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Trend of Floods in Western India – An assessment of Flood Prone States and Disaster Management Plans

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Abstract: Floods are amongst the most frequent and destructive type of disaster, causing significant damage and disrupting livelihoods throughout the world. In recent years, the effects of climate change are prominent as irregular rainfalls wreck havoc in many states across India as the major rivers overflow. It has been found that the incidences of the flood are increasing very rapidly. This paper aims to study the trends of flood across western states in India and their disaster management plans in place. Disaster management in India has very organised but administration and implementation of these programs demand more efficiency.

Keywords: *Natural Disaster, Flood, Flood Management, Disaster Management, Kerala Floods*

I. INTRODUCTION

The frequency of flooding in India is more than 50% of the total number of floods occurring in Asia in each decade (Parasuraman & Unnikrishnan, 2000). India has a highly diversified range of natural features. Its unique geo-climatic conditions make the country among the most vulnerable to natural disasters in the world. It is highly prone to floods, droughts, cyclones, earthquakes, etc. India has a peculiar geographical setting that there are floods in some parts and droughts in other regions, and sometimes they co-exist. Over 8% of the area in India, i.e., 40 million hectares, is prone to floods. And the average area affected by floods annually is about 8 million hectares.

Affect of floods in India (1953-2017):

Year	Area affected (in m.ha)	Population affected (in million)	Damage to Crops (Value in Rs.Crore)	Human lives Lost	Damage to Public Utilities in Rs.Crore
1953	2.29	24.28	42.08	37	2.9
1954	7.49	12.92	40.52	279	10.15
1955	9.44	25.27	77.8	865	3.98
1956	9.24	14.57	44.44	462	1.14
1957	4.86	6.76	14.12	352	4.27
1958	6.26	10.98	38.28	389	1.79
1959	5.77	14.52	56.76	619	20.02
1960	7.53	8.35	42.55	510	6.31
1961	6.56	9.26	24.04	1374	6.44
1962	6.12	15.46	83.18	348	1.05
1963	3.49	10.93	30.17	432	2.74
1964	4.9	13.78	56.87	690	5.149
1965	1.46	3.61	5.87	79	1.07
1966	4.74	14.4	80.15	180	5.736
1967	7.12	20.46	133.31	355	7.857
1968	7.15	21.17	144.61	3497	25.373
1969	6.2	33.22	281.9	1408	68.112
1970	8.46	31.83	162.78	1076	76.441
1971	13.25	59.74	423.13	994	129.113
1972	4.1	26.69	98.56	544	47.174
1973	11.79	64.08	428.03	1349	88.489
1974	6.7	29.45	411.64	387	84.942
1975	6.17	31.36	271.49	686	166.05
1976	11.91	50.46	595.03	1373	201.495
1977	11.46	49.43	720.61	11316	328.948
1978	17.5	70.45	911.09	3396	376.1
1979	3.99	19.52	169.97	3637	233.627
1980	11.46	54.12	366.37	1913	303.283
1981	6.12	32.49	524.56	1376	512.314
1982	8.87	56.01	589.4	1573	671.607
1983	9.02	61.03	1285.85	2378	873.429
1984	10.71	54.55	906.09	1661	818.164
1985	8.38	59.59	1425.37	1804	2050.043
1986	8.81	55.5	1231.58	1200	1982.535
1987	8.89	48.34	1154.64	1835	950.59
1988	16.29	59.55	2510.9	4252	1377.8
1989	8.06	34.15	956.74	1718	1298.77
1990	9.303	40.259	695.61	1855	455.266
1991	6.357	33.889	579.015	1187	728.893
1992	2.645	19.256	1027.578	1533	2010.67
1993	11.439	30.409	1308.627	2864	1445.534
1994	4.805	27.548	888.622	2078	740.762
1995	5.245	35.932	1714.787	1814	679.627
1996	8.049	44.729	1124.491	1803	861.393
1997	4.569	29.663	692.743	1402	1985.934
1998	10.845	47.435	2594.167	2889	5157.771
1999	7.765	27.993	1850.873	745	462.83
2000	5.382	45.013	4246.622	2606	3936.979
2001	6.175	26.463	688.481	1444	5604.461
2002	7.09	26.323	913.092	1001	1062.083
2003	6.12	43.201	7307.23	2166	3262.154
2004	5.314	43.725	778.694	1813	1656.09
2005	12.562	22.925	2370.923	1455	4688.219
2006	1.096	25.224	2850.668	1431	13303.926
2007	7.145	41.402	3121.532	3389	8049.037
2008	3.427	29.91	3401.563	2876	5046.481
2009	3.844	29.537	4232.609	1513	17509.353
2010	2.624	18.297	5887.38	1582	12757.253
2011	1.895	15.973	1393.847	1761	6053.57
2012	2.141	14.689	1534.108	933	9169.968
2013	7.546	25.927	6378.078	2180	38937.843
2014	12.775	26.505	7255.151	1968	7710.948
2015	4.478	33.203	17043.948	1420	32200.182
2016	7.065	26.555	4052.723	1420	1507.926
2017	0	17.915	6923.8	2015	2179.35
Total	460.26	2058.18	109197.443	107487	201909.504
Average	7.081	31.664	1679.961	1654	3106.3
Maximum	17.5	70.45	17043.948	11316	38937.843

Source: – CRED

Due to recurrence, the economic loss and deaths caused by the flood have put more burdens on the economy than any other natural disaster. The damage caused by the flood lasts several years from its advent. In the absence of an effective method to measure the impact of the flood, the assessment of loss and damage is often not actual and far less than the actual cost. The immediate cause of the flood may be natural, but due to anthropogenic interventions, the impacts get amplified.

Flood effects are not confined to individuals alone; instead, they engulf the entire community, which necessitates synergized efforts for flood mitigation, as any group response to disaster effectively lessens its impact on livelihood resilience of the affected households.

II. METHODOLOGY

This paper adopts a case study approach dealing with the most flood-prone states in India. The data has been collected from the EM-DAT: The Emergency Events Database - Université Catholique de Louvain (UCL) – CRED and government

websites such as the Ministry of Water Resources, Indian Meteorological Department and Rajya Sabha Session data.

III. RESULTS AND DISCUSSION

Floods are now an annual nightmare in many parts of western and southern India. Valleys in the states of Karnataka, Kerala, and Maharashtra, which were not considered flood-prone until recently, are at risk. During landslides and floods occurring in August 2019, two villages were completely destroyed, killing several people, while in 2018, Kerala suffered one of its worst floods. Climate change is causing torrential and irregular rainfall with recurrent floods in low-lying areas, while the population density is putting more people at risk. Deforestation in the mountain range where the majority of the water first fell: the Western Ghats, is also a cause for concern

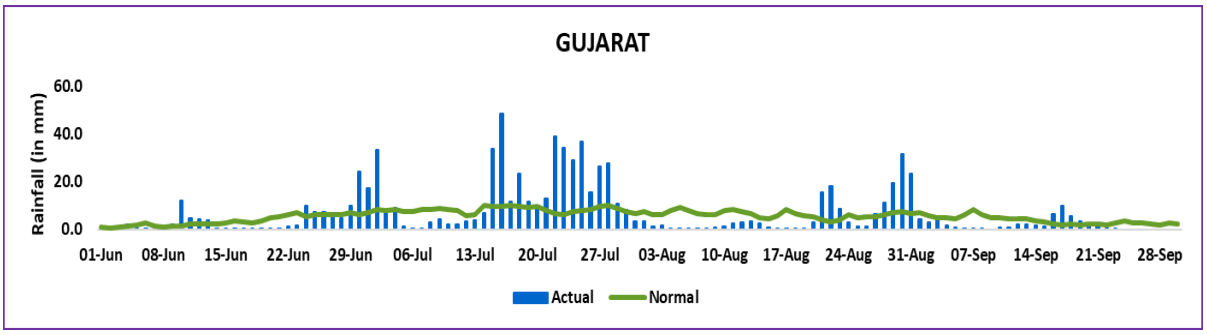
Flooding in Kerala, Photo: Office of the Prime Minister, India

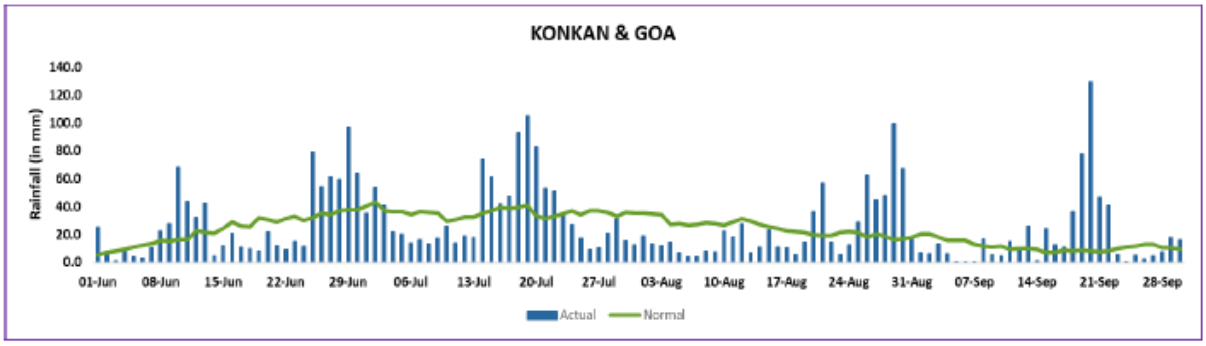
The Western Ghats extend for 1,600km parallel with India's west coast, from Gujarat to Tamil Nadu at the tip of the subcontinent. It showcases a picturesque landscape of steep gorges, serene valleys, and lush forests. However, recurring floods and landslides in the mountains and areas downstream show that India must reform its environmental law to balance the needs of nature and humans.

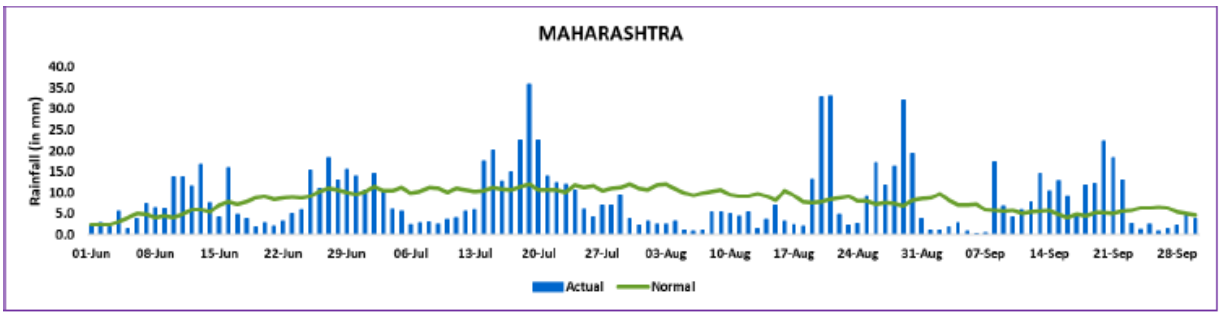
Climate change already has a noticeable impact, with irregular rains in the monsoon and severe droughts in the summer. As the population has been increasing, forests are being cleared and replaced by spices, coffee, rubber, and tea plantations. Thousands of illegal stone quarries now also operate in the Ghats to generate stones and sand for the construction industry. Deforestation and the use of explosives mean these areas are prone to seismic tremors and landslides.

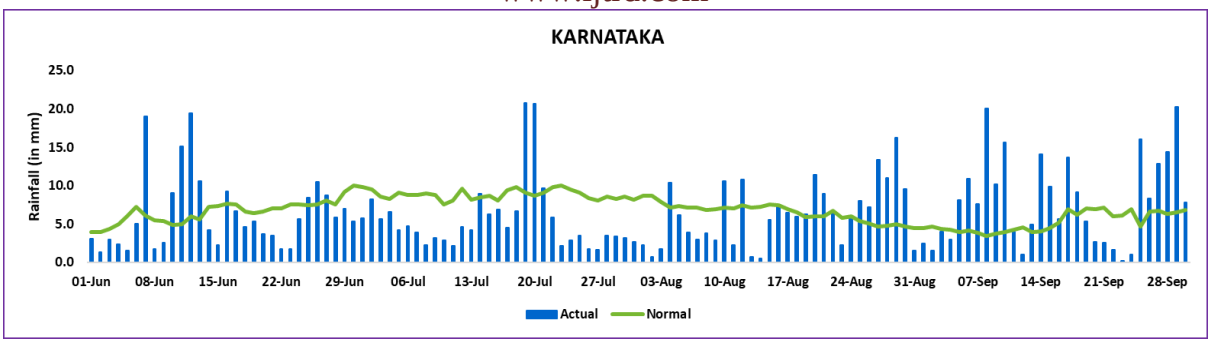
Large dams on major rivers provide renewable energy yet also raise another set of environmental problems. In Kerala, many are located in ecologically sensitive parts of the Western Ghats, with some dating back to British rule. As demand for energy increases, India plans to build more dams, which could lead to massive deforestation and water disputes with the downstream regions. All this makes flooding more severe, as deforestation in the catchment area of a river reduces the land's ability to retain water. Whether triggered by damming, deforestation, or exacerbated by climate change, human-induced natural disasters in the region have pointed to a need for stronger environmental protection laws.

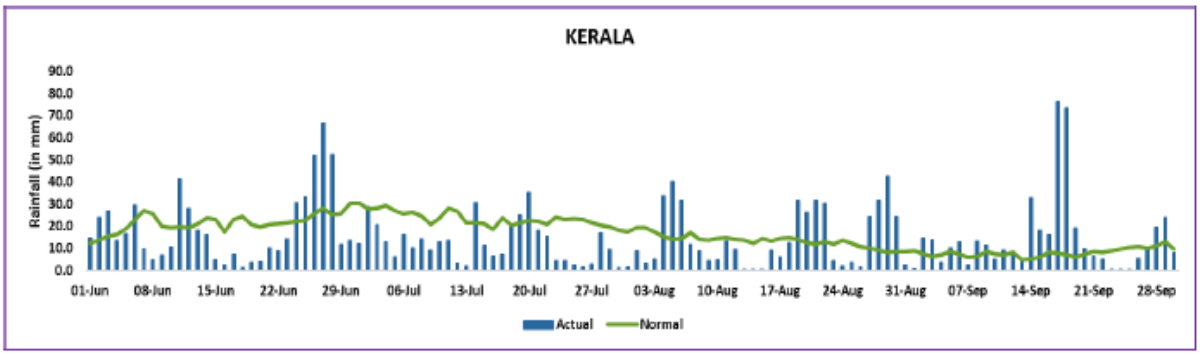
Rainfall Distribution - SW Monsoon 2017











Source: Rainfall Statistics 2017 – IMD

Kerala Floods 2018:

The state has mainly two rainy seasons viz. the Southwest monsoon that arrives towards the end of May or early June, which is known as *edavapathi* and Northeast season, which hits the state during mid-October which is known as *thulam*. The Southwest season of 2018 had a different impact as the monsoon resulted in a disastrous flood.

In 30 days, 339 human lives were lost, thousands of houses damaged, over a million and a half people were moved to relief camps, vast stretches of significant roads got washed away, and many bridges got destroyed. Cochin International Airport which is one of the busiest International airports of the country got flooded and suspended its operations from 15th to 29th of August 2018. Uninterrupted rains lashed most areas of the state from 8th to 18th of August 2018, which resulted in widespread destruction in all the major sectors of the state.

Human Fatality (Source: Daily report from Commissionerate of Land Revenue)

District	Fatalities	Total @ ₹4 lakhs
Thiruvananthapuram	11	44
Kollam	5	20
Pathanamthitta	3	12
Alappuzha	43	172
Kottayam	14	56
Idukki	54	216
Ernakulam	58	232
Thrissur	72	288
Palakkad	20	80
Malappuram	30	120
Kozhikode	16	64
Wayanad	6	24
Kannur	6	24
Kasaragode	1	4
Total	**339**	**1356**

District	Actual Rainfall (mm)	Normal Rainfall (mm)	Percentage Departure (%)	
Thiruvananthapuram	373.8	142	163	Large Excess
Kollam	644.1	258.7	149	Large Excess
Pathanamthitta	764.9	352.7	117	Large Excess
Alappuzha	608.2	343.1	77	Large Excess
Kottayam	619.2	386	60	Large Excess
Idukki	1478.9	527.3	180	Large Excess
Ernakulam	648.3	401.3	62	Large Excess
Thrissur	734.7	440.1	67	Large Excess
Palakkad	848.8	333.8	154	Large Excess
Malappuram	913.7	395.3	131	Large Excess
Kozhikode	836	500.9	67	Large Excess
Wayanad	1053.5	592.9	78	Large Excess
Kannur	665.3	540.9	23	Excess
Kasaragode	636.9	636.3	0	Normal
TOTAL	821	419.3	96	Large Excess

Monsoon Rainfall Assessment from 1st to 30th August 2018 (Source: IMD)

The floods of the Southwest season can be comprehended as an evident example of global climate change impact with hefty rainfall in a short period as indicated and predicted by the Fifth Assessment Report published by the Intergovernmental Panel for Climate Change (IPCC) in 2014.

The table indicates that Kerala received completely unprecedented rainfall. It may be seen that, while on 8th August, the expectation was to receive heavy to very heavy rain in most districts of the state, but it exceeded, and the state received heavy rainfall in Idukki and Wayanad. On 9th August 2018, while there was no significant alert requiring actions, the actual daily rainfall received in the district was heavy to very heavy rainfall in 7 districts (Idukki, Wayanad, Kozhikkode, Malappuram, Palakkad, Kottayam and Pathanamthitta). This unforeseen exceedance and high intensity of rain resulted in tremendous overland flow. It is leading to complete saturation of topsoil caused deep-seated landslides, debris flows, and substantial sheet erosion resulting in the rivers exceeding the levee areas and causing destruction to life and property.

DISTRICTS	DISTRICT WISE DAILY RAINFALL FORECAST (24 HR PRIOR FORECAST FOR EACH DAY) FROM 08.08.18 TO 22.08.18 (SOURCE: IMD)														
	08.08.18	09.08.18	10.08.18	11.08.18	12.08.18	13.08.18	14.08.18	15.08.18	16.08.18	17.08.18	18.08.18	19.08.18	20.08.18	21.08.18	22.08.18
Thiruvananthapuram	Yellow	Green	Yellow	Green	Green	Green	Green	Yellow	Orange	Yellow	Green	Green	Green	Green	Green
Kollam	Yellow	Green	Yellow	Yellow	Yellow	Green	Green	Yellow	Orange	Orange	Yellow	Green	Green	Green	Green
Pathanamthitta	Yellow	Yellow	Yellow	Orange	Yellow	Orange	Yellow	Yellow	Orange	Red	Yellow	Yellow	Green	Green	Green
Alappuzha	Orange	Yellow	Yellow	Red	Red	Orange	Orange	Orange	Orange	Orange	Yellow	Yellow	Green	Green	Green
Kottayam	Orange	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Orange	Yellow	Yellow	Green	Green	Green
Ernakulam	Orange	Yellow	Yellow	Red	Red	Orange	Orange	Orange	Red	Red	Red	Yellow	Green	Green	Green
Idukki	Orange	Yellow	Red	Red	Red	Red	Red	Red	Red	Red	Red	Yellow	Green	Green	Green
Thrissur	Orange	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Red	Yellow	Yellow	Green	Green	Green
Palakkad	Orange	Yellow	Red	Red	Red	Orange	Yellow	Yellow	Red	Red	Yellow	Yellow	Green	Green	Green
Malappuram	Orange	Yellow	Orange	Red	Red	Orange	Yellow	Yellow	Red	Red	Yellow	Yellow	Green	Green	Green
Kozhikkode	Orange	Yellow	Red	Red	Red	Orange	Yellow	Yellow	Red	Red	Yellow	Yellow	Green	Green	Green
Wayanad	Orange	Yellow	Red	Red	Red	Red	Red	Red	Red	Red	Yellow	Yellow	Green	Green	Green
Kannur	Orange	Yellow	Red	Red	Red	Orange	Yellow	Red	Red	Red	Yellow	Green	Green	Green	Green
Kasaragod	Orange	Yellow	Yellow	Yellow	Orange	Yellow	Yellow	Red	Orange	Yellow	Green	Green	Green	Green	Green

COLOUR CODE		RAINFALL INTENSITY (MM)	
Green	NO WARNING (No Action)	Light to Moderate at Isolated places	Light (2.5-15.5mm)
Yellow	WATCH (Be Updated	Heavy Rainfall at Isolated Places	Moderate (15.6-64.4mm)
Orange	ALERT (Be Prepared)	Heavy to Very Heavy Rainfall at Isolated Places	Heavy (64.5-115.5mm)
Red	WARNING (Take Action)	Heavy to Very Heavy Rainfall at few Places	Very Heavy (115.6-204.4mm)
			Extremely Heavy (> 204.5mm)

Source: Government of Kerala

Various sectors of industry were affected, and the livelihoods of lower-income people were gravely affected. Strong winds, rainfall, and floods caused widespread damages to the fisheries sector of the state. Fishing assets such as boats and nets were destroyed. Houses of fishermen were damaged beyond repairs. Aquaculture of the state had been adversely affected to a great extent. Many government fishery farms, hatcheries, and other assets of the Department of Fisheries such as National Fish Seed Farm and Centre for Freshwater Aquaculture at Neyyar dam and National Institute of Fisheries Administration and Management (NIFAM) at Aluva were severely affected. Moreover, alternative livelihood flagship activities aimed at the fishermen community (such as Theeramythri program that impacts the fishermen women) have also been badly hit. Other sectors affected were – Agriculture, Animal Husbandry, Power, Water Supply and Irrigation.

In the aftermath of this disaster, a large number of resources were required to get the relief activities underway. The local government, with the self-help groups, started cleanup activities of the debris after the government provided funds. The costs incurred by the government were relatively high for the restoration of infrastructure and compensation to the local businesses that were given to maintain their livelihood. The donations from the private sector and by the citizens of India also played a critical role in providing necessities for the thousands of people affected.

CONCLUSION

Flood Mitigation measures should be adopted with revised policies after taking into consideration the possibility of high rainfall due to climate change. Modifying susceptibility to flooding damage and disruption is the floodplain management strategy of avoiding dangerous, uneconomic, undesirable, or unwise use of the floodplain. The tools used to implement this strategy are regulations, development and redevelopment policies, flood roofing, and elevation.

Task	Activities	Responsibility
Development of techno-legal regime/ regulations	➢ Prohibition of development in wet lands, flood zone and low lying areas ➢ encourage for flood proofing structures in flood prone areas ➢ Build new water and sewage systems and utility lines ➢ Prescribing standards for different flood prone zones on flood maps. ➢ Enactment and enforcement of laws regulating developmental activities in flood plain ➢ Specific building by-laws for flood plains	➢ Revenue Dept. ➢ Secy. R & R ➢ Irrigation Dept. ➢ UD Dept, Panchayat & Rural Housing ➢ Local Governments

Source: Government of Maharashtra

To meet these requirements, local governments will have to adopt specific floodplain management or stormwater management regulations into zoning and subdivision regulations, housing and building codes, and resource protection regulations.

Task	Activities	Responsibility
Arrangement of safe siting in flood hazard areas	➢ Development of flood hazard map ➢ Study of past history on floods occurred and estimated loss and damage ➢ Asses the vulnerability of risk elements ➢ Build houses in safer zone	➢ Revenue Dept. ➢ Secy. R & R ➢ Irrigation Dept. ➢ UD Dept, Panchayat & Rural Housing ➢ Local Governments

Source: Government of Maharashtra

In low-lying areas, close to the coast, and on flat land in river valleys, there may be a potential for coastal or river flooding. In geologically younger river valleys, in the mountains, and foothills, there may be a potential for flash-flooding. It is essential to check the history of flooding in the area. Wherever possible,

- Map the extent of land covered by past floodwaters.
- Get an indication of the depth of past floodwaters.

- Find out about the severity of past floods, how much damage they have caused, how fast they flowed, and how much debris they left behind.
- Find out how often flooding has happened over at least the past 20 years.

Modifying flooding is a floodplain management strategy of using structural means to divert the floodwater. Structural measures are dams, reservoirs, dikes, levies, floodwalls, channel alterations, shoreline protection works, and stormwater management facilities. Also permit deliberate changes in the volume of run-off, peak stage of the flood, time of rising and duration of floodwaters, location of flooding, the extent of the area flooded, and velocity and depth of floodwaters. The effectiveness of these measures for protecting property and saving lives has been well demonstrated. Flood control projects can save people from anxiety, injury, and death and prevent economic losses.

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