

Can Destruction Through Pakistan's Continuous Floods Be Prevented Using Machine Learning?

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Abstract

Machine Learning is the study of computer algorithms that can improve automatically through experience and by the use of data. The complex mathematical expressions of physical processes of floods, during the past two decades can be studied through Machine Learning and these methods have contributed highly in the advancement of prediction systems providing better performance and cost-effective solutions. Due to the vast benefits and potential of Machine Learning, it is heavily popular among hydrologists. Researchers through introducing novel Machine Learning methods and hybridizing of the existing ones aim at discovering more accurate and efficient prediction models. Flooding is the most devastating natural hazard in Pakistan and the recently flooding has demonstrated its severeness through large scale destruction and displacement of homes and businesses in Interior Sindh. This paper aims to explore the methodologies of flood detection currently used in Pakistan, and the potential of Machine Learning in prediction systems within the country. Drawing on sources such as journals, scientific articles, and websites, the research assembled relevant information concerning floods and their prevention.

Methodology

In this research, a secondary data-gathering approach was employed. Existing data about flood prevention methods was evaluated, potential use of machine learning in its place was hypothetically concluded upon. Google Scholar was the primary search engine used for this research.

A systematic literature review was also performed using keywords such as “*Floods*”, “*Floods in Pakistan*”, “*Machine Learning*”, “*Pakistan’s current flood detection methods*”, “*Machine Learning and Flood Detection*”.

Discussion

In August 2010, Pakistan experienced one of its most severe floods on record. Floods are the most common and destructive natural disasters in the country. Among the population affected by natural hazards, 90% face the challenge of flooding (Haider, 2006). The recent flood event resulted in the tragic loss of nearly 1800 lives, and the financial toll reached tens of billions of US dollars. According to officially available data, around 8000 people lost their lives, and economic losses totaled approximately \$10 billion from the time of independence in 1947 until the 2010 flooding (Baig, 2008). These assessments are conducted at the local administration level, and the level of uncertainty in these values remains unknown. Despite the absence of major floods since 1995, the devastating flooding in 2010 highlighted the persistent threat of flood risks. [2]

Year	Direct losses	Lost lives (number)	Affected villages (number)	Flooded area (Km ²)
1950	488	2,190	10,000	17,920
1955	378	679	6,945	20,480
1956	319	160	11,609	74,406
1957	301	83	4,498	16,003
1959	234	88	3,902	10,424
1973	5,134	474	9,719	41,472
1975	684	126	8,628	34,931
1976	3,845	425	18,390	81,920
1977	338	848	2,185	4,657
1978	2,227	393	9,199	30,597
1981	299	82	2,071	4,191
1983	135	39	643	1,882
1984	75	42	251	1,093
1988	858	508	100	6,144
1992	3,010	1,008	13,208	38,758
1994	843	431	1,622	5,568
1995	376	591	6,852	16,686
2010	10,000	1,985	17,553	160,000
2011	3,730	516	38,700	27,581
2012	2,640	571	14,159	4,746
2013	2,000	333	8,297	4,483
2014	500	367	4065	9779
2015	170	238	4,634	2,877
2016	6	153	43	—
2017	—	172	—	—
Total	38,171	12,502	197,273	616,598

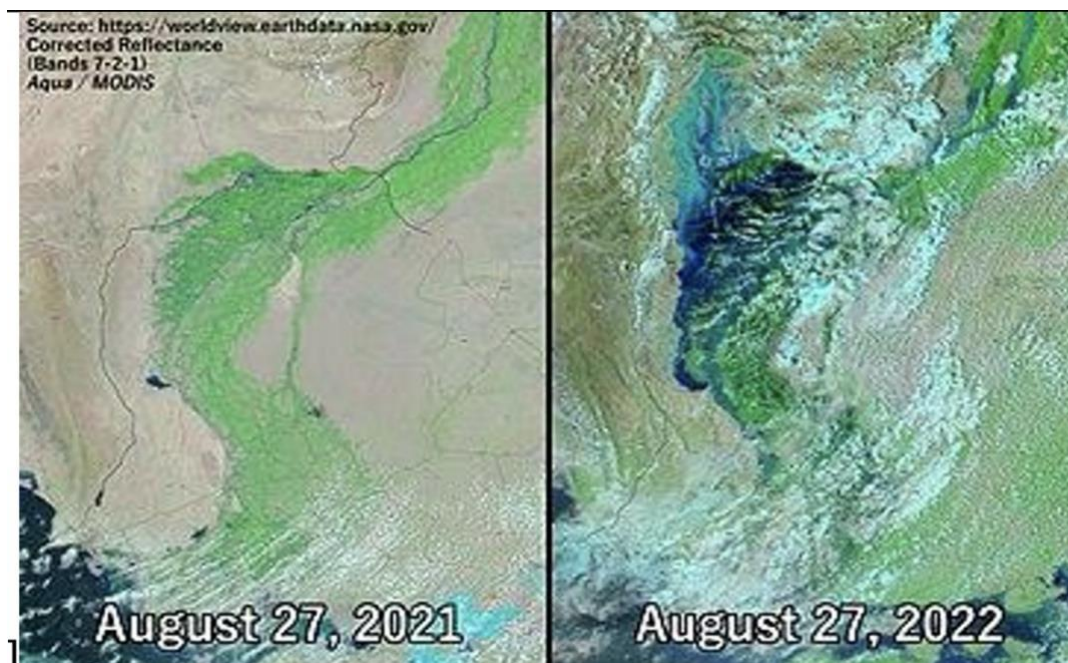
Flood Prevention In Pakistan

Crafting a flood prevention strategy poses a complex challenge in Pakistan, marked by varying intricacies across the four provinces due to distinct physiographic, climatic, geographical, and socioeconomic conditions (Chaudhri, 1981). Severe flooding struck early after independence in 1950, 1956, and 1957. Despite these events, there was no comprehensive national flood control program, primarily due to limited funding and administrative structures. Until 1976, protection and control of flooding were solely the responsibility of regional governments. Improvement began after the 1973 floods, which claimed 474 lives and caused damage amounting to 160 billion Pakistani Rupees (Tariq and van de Giesen, 2012).

Recent floods have exposed insufficient collaboration among flood control agencies, partly due to technological limitations in warning signals, preparedness initiatives, disaster response, and systemic

flood prevention measures. Strengthening flood monitoring and alert systems is crucial to mitigate potential damages. While Pakistan's flood warning and detection systems have demonstrated effectiveness, the forecasting ability of the network remains weak. The institutions NDMA and PDMA operate at national and provincial levels, delegating rehabilitation responsibilities to local bureaucracy rather than establishing a grassroots-level structure for small cities and villages. This approach weakens rehabilitation procedures in most areas.

Nonetheless, a unified response from the Pakistani community and concerted efforts from international and domestic agencies are indispensable (Tariq and van de Giesen, 2012). [5]



Satellite imagery showing a side-by-side comparison of southern Pakistan on 27 August 2021 (one year before the floods) and 27 August 2022 [Wikipedia]

Potential of Machine Learning on Predicting Pakistan's Floods

Data collection is crucial for Machine Learning in predicting flood patterns, and the limited availability of data poses a significant challenge in addressing Pakistan's floods. This limitation hampers our ability to enhance process understanding and develop dependable models. To tackle the data availability challenge, various approaches can be employed: enhancing data sharing, utilizing new sources like satellite or crowd-sourced data, increasing sample size through streamflow reconstructions, stochastic simulation methods, and high-resolution streamflow simulation for future conditions.

Another critical challenge is the regional nature of hydrologic extremes. Spatial correlations must be considered when modeling extremes, along with factors like extents and regional occurrence probabilities when predicting them. Human-extreme interactions present an outstanding challenge, often overlooked in models due to insufficient data and understanding. Addressing this challenge involves leveraging new data sources to understand direct human impacts and explicitly representing human influences in models.

Non-stationarities arising from changing climate, land use, channel morphology, or water management are also crucial challenges. Understanding these non-stationarities and associated uncertainties with different statistical modeling techniques is essential. Additionally, studying droughts and floods together in a joint framework can provide insights into fast event transitions. This requires stochastic continuous models and an improved joint representation of both types of extremes in hydrological models, achieved by better incorporating processes important for both in model structures and developing calibration strategies for both droughts and floods.

Overcoming these challenges will lead to more reliable flood and drought predictions, ultimately minimizing the negative impacts of extreme event.[9]

Conclusion

Using Machine Learning to predict Pakistan's floods is a useful but difficult approach. Due to difficult economic conditions, there is a lack of funds to support projects used to collect data for application of Machine Learning methodology. Floods are also heavily prevalent in areas where detection can not prevent heavy destruction due to the vast areas they cover and complicated topography. Pakistan relies more on physical methods, like building dams, however recent studies have shown that one of Pakistan's largest dams, Tarbela Dam is the world's largest Earth-filled dam rendering it inefficient in doing so. This portrays the need for more physical structures which can further boost the efficiency of flood control methodology. It should also to be noted that the impact of destruction can not be completely eradicated but can be prevented through machine learning methods, that is if funding is secured and they are heavily applied.

Citations

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