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About the Project :

This project is taken by Abhinav Singh Tawar (B20CI004) and Satyam Soni (B20CI039), under the guidance of Dr. Saran Aadhar for the course Water Resource Engineering for the academic year 2022-23. The title of the project is Analysis of Kerala Floods to Ensure Safety in the Future.

Links to the sources used :

Dataset: https://drive.google.com/file/d/1QE6-_EHwu6XrmeZuBwF7D-hRpPYUaB3E/view?usp=sharing

Google Colab Notebook :
https://colab.research.google.com/drive/1Jm1KKzvNo0oOonA-4ZjrACAFPHxYDzc8?usp=sharing

Chapter 1
Introduction

Kerala is a state located in the southwestern region of India. It is known for its rich culture, biodiversity, and natural beauty. However, Kerala is also known for being a flood-prone area, especially during the monsoon season. The state has witnessed several devastating floods in recent history, with the most severe being the floods of 2018. In this essay, we will explore the reasons why Kerala is prone to flooding, the impact of flooding on the state, and what measures can be taken to mitigate the risks.

Kerala is located in a region that receives heavy rainfall during the monsoon season, which typically lasts from June to September. The state is also home to several large rivers, including the Periyar, the Chaliyar, and the Pamba, which drain into the Arabian Sea. These factors make Kerala vulnerable to flooding, especially when heavy rainfall coincides with high tides or when water is released from the state's dams.

The topography of Kerala is another factor that contributes to flooding. The state is characterized by hilly terrain, with steep slopes and valleys. This makes it difficult for water to be absorbed into the ground, leading to run-off and the accumulation of water in low-lying areas. The construction of roads, buildings, and other infrastructure has also disrupted the natural drainage systems of the state, exacerbating the risk of flooding.

The impact of flooding on Kerala has been devastating. In addition to the loss of life and damage to property, flooding has also led to the displacement of thousands of people. The floods of 2018, in particular, had a significant impact on the state's economy, with estimates suggesting that the total economic loss could be as high as 31,000 crore rupees. The floods also had a significant impact on the state's agriculture sector, which accounts for a large proportion of the state's economy.

Several measures can be taken to mitigate the risks of flooding in Kerala. One of the most important measures is the construction of infrastructure that can withstand floods, such as flood-resistant buildings and roads. The state government has also implemented measures to improve the natural drainage systems of the state, including the construction of check dams and the removal of silt from riverbeds. The state has also invested in early warning systems that can alert residents to the risk of flooding and provide them with information on evacuation and relief measures.

Another important measure is the preservation of the state's natural resources. The state's forests, wetlands, and other natural ecosystems play a vital role in regulating the flow of water and reducing the risk of flooding. Protecting these resources can help to maintain the natural drainage systems of the state and reduce the impact of flooding.

Here, we talked about some measures that can be taken to avoid floods. But, we have developed an algorithm using Machine Learning Models, which can predict the possibility of flooding in Kerala, the critical months, the trend of rainfall and floods with years, etc. using which actions can be taken in advance.

In short, Kerala is a flood-prone area due to a combination of factors, including heavy rainfall, hilly terrain, and the construction of infrastructure. The impact of flooding on the state has been devastating, with the loss of life, damage to property, and economic losses. However, measures can be taken to mitigate the risks of flooding, including the construction of flood-resistant infrastructure, the preservation of natural resources, and the implementation of early warning systems. By taking a holistic approach to flood management, Kerala can reduce the impact of flooding and build a more resilient future.

Chapter 2

Problem Formulation and Implementation

As discussed in the introductory chapter, in this project we aim to analyze the data of rainfall, check the trend of rainfall and floods and predict the possibilities of floods in Kerala with the help of machine learning algorithms like Support Vector Regression (SVR) and Grid Search by plotting the trend, identifying the critical months, etc.

Starting with the analysis part, we first took the dataset of Kerala floods of 118 years and checked every year in which month, there is the maximum rainfall and how much is it.

Next, we plotted one graph to analyze the fluctuations in the rainfall and plotted a trendline using a Support Vector Regressor (SVR) to identify the trend of the maximum rainfall happening each year.

Now, for the identification of flooding conditions, we decided to have a threshold of 2900 mm annual rainfall. If the rainfall throughout a particular year is more than 2900 mm then it is a flood else not. This value is chosen with the help of the dataset. We observed the trend that around 2900 mm, the threshold lies and if the rainfall is more than this value, then a flood is happening. However, this is not true for every case, but for most cases. Now, after doing this, we observed how many years there are whose annual rainfall lies above this threshold limit.

Next, we tried to identify the months which are critical for the occurrence of floods. For this, we plotted the box plot.

Such analysis can help us predict the critical months and trend of rainfall and accordingly, safety measures can be taken for the safety of the people living in the state.

Chapter 3
Observations and Results

Maximum Rainfall in a Month:

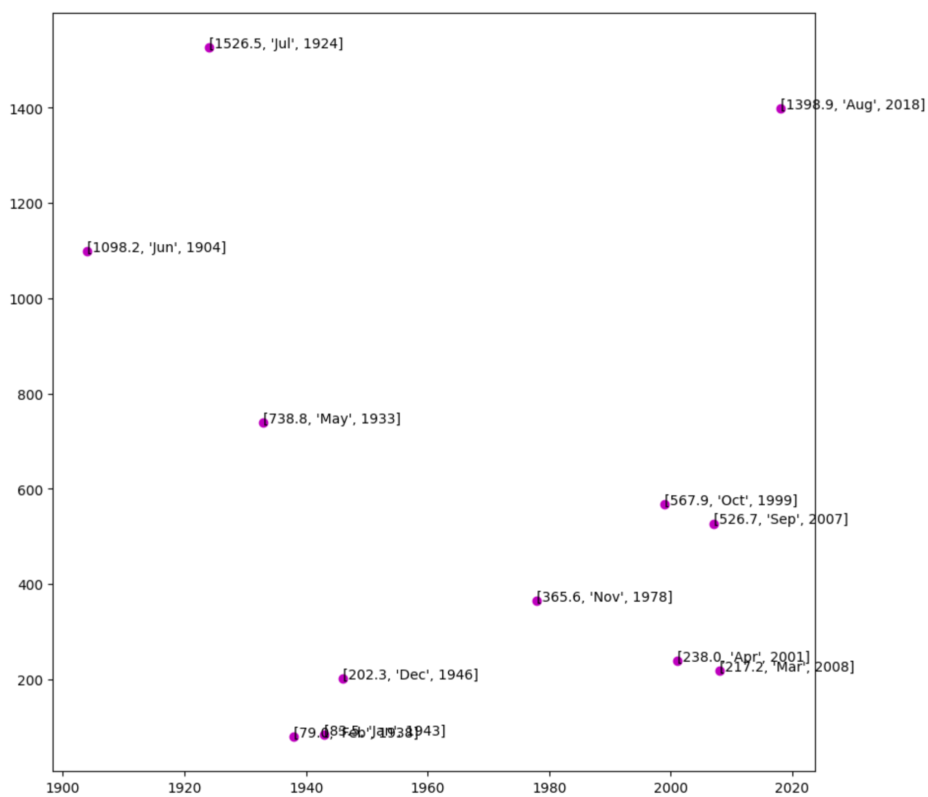

Fig.1

According to the above graph, 2018 was a tragedy for Kerala because there was no rainfall before 2018 as much as it was in 2018. As we can see in the graph, there was rainfall of 1398.9 mm in August 2018. In the past, it happened once that was in July 1924.

In this plot, we can see the annual rainfall that occurred, in which month there was the maximum rainfall, and in which year that amount of rainfall happened.

Fluctuations of Rainfall over the years :

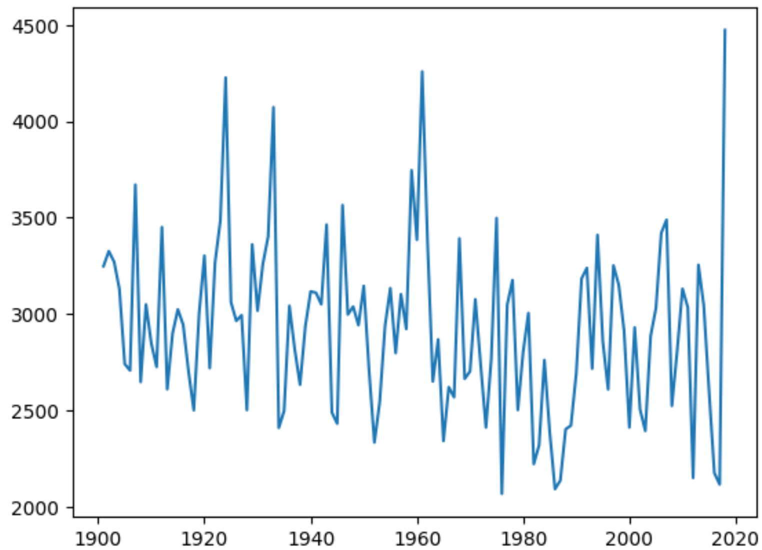

Fig. 2
The x-axis shows the year and the y-axis shows the amount of precipitation.

The Trend of Rainfall over the Years :

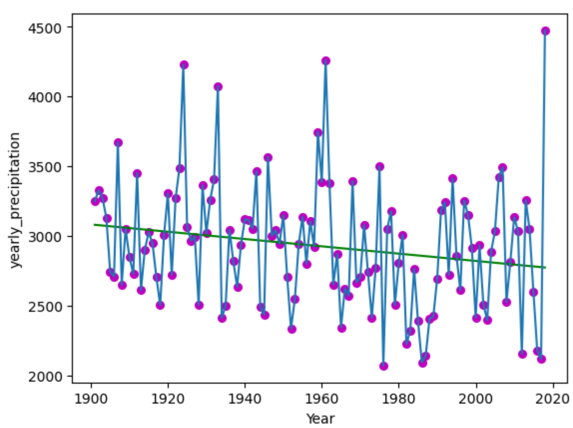

Fig. 3

Trend using linear regression shows a decrease in rainfall per year.

The straight line shows that the trend of rainfall over the years is negative and when we extend this line such that it intersects the x-axis, we get to know that in the year 3077, the rainfall in Kerala will be negligible.

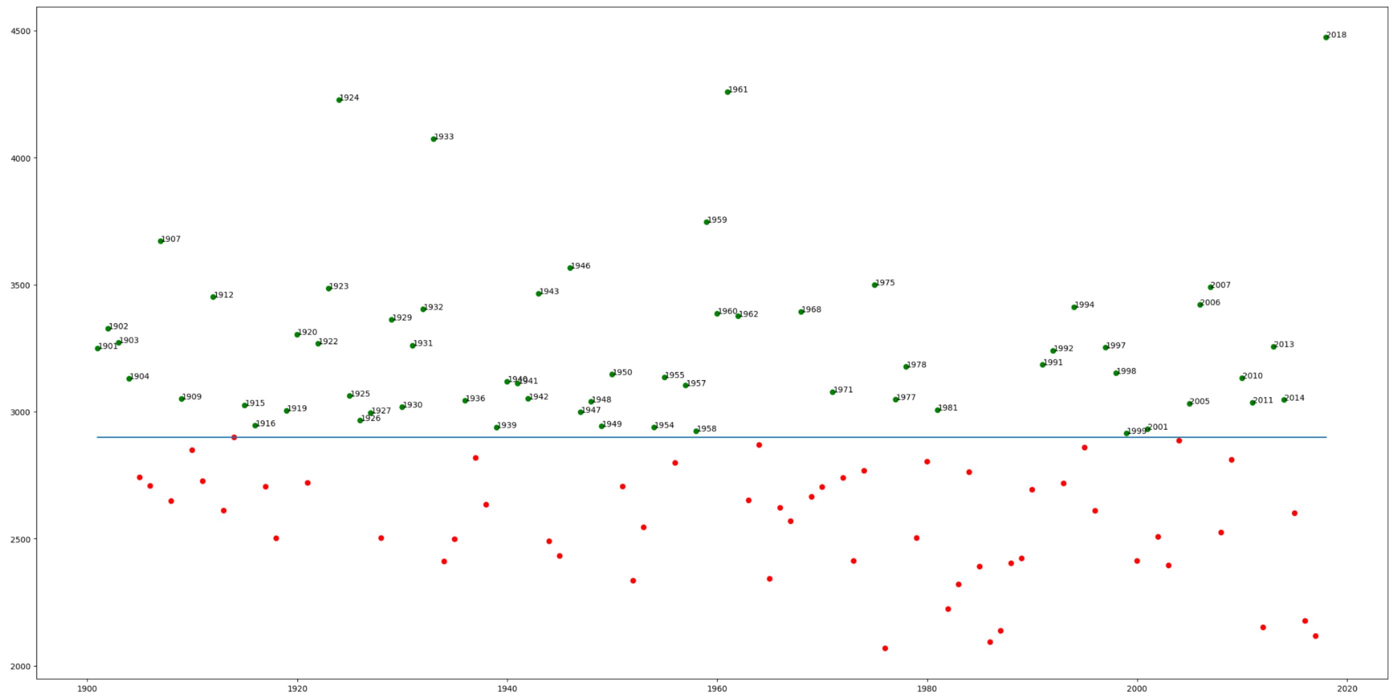

Fig. 4

The above plot (fig 4) shows those years in which the rainfall was more than our threshold of 2900. The straight horizontal line represents the threshold line.

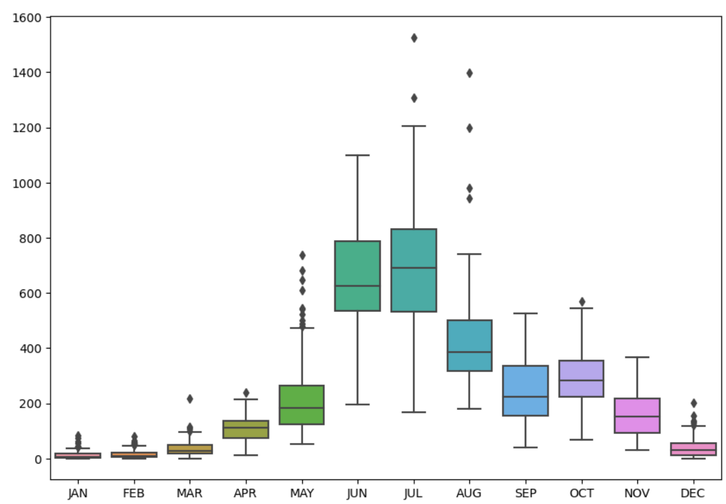

Fig. 5

Box plot showing the criticality of months for the occurrence of floods

```
Feature importances:

1. JUL (0.194499)
2. SEP (0.175958)
3. AUG (0.124765)
4. JUN (0.102972)
5. NOV (0.084565)
6. JAN (0.059915)
7. APR (0.050072)
8. MAY (0.045548)
9. DEC (0.044535)
10. OCT (0.040635)
11. MAR (0.039607)
12. FEB (0.036930)
```

Here, we can observe that the feature importance for July is maximum, followed by September, August, and June. This means that these months are critical for the occurrence of heavy rainfall and floods.

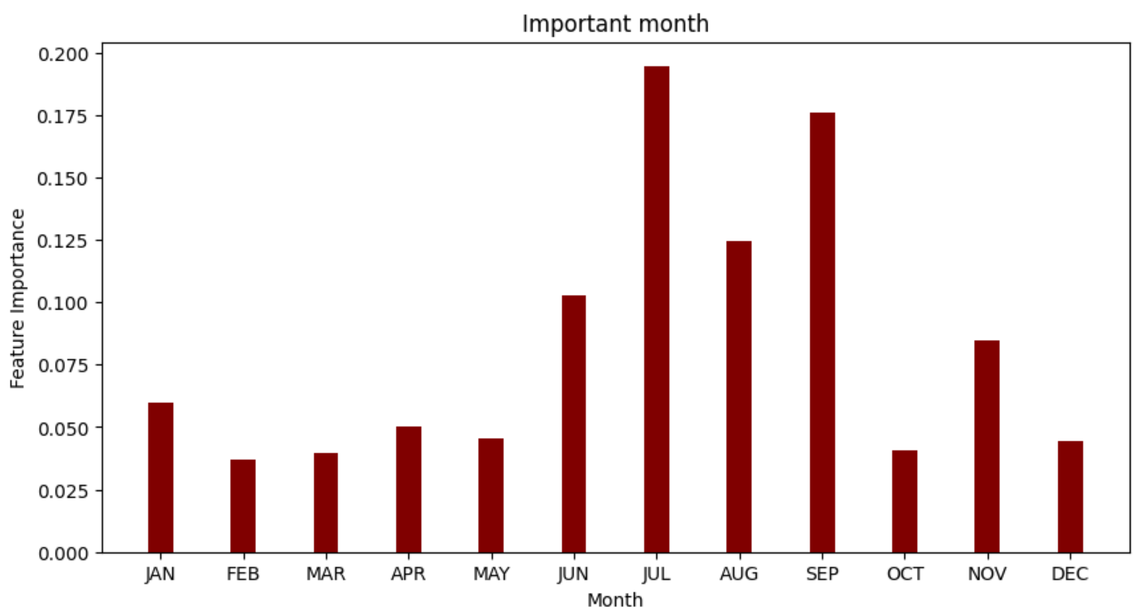

Fig. 6
Same representation in the form of a Bar Chart

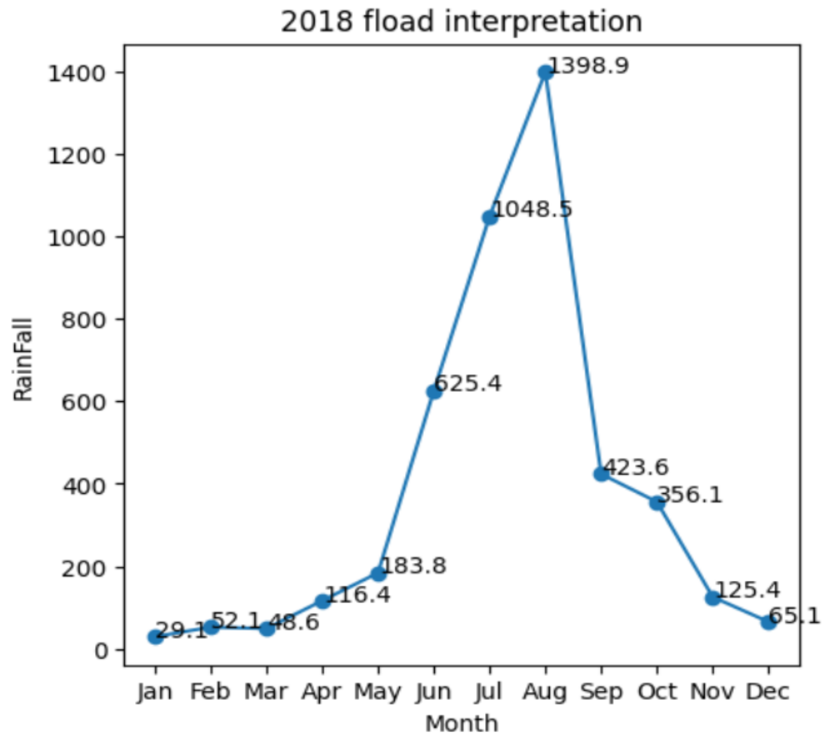

Fig. 7
The general trend of rainfall across various months in a year

Fig. 7 is showing a trend of rainfall over the month of 2018. Sudden heavy rainfall, caused heavy floods in the history of Kerala.

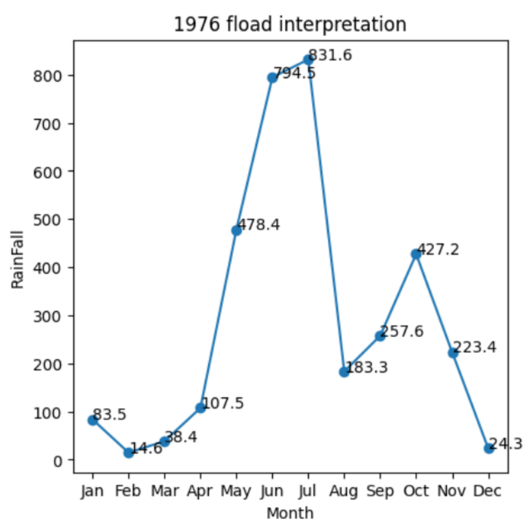

Fig. 8

Fig. 8 shows the trend of rainfall for the year (1976) having total minimum rainfall over 100 years of rainfall.

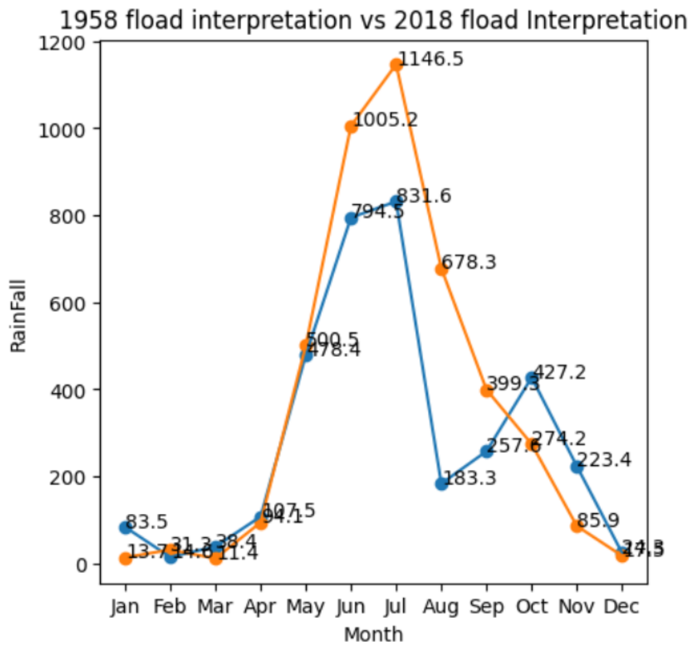

Fig 9

The trend is to compare the heavy flood year (2018) and the minimum flood year(1958).

Accuracy of our model :

```
R^2_score :  0.9600516128778487
MAE: 0.09993489586335777
MSE: 0.09993546307761741
explained_variance_score:  0.9600516255460071
```

These values explain how our model works. Roughly discussing, we achieved an accuracy of about 90% with Mean Absolute Error (MAE) and Mean Squared Error (MSE), both of about 9.99%. With these values, we can say that our model is fairly accurate.

Chapter 4
Summary and Conclusions

In this project, we developed an algorithm using Machine Learning Models, which can predict the possibility of flooding in Kerala, the critical months, the trend of rainfall and floods with years, etc. using which actions can be taken in advance.

Fig 8,9 shows that sudden heavy rainfall happens every year in Kerala but it is important to know the rainfall value at the start of June and July. If rainfall comes greater than 800 mm then, it is an indication of flood in that area.

We observed our dataset, analysed it, and using ML models, we did our predictions.

We achieved an accuracy of about 90% with Mean Absolute Error (MAE) and Mean Squared Error (MSE), both of about 9.99%. With these values, we can say that our model is fairly accurate and reliable. For maximising the accuracy we tuned the hyperparameters of the model and used the best ones that gave the most accurate results. However, more accurate predictions are possible which can be achieved by further tuning the hyperparameters of our model but as per our trials, the maximum accuracy we achieved is reported above.

Now, after doing such predictions, we need to take necessary actions for the safety of people during floods :

- **Evacuation planning**: Evacuation planning is an important part of flood management. Evacuation plans should be developed for areas at high risk of flooding, and residents should be informed of the evacuation routes and procedures in advance. The evacuation plans should also consider the needs of vulnerable populations, such as the elderly, children, and people with disabilities.

- **Emergency response planning**: Emergency response plans should be developed in advance of flooding events. This includes plans for rescue and recovery operations, as well as plans for the distribution of relief supplies, such as food, water, and medical supplies. The food and other resources should be arranged beforehand, especially for the critical months identified by our model.

- **Flood-proofing**: Flood-proofing measures can be taken to protect buildings and infrastructure from flood damage. This includes the construction of flood walls, barriers, and gates, as well as the installation of flood-proof doors and windows. Buildings can also be raised above the flood level, or flood vents can be installed to prevent structural damage. This can be done before the predicted time of the flood.

- **Early warning systems**: Early warning systems can be deployed when there is a high possibility of floods like in June to September to provide advance notice of potential floods, giving residents and emergency responders more time to prepare. These systems can include flood sensors, weather monitoring systems, and public warning systems, such as sirens and text message alerts. Actually, if we look at our model, it is also predicting the possibility of floods. So, this model can be combined with the early warning systems for better results and performance

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