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Kerala flood –The disaster of the Century

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Abstract

A flood is the rapid burst of water that submerges land. Flood may arise as an overspill of water from water bodies such as a lake, river, etc. It may also occur due to an accumulation of rainwater on the ground in an aerial flood. Flash floods are caused by rapid and excessive rainfall that raises water heightsvery quickly. It might be influenced by several factors including encroachment of flood plains and other natural factors, reservoir storage, land usage etc. The climatic change at the global level has made a severe effect on the flood situation in the state and thereby results in more intense and extreme rainfall. Deforestation, emission of greenhouse gases etc are also the reason behind this flood. The first flood in Kerala occurred in 1924 and after a long gap, the flood again takes place in 2018. And it was sustained to happen in successive years 2019, 2020 and 2021.This article describes the factors influencing flood and occurrence of this disaster in different periods, the steps taken by the Government and the local people to mitigate the flood and associated landslides were analysed.

Floods are the most common disaster all over the world. Their rate of recurrence, degree and the cost of damage of the flood is very high. Kerala is situated along the Western Ghats, with many of the towns and cities located on foothills. The State has several small intra-State rivers, almost all of them flowing west towards the Arabian Sea. These rivers have very small catchment areas. Also, the steep slopes of rivers leave very little response time to issue a conventional statistical-correlation based (level) forecast for any station concerning any base station upstream. Thus, rivers are flashy and swell up pretty quickly, and hence, an effective level-based forecast is very difficult to make[7]. Life-threatening precipitation events and flooding that cause damages to human lives and infrastructure have increased under the warming climate. The survey on the frequency and intensity of extreme rainfall events proposed a worldwide rise in as a consequence of global warming caused by the

growing amounts of CO_2 in the atmosphere [1,2,4]. Starting from 2018, the state of Kerala witnessed large-scale flooding, which affected millions of people and caused many deaths. The heavy rainfall resulted in filling dams to maximum capacity made all barriers open andcaused over flooding. The effect of the flood had altered the life of farmers; the wave had swept away their cultivations. The flood has not only affected the fields but also their homes, live stocks,agriculture implements, aquaculture, assets, and so on. The main struggles faced by farmers are the insufficiency of assistance, drop-in yield and lack of pure water, delay in getting support, reimbursement of the loan, and so on. In the course of the flood, the Government has financed urgent aid and relief material quickly and devoid of restrictions[12]. This is a case study that focuses on the flood in Kerala. Flood has occurred in Kerala 4 times. The first flood occurred when the Periyar River in the Kerala state of India flooded in July 1924 followed by 2018 and sustained in 2019,2020 and currently in 2021. In this context, an effort has been taken in this present study to analyse the precipitation level, mortality rate and property damages due to this widespread extremely heavy to very heavy rainfall with the following objectives.

Objectives :

- To analyse the cause of flood and precipitation levels in Kerala.
- To compare the mortality rate and property damages due to flood in different duration
- To findout the precautions taken by the Government to avoid the calamity.
- To recommend the Integrated Flood Management with a judicious mix of structural and non-structural measures

Duration of the study :

Kerala witnessed calamitous flood[13] during the monsoon seasons of 4 repeated years, 2018, 2019, 2020 and 2021. Extreme Rainfall Events (EREs) and related floods set off significant damage to mankind, infrastructure, and the physical environment are a subject of global concern. The degree of human and livestock deaths, crop damages and economic losses because of the floods were massive. In August 2018, Kerala state go through some of the most serious EREs on record. This resulted in wide-ranging flooding and landslides across most Districts of the state,affecting severe damage to both the built and natural ecosystems[6]. In view of the above facts, an attempt has made to compare the precipitation and flood levels in 1924, 2018, 2019, 2020 and 2021 and its impact on human life and the damage to the property.

Background :

Kerala is a state situated on the southwestern, Malabar Coast of India (Figure 1). Kerala has the 13th largest population in India. Kerala lies in the tropic region and it is generally subjected to humid tropical wet climate felt by most of Earth's rainforests. So, Kerala's climate is mostly wet and tropical, heavily influenced by the seasonal heavy rains carried up by the monsoon. The average annual rainfall in Kerala is around 300 cms and it is caused by high numbers of low to moderate intensity rainfall days.

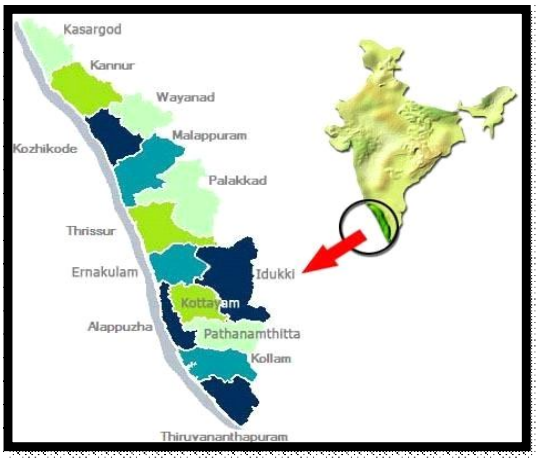

Figure 1. Kerala District Map

History :

Flood of 99 :

The Great flood of July 1924, or popularly known flood of 99, which occurred in 1099 ME (Malayalam Era), when the Rivers of Periyar, Meenachil, Pampa, Muvattupuzha and others originating from Sahyadri Mountains and hills flooded in Kerala state. The rain continued for approximately three weeks. Many districts of Kerala were severely submerged in water by this flood –From Trichur to Ernakulam; from Idukki to Kottayam and Alappuzha together with the Kuttanad region. Karinthiri Malai is a gigantic mountain that was also washed away by this flood and the road to Munnar was well wiped out all along with it. A new road from Ernakulam to Munnar became essential after the road washed out. The present-day road from Ernakulam to Munnar was built after this event. The destructive flood took thousands of lives, animals and birds, and set off serious destructions to buildings, roads and other structures, and serious damages to crops in Kerala. In Munnar, about 485 cm of rainfall was reported during the flood and extensive damage occurred. Kerala state received exceptional rains all through July 1924. Kerala received 3,368mm of rain during the monsoon season (June to September), 64 per cent higher than standard and is the highest recorded rainfall.

Kerala flood of 2018 :

Enormously extreme anomalous precipitation (over 500 mm) and release of water from reservoirs located in an upper catchment initiated in dangerous flood conditions in down slope regions of Kerala State in August 2018. From 1 June 2018 to 19 Aug 2018 Kerala suffered an intensely high rainfall, which caused severe flooding in 13 Districts of Kerala. The developed rainfall was 42% above the expectation[5]. On 16 August 2018, severe floods affected the south Indian state Kerala, due to remarkably high rainfall during the monsoon season. It was the most terrible flood in Kerala, about a million people were evacuated, mainly from Chengannur, Pandanad, Kozhencherry, Edanad, Aranmula, Ayiroor, Ranni, Pandalam, Kuttanad, Malappuram,Aluva, Chalakudy, Thiruvalla, Thrissur, Eraviperoor, Vallamkulam, North Paravur, Chellanam,Vypin Island and Palakkad. In the state, all 14 Districts were set down on red alert. According to the Kerala Government, one-sixth of the whole population of Kerala had been instantaneously affected by the floods and correlated events. The Indian Government had declared it a Level 3 Calamity, or "calamity of a severe nature". It is the terrible flood in Kerala after the great flood of 99 that took place in 1924. There are 54 dams in Kerala. The reservoirs were already filled

in July end, not like other years and there was no place in the reservoirs to contain any more extra rainwater.

Considering the safety of the dams, the water had to be discharged from all the dams. So out of 54,35 dams were opened for the first time in history. All five gates of the Idukki Dam were opened at the same time, and for the first time in 26 years, 5 gates of the Malampuzha Dam of Palakkad were opened. Heavy rains have triggered severe landslides and have left the hilly Districts isolated in Wayanad and Idukki. The calamity that hit in the mid of August changed the ecosystem, evenly onland and water, which critically affected the bioresources (bio-diversity), livelihood and capital wealth (Infrastructure). The flood was very exceptional and rainfall in hilly Districts were three times more, and the State was also not ready for such a large scale, as it has not experienced a flood of this degree and consequences, apart from the recorded one in 1924. This flood can be called the 'Flood of this Century'. The flood made a massive influence across diverse sectors, particularly dam management, power generation, agriculture, housing, environment, biodiversity etc.

Kerala flood 2019 :

After the heavy flood in 2018 severe rainfall occurred on 8th August, 2019 and again affected Kerala severely. There have been 80 landslides in 2 days. Wayanad, Malappuram, Kozhikode, Kannur, Palakkad, Thrissur and Ernakulam districts were severely affected by this flood.There have been 80 landslides in between 2 days and many of them died and many went missing and injured.

Kerala flood 2020 :

From June 1st to August 18th 2020, all 14 Districts in Kerala were affected by heavy rainfall over the monsoon season. Idukki, Wayanad, Malappuram, Thrissur and Kottayam were flooded on 7th August. The flood in 2020 was marked the third year in a row of severe monsoon flooding.

Kerala flood 2021 :

Kerala witnessed high-intensity rainfall recently in this year. This rainfall started to intensify on October, 15th. The critically - affected areas are Kottayam and Idukki. The heavy rains caused landslides and swelled many rivers across the state. Roads are moved away; houses are spoilt and trees uprooted.

Causesof flood :

- Kerala flood was a united impact of tremendous rainfall and reservoir storage.
- All the dams in the state were opened simultaneously, which was a major contributing factor to the flood.
- Over the last 20 to 30 years, the land-use pattern in the state had completely changed due to the reduction in forest land.
- It is also affected by several factors including encroachment of flood plains and other natural factors, reservoir storage, land usage etc.
- The climatic change at the global level has made a severe effect on the flood situation in the state and thereby results in more intense and extreme rainfall.

- This rainfall is the effect of two factors, namely, manmade and natural calamity.
- The latest episode of flash floods in 2021 was due to excessive rainfall caused by the formation of a low-pressure area over east-central and connecting south-east the Arabian Sea off Lakshadweep area and its movement to east-south-eastwards as a low-pressure area towards the Kerala coast.
- Prevailing river streams and drainage of the state of Kerala are not capable to manage up with the heavy flow of water and it has guided to flash flood.
- During this heavy rainfall, much of the water will be slowed down by trees and some other natural obstacles. But over the past four decades, Kerala has lost about half its forest, which accounts for an area of 9,000 sq. km. It suggests that a reduced amount of rainfall is being interrupted, and more water is quickly running into overflowing streams and rivers.
- Haphazard and damaging activities such as mining, quarrying, illegal repurposing of forests and high-rise building constructions are manmade activities that also played a major role in the cause of the flood.
- Deforestation of hilly areas causes the sudden rising of water as cutting of trees reduces the water carrying or storing capacity of the ground. Random construction on hills, failure of embankments to check water flow when heavy rainfall occurs, aggravate the flood problem.
- Paddy fields which acted as water reservoirs & the low-lying flood plains of many rivers made their way out in the name of development like airports, bungalows & villas, malls, etc.
- The lack of inadequate data with dam authorities, co-relating the rainfall precipitation at various points of the catchments and rate of an uprising of water in the reservoir with the time lag between rainfall and uprising of water level.
- All the dams in the state were opened simultaneously, which was a major contributing factor to the flood.

Causesof Landslides :

- Landslides are normally triggered by heavy rains, earthquakes, or rise in ground water and undercutting by rivers.
- In Kerala, landslides commonly occur in localised areas of the Western Ghats region, where the slope is sharp and the soil is oversaturated as a result of long-standing rainfall. most of which happened in the Districts of Idukki and Wayanad.
- Explosions, which go further than a particular range, can influence the prevailing structure of the slopes and make them susceptible. The cracks which appear on hills can offer pathways for water and pave the way to landslides in the occurrence of heavy rainfall.
- Tall deep-rooted tress on the mountain side attaches the bedrock and keeps the top soil locked. Uprooting these trees can also intensify the occurrence of landslides.
- The landslide-prone regions are expected to intensify in future due to climate change.
- It is essential to control and forbid unscientific constructions, control land development activities and functioning of quarries in landslide hazard-prone areas of the District for preventing such disasters in future.

Kerala flood havoc and its magnitude:

Considering the importance of the effect of floods that happened in Kerala is concerned, so far, the floods destroyed roughly 982,341 hectares worth of crops. The state was forced to open the gates of 35 of its 54 dams in 2018, knowing fully well what was to come. Due to severe floods, the residents were forced to flee, on important roads that happened to be engulfed in flood water and landslides. Many people lost their own homes. About 800 people died in these floods. Millions of properties were damaged in these flash floods. Acres of crops were destroyed and there was a huge loss of livestock. The health conditions of the people became worst and weak and more susceptible to waterborne diseases. As communication links and infrastructure such as power plants, bridges and roads were broken and disordered, several economic activities came to a standstill, people avere forced to leave their homes and normal life was disrupted. Floods also disturbed victims and their families for long periods. The loss of loved ones deeply affected, particularly the children. Dislocation from one'shome, damage of property and disturbance to business and social affairs produced continuing stress.

Total Rainfall received in Kerala :

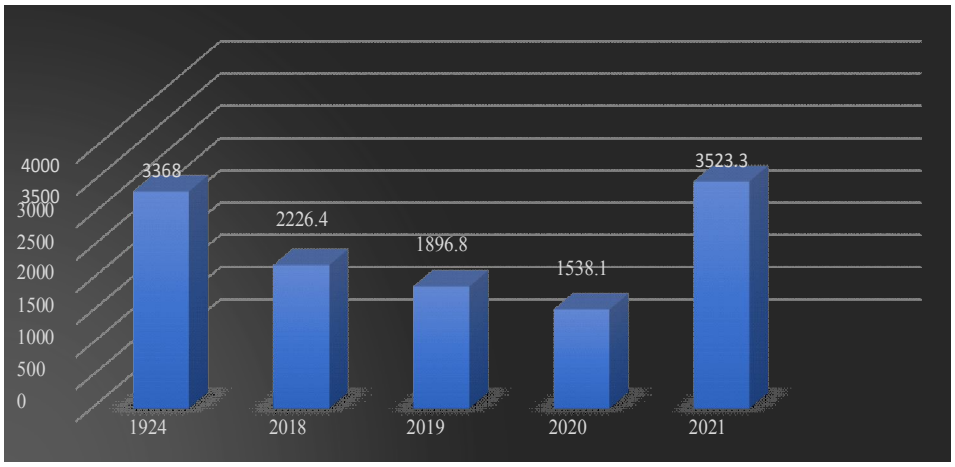

Figure 2. Rainfallreceived (In mm)

The precipitation level in different duration are depicted in Figure 2. The total rainfall received recently in 2021 was recorded highest with 3523.3mm. which was followed by 3368mm in 1924. Records of rainfall during 2018,2019 and 2020 were moderate (1538.1 to 2226.4mm.

Mortalityrate :

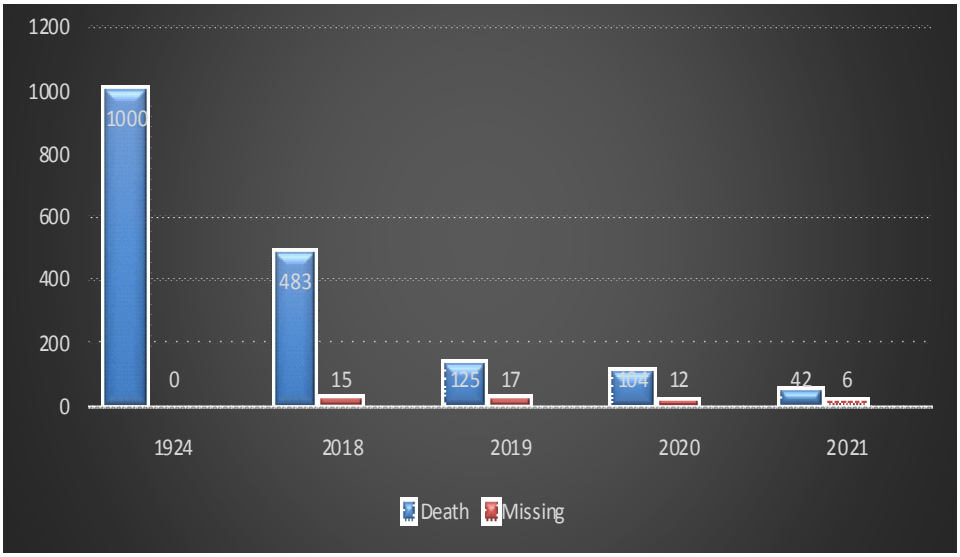

Figure 3. Mortality Rate (In Nos.)

The state of Kerala in India is witnessing unprecedented death and damage since 1924, 2018, 2019, 2020 and 2021 (Figure 3) due to floods and landslides triggered by heavy rainfall. Despite the highest rainfall in 2021, the mortality rate was minimum (42 Nos.) with the implementation of an effective flood management system by the Government. The highest mortality was recorded in 1924 with the death rate of 1000 and in 2018 with the death rate of 483 and about 15 of them were going missing. Minimum no of death were recorded during 2019 and 2020 (125 and 104 No. respectively).

Property damage :

The damage caused by flood mainly depends on rainfall duration and intensity, soil type, slope, and land-use land-cover (LULC). The frequency of flood and associated damage have eventually increased due to climate change[3,8]. The estimated damage in the year 2018 was maximum with 4,00,000 crores and in 1924, it was recorded as 20,000 crores (Figure 4). It was very high because the rainfall and flood were unexpected and unaware by the people. A sudden decline in the damage was noticed in the following years, 2019, 20 and 21(31,000, 19,000, 300 crores respectively) due to alertness by the Government and the people.

Precautions taken by the Government :

- Precautionary measures were taken by the State Government to meet the floods by following National Disaster Management Plan.
- In Thiruvananthapuram, the Government

has set up a control room to coordinate the cleaning process across the state and the civic bodies have been trusted with the task of managing the work.

- Haritha Kerala Mission, a mission integrating waste management, organic farming and water resource management, also organized the cleaning process.
- From different areas, many teams were drawn which including electricians and plumbers.They would work besides with more than 50,000 volunteers to clean houses and public places filled with sludge and debris.
- The state government declared that to each district they were deputing senior IAS officers to help in organizing rescue and relief measures. That was the first time in which such instructions were given to IAS officers.
- The district collectors were generally in charge of their districts, while superintendents of police (SPs) were given the responsibility of rescue operations.
- Along with the districts, other elected representatives like MPs and MLAs, one minister of the state government was also assigned to each district to give the necessary support.
- From panchayats to municipal corporations all local bodies staff was asked to work in rescue and relief operations and, significantly, start using their funds as they deemed fit.
- Engineering wings of panchayats were also forced into service.
- The local bodies, while given the freedom to act immediately in saving people and taking other measures like setting up relief camps, were instructed to not work in contradiction to the disaster management authorities' directions let there be confusion.
- The NDRF and the armed forces that were later deployed coordinated their work through the district authorities mostly.

Precautions taken by the people :

- People united to organise rescue and relief work, run by all kinds of people's organisations, which ranged from trade unions and student-youth organisations (across political lines) to self-help groups, charitable organisations sports clubs and other collective bodies.
- Mass participation of people led to very fast and effective rescue operations which restricted the death toll.
- The further equally important component of Kerala's response was how people from across the state, but particularly in the affected areas, rose to help.
- During those times there was an over-arching sense of collective solidarity and desire to support that was cutting across religious, political or class lines. It was humanity at its best.
- Organisations like NSS, NCC etc are working to clean the villages from mud and debris that flood waters have left behind.
- Thousands of volunteers are working in relief camps including doctors and para-medical staff. They are undertaking a range of duties including cooking food, unloading supplies of relief material, looking after thosewho are elderly or sick, or caring for kids.
- The very range of places where relief camps have opened up is mind-boggling. Temples,mosques, churches, schools, sports clubs, community halls – there are nearly 5000 such relief camps across the affected districts.
- Another aspect of this people's support is

the donations that have flooded in from common people, both from within the state and from outside. Although concrete figures are not yet available, rough estimates put the individual donations at over Rs. 300 crore.

Integrated flood management strategies :

The concept of Integrated Flood Management suggests a judicious mix of structural and non-structural measures. Structural measures (dams/reservoirs, embankments, anti-erosion work *etc*.) aim at preventing flood waters from reaching potential damage areas, whereas non-structural measures (flood forecasting, flood plain zoning, etc.) strive to keep people/assets away from flood waters. Structural measures are to modify flood magnitudes. Non-structural measures are tantamount to strategies akin to living with floods. These are planned activities to modify susceptibility to flooding damage[7].

Another dimension of Integrated Flood Management is to work holistically in a well-coordinated manner with all stakeholders, including different Government Departments (State as well as Centre), public, media, etc. rather than an isolated effort by single entities. Further, flood management work should be planned at the hydrologic basin level and not limited to critically affected areas only.

The reason behind the flash floods in Kerala was extreme rainfall against normal fall associated with massive landslides in Kottayam and Idukki Districts leading to loss of lives and damage to property as well. Rampant development, loss of local ecology and blocking of natural water streams by construction is said to be the other reasons for Kerala's dreadful rain-related disasters in the past years. The considerable increase in intensive anthropogenic activities in the Western Ghats over the past two decades might also have exacerbated the flood hazard in Kerala[11]. Non-availability of real-time rainfall data for a sufficient number of locations has been a major limitation for an effective forecast of floods in Kerala says Sharad Chandra, Director, Flood Forecast Monitoring, Central Water Commission (CWC). As the poor and uneducated people are more vulnerable during floods, extra attention should be given to them. In addition to that, proper reservoir operation, planning and maintenance of embankments (otherwise breaches cause more damage than the flood wave itself), avoiding encroachment near river channels and in the downstream areas of a reservoir, etc are necessary to manage torrential rain and landslide.

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