetic Survey, the North Carolina Department of Transportation, the United States Geological Survey, as well as field surveys that have been recorded by the respective county (ArcGIS Hub 2020).

2 Data Wrangling

The mitigated properties dataset required three different types of wrangling for the analysis. First, we wrangled the data to result in a dataset with the total number of properties that received a grant for any type of flooding adaptation and the total amount paid for these per year. Second, we wrangled the data to have this same information, number of properties and total amount paid, for ex-situ adaptation, or buyouts, per year and did the same for in-situ adaptation. Finally, we wrangled the mitigated properties dataset in the same ways - finding number of properties and total amount paid for all flooding grants, ex-situ grants, and in-situ grants but instead of summarizing per year, we selected for only North Carolina grants and grouped the data by county for our spatial analysis.

MAKE A TABLE for type codes

In order to do so, we first examined and explored the dataset and found that some entries had a total amount paid that was negative. Because the OpenFEMA information page included a note that these were manually entered data and subject to human error, we made the assumption that this was due to human error and removed these negative values from our analysis. After doing so, we used this cleaned mitigated properties dataset to create

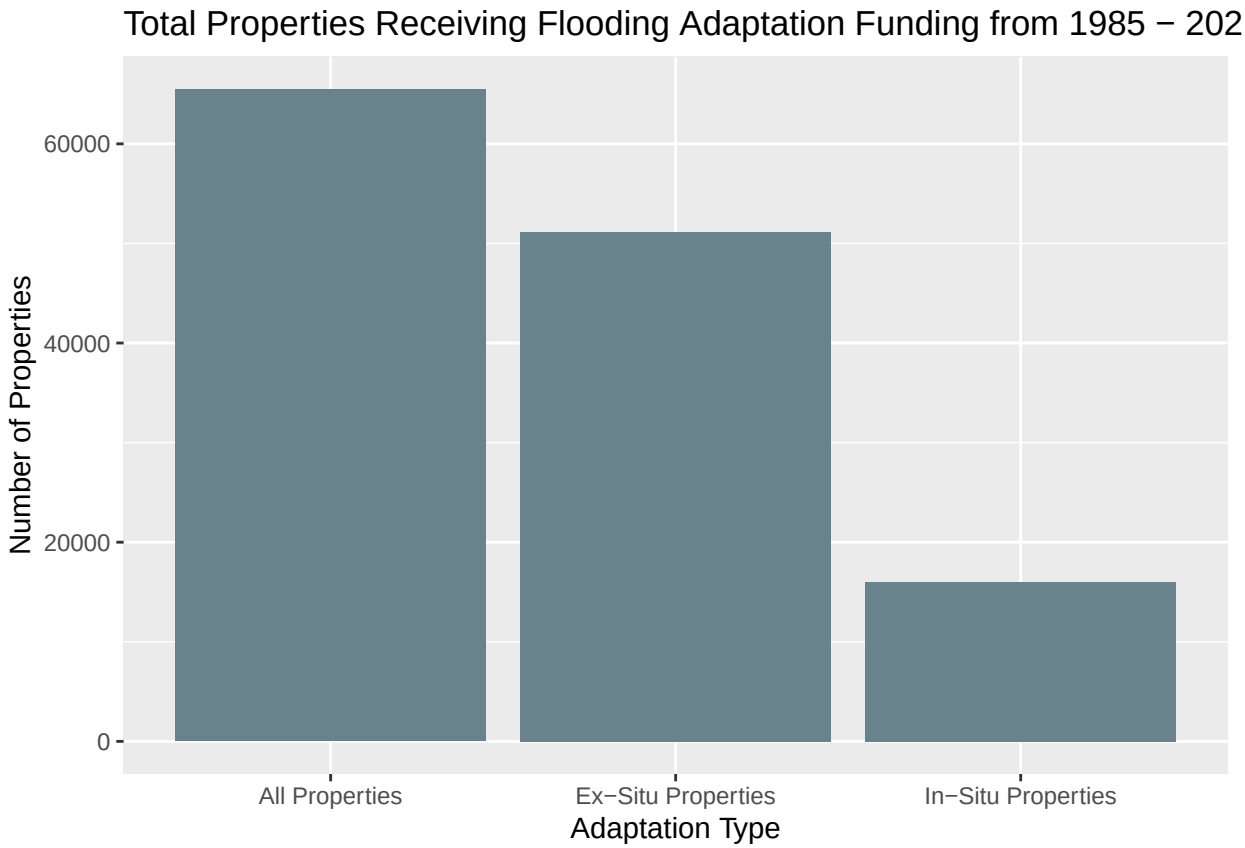
our three different types of wrangled datasets. This involved, first, examining the "type" codes to identify which type codes indicate that the grants were used for flooding. Table 1 shows the type codes that were used, grouped by ex-situ and in-situ codes. These type codes together were used to find all flooding grants regardless of adaptation type.

After selecting out the relevant flooding type codes, we grouped by year or county and summarized the datasets to find the sum of the number of properties and the total amount paid for each category we were examining in this analysis (amount paid for all flooding grants per year, amount paid for ex-situ grants per year, etc.).For the total amount paid categories specifically, using the "priceR" package, we adjusted each of the total amount paid values per year for all adaptation, ex-situ, and in-situ for inflation. Summary statistics for the respective wrangled datasets can be found in table 2.

2.1 Exploratory Analysis

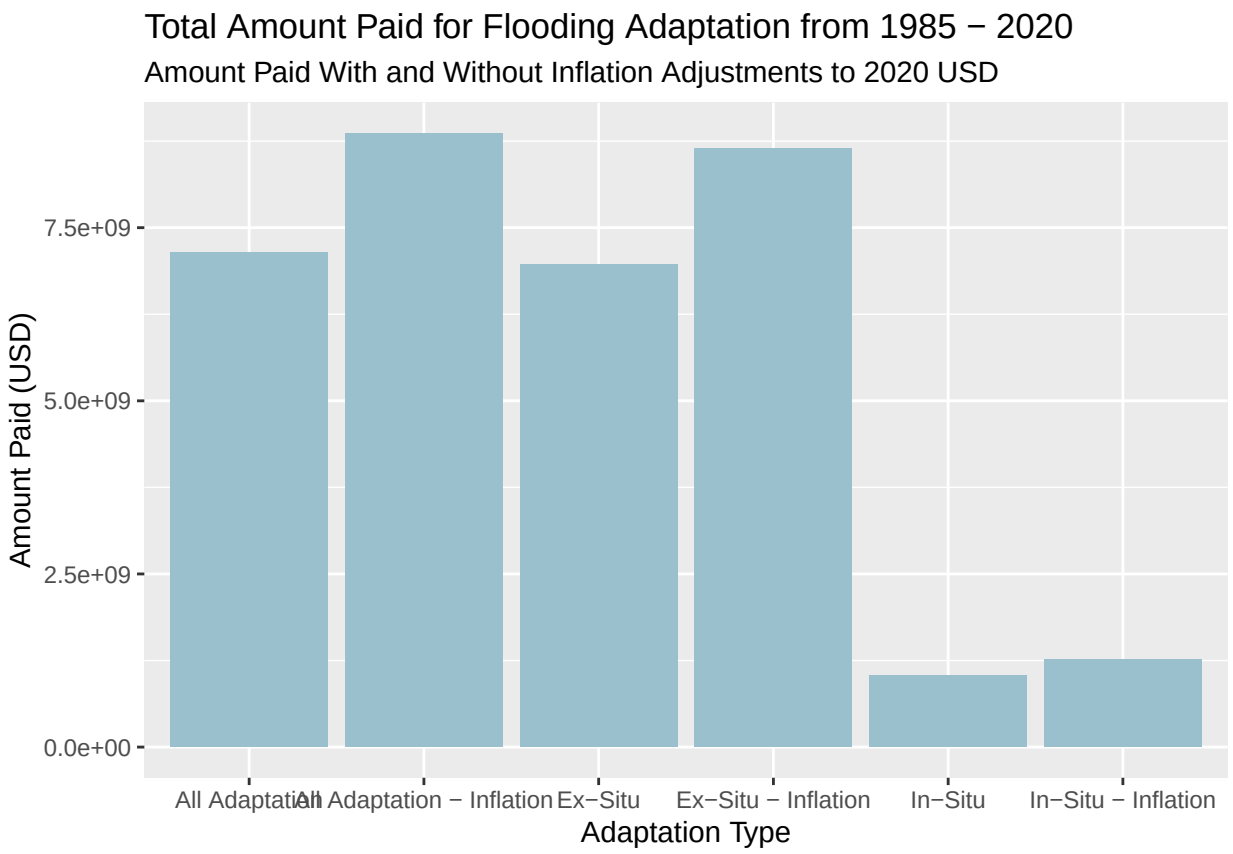
After wrangling the data, we explored the data both over time as well as totals for the number of properties and amount paid in our dataset, compared between all flooding and ex-situ vs. in-situ. Figure 1 shows the differences in the total number of properties between 1985 and 2020 that received adaptation flooding, comparing all of the properties with ex-situ and in-situ. The graph shows that more properties received ex-situ than in-situ grants by a considerable amount.

```
ggplot(data = totalprops_pivot, aes(x = Category, y = Total)) +
  geom_bar(stat = "identity", fill = "lightblue4")+
  labs(
    title = "Total Properties Receiving Flooding Adaptation Funding from 1985 - 2020",
    x = "Adaptation Type",
    y = "Number of Properties")
```



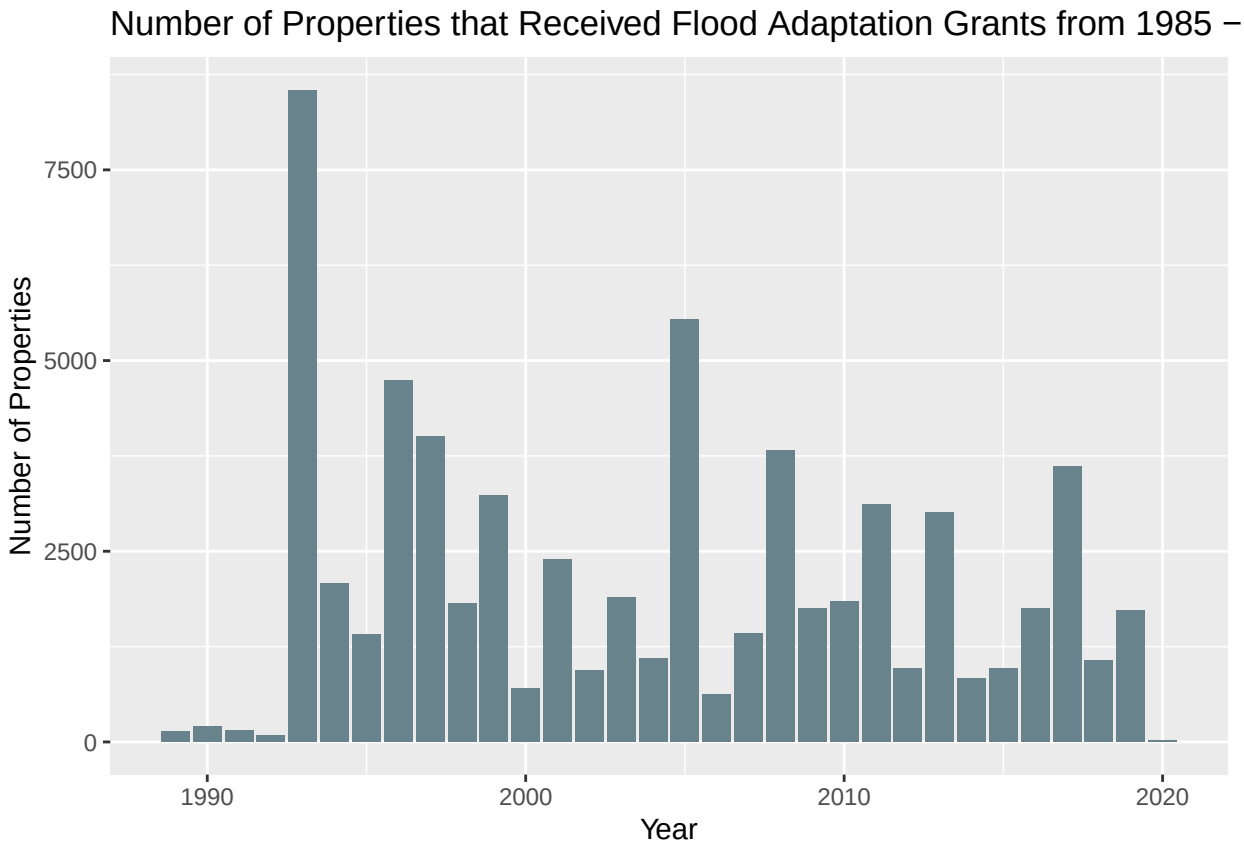
To examine this relationship further, we compared the total amount paid for all adaptation types and in-situ vs. ex-situ in Figure 2. In including both the total amount paid as reported by FEMA as well as these values adjusted to 2020 dollars, this figure helps to also show the difference that inflation makes in the resulting total amount paid.

```
ggplot(data = totals_inflation_pivot, aes(x = Category, y = Total)) +
  geom_bar(stat = "identity", fill = "lightblue3")+
  labs(
    title = "Total Amount Paid for Flooding Adaptation from 1985 - 2020",
    subtitle = "Amount Paid With and Without Inflation Adjustments to 2020 USD",
    x = "Adaptation Type",
    y = "Amount Paid (USD)")
```

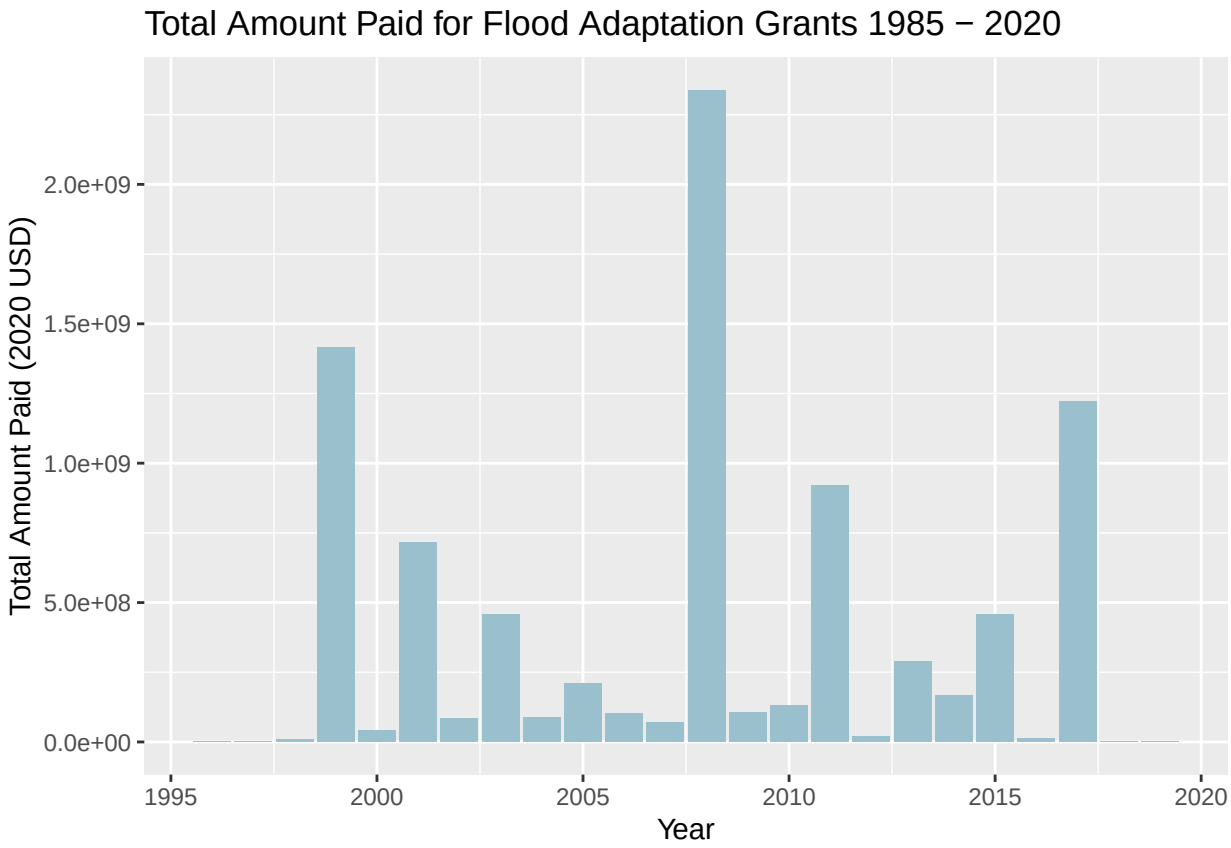


Finally, figures 3 and 4 show this same data over time specifically focusing on the number of properties and total amount paid for all grants that went towards flooding adaptation. These graphs, as well as the graphs of ex-situ and in-situ data over time, are further examined in the analysis section including trendlines to complement the time series analysis.

```
ggplot(data = databyyear, aes(x = programFy, y = Floodpropertiesperyear)) +
  geom_bar(stat = "identity", fill = "lightblue4")+
  labs(
    title = "Number of Properties that Received Flood Adaptation Grants from 1985 - 2020
    x = "Year",
    y = "Number of Properties")
```




```
ggplot(data = inflation_data, aes(x = programFy, y = InflationAdjusted_AllAmountpaid)) +
  geom_bar(stat = "identity", fill = "lightblue3")+
  labs(
    title = "Total Amount Paid for Flood Adaptation Grants 1985 - 2020",
    x = "Year",
    y = "Total Amount Paid (2020 USD)")
```


Total Amount Paid for Flood Adaptation Grants 1985 − 2020
Total Amount Paid (2020 USD)
2.0e+09
1.5e+09
1.0e+09
5.0e+08
0.0e+00
1995
2000
2005
2010
2015
2020
Year

2.2 Analysis

This analysis involved nine time series analysis that can be understood based on these more detailed research questions that the time series helps to answer:

- Total Number of Properties: Is there a monotonic trend in the total number of properties that receive grant funding over time?

- Total Amount Paid for All Adaptation: Is there a monotonic trend in the total amount paid for flooding adaptation grants over time?

- Total Amount Paid - Inflation Adjusted: Is there (still) a monotonic trend in the total amount paid for flooding adaptation grants over time when adjusting for inflation to 2020 dollars?

- Number of Buyouts: Is there a monotonic trend in the total number of properties that received ex-situ grant funding, or funding to buyout the property, over time?

- Amount Paid for Buyouts: Is there a monotonic trend in the amount paid for buyouts over time?

- Amount Paid for Buyouts - Inflation Adjusted: Is there (still) a monotonic trend in the amount paid for buyouts after adjusting for inflation to 2020 dollars?

- Number of In-Situ Properties: Is there a monotonic trend in the total number of properties that received in-situ grant funding to adapt in place over time?

- Amount Paid for In-Situ Adaptation: Is there a monotonic trend in the amount paid for in-situ adaptation over time?

- Amount Paid for In-Situ Adaptation - Inflation Adjusted: Is there (still) a monotonic trend in the amount paid for in-situ adaptation after adjusting for inflation to 2020 dollars?

2.3 Question 1: <insert specific question here and add additional subsections for additional questions below, if needed>

2.4 Question 2:

3 Summary and Conclusions

4 References

<add references here if relevant, otherwise delete this section>