Missing Not Dead: The Horrifying Story of Man-made Flood Disasters

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Sapna had to choose. Her father was a priest at the popular shrine, Kedarnath. The family never saw him after 15 June 2013, the fateful day when nature decided to raze all signs of human presence from the flood plains of the mighty Mandakini. Over 8,000 cubic meter of water gushed across the valley in about 3 seconds, erasing all signs of an anthropogenic past. His body was never found. Donations from patrons kept the family afloat for a while. The laughable government compensation did little to help their predicament. Especially, as her father had gone missing and was not dead, compensation was provided accordingly.

When her grief-stricken mother started showing symptoms of a full mental breakdown, Sapna moved closer to her relatives in the valley. The younger siblings, a boy of 17 and an 8-year-old girl, could no longer be entrusted to her mother's care. Soon, the relatives' empathy and finances dried up. Sapna, now had to find a way to support her family. It was at the precipice of this new endeavour that our paths crossed. We had just started studying for a postgraduate degree in remote sensing, geared towards natural hazard mitigation. As we sat in the class for our first day at university in the flood-battered state of Uttarakhand, each lecturer described the catastrophic disaster as a means to stress the significance of our chosen specialisation. At the end of the day, I expressed my admiration for Sapna's apparent insouciance on what was obviously an emotional subject and my heartfelt condolences for losing her father. She looked at me with quiet determination and said, "He's missing, not dead."

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Scientists agree that the impacts of the *"Himalayan Tsunami"* of 2013 were intensified by unbridled and unplanned development in the river flood plains. The scale of the tragedy was apparently exacerbated by a monumental failure of inter-agency communication. Warnings were left unheeded, rising water levels in the glacial lake upstream went unreported. State officials delayed taking any action as the "pilgrim season" was underway and closing the gates to the shrine would cost them the precious spoils of tourism. I for one, have never been able come to terms with the fact that most of the deaths from this catastrophe were preventable. It was then that I decided to specialise in hydrometeorological disasters like floods, determined to work towards more reliable early warning systems.

In pursuit of this arduous but rewarding goal, I was recently able to develop a new semi-automatic flood-mapping algorithm with others from the IITBMonash Research Academy, which promises significant improvements in accuracy over existing techniques. The algorithm explicitly utilises patterns of the radar backscatter, which are observed in the image, in addition to the recorded backscatter itself. Specific arrangements of backscatter values in the image are first identified and then optimised by using advanced mathematical techniques to amplify the information content that is used in flood identification. Finally, a fuzzy machine learning algorithm is used to classify the image into flooded and non-flooded areas, which also expresses the level of confidence in the flood mapping at each pixel. Validating flood maps that are generated by using this technique against aerial photographs demonstrated an improvement of almost 54% in some areas over traditional methods. These results are encouraging as the validation zone also included a notable portion of urban and agricultural land-use.

Urban landforms are, perhaps, the most challenging in radar-based flood detection and, arguably, the most crucial from a flood management perspective. While radar images are widely accepted as the most reliable resource for flood monitoring given their ability to penetrate cloud cover; they are notoriously difficult to interpret and are affected by a variety of uncertainties. Urban and vegetated landscapes, which present an inherently large number of potential scatterers to the radar beam, often result in complex images. Therefore, to arrive at any practicable intelligence, radar-based flood maps generated using automated methods often require post-processing by experts, trained in the physical principles of radar backscattering mechanisms. Automatic image processing chains have recommended the use of supporting datasets such as distance or height above the closest river channels, and land-use and cover information to enhance the accuracy of flood mapping. However, in developing countries where such ancillary information is seldom available with reasonable accuracy, this approach could potentially revolutionise rescue and response operations.

While disaster preparedness has evidently improved, given that the number of fatalities caused by floods of similar magnitudes has declined over the years, what has been accomplished is not nearly enough to cope with the increasing intensity and frequency of weather-related disasters under a rapidly changing climate. This is evident especially in cascading disasters such as flooding, when the rainfall event often leads to landslides, cutting off transport access and communication in the affected areas. If the downstream consequences, such as waterborne diseases and the mental trauma suffered by flood-affected communities are also considered, floods can be viewed as the single most devastating natural disaster worldwide.

During the initial rescue and response operations, localised information on the whereabouts of flooding is critical in the ensuring of effective regional prioritisation and efficient resource allocation. However, one can intuitively imagine that travelling into flood-affected areas to gather such information during the event is far from safe. Satellite imagery is an attractive and cost-effective alternative to observing the inundated area synoptically. This can facilitate the planning of evacuation strategies and optimise the often limited resources that are available. For example, during the 2013 Himalayan floods, a rescue chopper with 12 Indian Air Force officials crashed, killing all on-board, delaying operations and compounding the magnitude of the disaster. The Himalayas, as well as other flood affected regions, are not easy to navigate without accurate localised information. We hope that by improving the accuracy of single-image flood mapping, we can contribute at least slightly to the safety of rescue workers.

This research constitutes the first part of my PhD project titled, 'Towards a Comprehensive Data Assimilation Framework for Operational Hydrodynamic Flood Forecasting'. My research strives to integrate all the seemingly disparate sources of flood information presently available, such as satellite and crowd-sourced data, to arrive at more accurate and timely flood forecasts. I am undertaking this research at the IITBMonash Research Academy a collaboration of IIT Bombay, India and Monash University, Australia which was established to strengthen their bilateral scientific relationship. My research team includes A/Prof. RAAJ Ramsankaran from IIT Bombay; and Prof. Jeffrey Walker, Dr Stefania Grimaldi, and A/Prof. Valentijn Pauwels from Monash University. I hope that the model-data integration proposed in this study leads to the development of more reliable flood early warning systems which can allow timely evacuation. Never again should someone like Sapna have to deal with the disappearance of family members due to a flood and abruptly be thrown into dire straits with only false hopes to look forward to.

This article is based on a paper that was published earlier this year: '*Towards operational SAR-based flood mapping using neuro-fuzzy texture-based approaches*'. It was published in Remote Sensing of Environment, which is a highly reputed journal in the field of remote sensing.