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

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**Abstract:**
Machine Learning involves the exploration of computer algorithms designed to enhance performance automatically through experience and data utilization. Over the past two decades, Machine Learning has been applied to decipher the intricate mathematical expressions underlying the physical processes of floods, significantly advancing prediction systems with improved efficiency and cost-effectiveness. The extensive benefits and potential of Machine Learning have garnered significant popularity among hydrologists. Researchers, aiming for more accurate and efficient prediction models, introduce innovative Machine Learning methods and hybridize existing ones. In the context of Pakistan, where flooding poses a severe natural hazard, recent events in Interior Sindh showcased the devastating impact through widespread destruction and displacement. This paper seeks to delve into the current flood detection methodologies in Pakistan and explore the potential of Machine Learning in enhancing prediction systems. Drawing from diverse sources, including journals, scientific articles, and websites, the research compiles relevant information related to 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 it's 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".

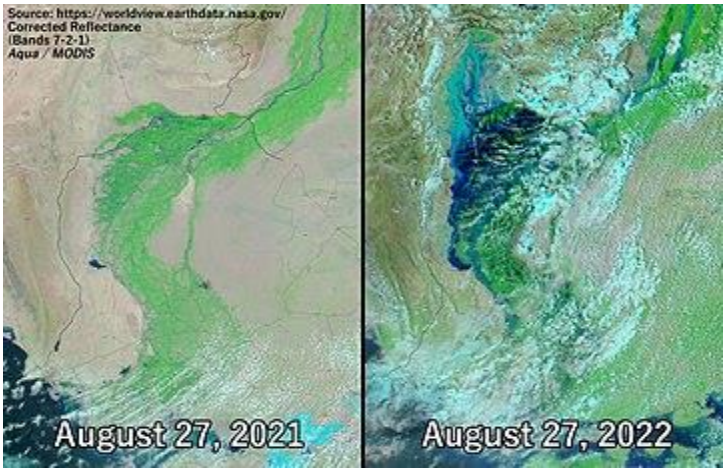
**Discussion:**
Pakistan has confronted one of its most devastating floods ever documented. Standing out as the predominant and harmful natural calamities in the nation, floods impact more than 80% of the populace grappling with such perils. The recent flood event led to a tragic loss of nearly 1800 lives, with financial damages reaching billions of dollars. Data released through official agencies indicates that 8000 have succumbed to death with economic setbacks of more $10 billion from 1947 up to the 2010 flooding. These evaluations are conducted at the local administrative level, and the extent of uncertainty within these figures remains undisclosed. Adding to this, the 2022 floods affected more than 30 million people, half of whom were children.

| Year | Direct losses | Lost lives (number) | Affected villages (number) | Flooded area (Km²) |
|---|---|---|---|---|
| 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:**

Creating a plan to prevent floods in Pakistan is a complex task because each of the four provinces has unique challenges based on its geography, climate, and economic conditions. Extreme flooding incidents occurred shortly after Pakistan gained independence in 1957,1956 and 1950. However, comprehensive national flood mitigation initiatives were lacking due to limited funds and administrative structures. Until 1976, regional governments were solely responsible for flood protection and control. Progress started after the devastating 1973 floods, which resulted in 474 lives lost and damages of more than 200 million dollars.

Recent floods have revealed shortcomings in collaboration among flood control agencies, partly due to challenges in technology impacting signals used for early warning, readiness efforts, disaster response, and comprehensive measures for preventing floods. To avoid potential damages it’s essential to enhance systems which monitor floods as well as detect them in a timely manner making evacuation possible. Despite the demonstrated effectiveness of Pakistan's flood warning and detection systems, there's room for improvement in forecasting capabilities. The national NDMA and provincial PDMA assign rehabilitation responsibilities after a disaster to local government offices whereas they should establish a strong system for smaller cities and villages which are frequently targeted. Moreover, expand on their use of technological systems to help predict flood patterns.




Images from satellites revealing a direct juxtaposition of southern Pakistan on August 27, 2021 (a year preceding the floods) and August 27, 2022 [Wikipedia].

**Potential of Machine Learning on Predicting Pakistan's Floods:**

For Machine Learning to predict floods effectively, collecting data is vital. However, the lack of available data is a significant hurdle in addressing flood issues in Pakistan. This challenge limits our ability to understand the processes involved and create reliable models. To overcome the data scarcity, we can use different approaches, such as improving data sharing, using new sources like satellites or utilizing information contributed by the public, expanding the sample size via streamflow reconstructions, implementing probabilistic simulation techniques, and modeling detailed streamflow for upcoming scenarios.

Another critical difficulty is that floods have regional patterns. When modeling these extremes, we need to consider spatial correlations and factors like the extent and likelihood of regional occurrences. Human interactions with extreme events pose a significant challenge often overlooked due to insufficient data and understanding. Addressing this involves using newer data references to comprehend the impact humans have on these patterns and explicitly incorporating human influences into models.

Non-stationarities, resulting from changes in land use, climate, water management or channel morphology are additional crucial challenges. Understanding these non-stationarities and associated uncertainties using various statistical modeling techniques is essential. Moreover, studying droughts and floods together can offer insights into rapid event transitions. This involves using statistical continuous models and enhancing how hydrological models represent both types of extreme events. In order to achieve this we need to better integrate these important processes in models as well as develop strategies to calibrate both floods and droughts.

**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 being 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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