

Current Science Reports

Rainfall-induced Landslides *Monitoring the Western Ghats*

The Western Ghats are landslide-prone. During the monsoon, prolonged and intense rainfall saturates soil, triggering landslides along the steep westward slopes. Predicting how rainfall thresholds trigger landslides can save lives and infrastructure. However, rainfall data from ground-based rain gauges come too late.



Image: Lakshmi Kumar

So researchers use global satellite data. The Tropical Rainfall Measuring Mission provides data from 1997 and the high-resolution Global Precipitation Measurement satellite from 2014. Which is better for the purpose?

Lakshmi Kumar from the SRM Institute of Science and Technology, Kattankulathur and a team of researchers from various other institutions, investigated the question. From the global landslide catalogue, they selected three major rainfall-induced landslides: 12 August 2008 at Ayanur, Karnataka, 3 September 2009 at Andheri and 30 July 2014 at Malin, Maharashtra.

Using data from both satellites, they studied the rainfall pattern and accumulated rainfall amount over the landslide sites at the time of the events. The team found an intense or continuous rainfall pattern at the time of landslides. India Meteorological Department rainfall gridded data confirmed this.

Five days prior to the events, rainfall showed a steady increase.

The team found the Global Precipitation Measurement data for Malin more realistic. There is a consistent pattern: gradual increase of rainfall that reached the peak value at the time

of occurrence. However, data from the Tropical Rainfall Measuring Mission did not show the same pattern.

'Global Precipitation Measurement satellite products are as good as ground-based rain gauges and model-simulated data. The product from the Tropical Rainfall Measuring Mission was poor in comparison', says Lakshmi Kumar.

The method can be used to monitor landslide-prone areas during the monsoon to take steps before disaster strikes.

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Machine Learning Algorithm *To assess deforestation*

Remote sensing accurately gauges forest canopy cover. Scientists could use the images to demarcate zones susceptible to deforestation. However, determining the impact of the many factors responsible for deforestation is tedious. Can a statistical method or a machine learning algorithm make this easier and faster?

Recently, Sunil Saha and his research scholars from the University of Gour Banga, and Kaustuv Mukherjee, Chandidas Mahavidyalaya, West Bengal collaborated with researchers from Tehran and Vietnam to tackle the problem. They chose the Gumani river basin in the Chhotanagpur plateau, Eastern India, as a typical case. The population here increased recently from about 5.6 to more than 7.5 lakhs and forest cover decreased from about 24% to about 15%.

The researchers took Landsat images for 1990, 2000, 2010 and 2017 and processed the images to prepare forest canopy density maps of the river basin. They converted the maps into binary form, where 0 is non-forest and 1 is forest area.

These maps were used as dependent variables for binary logistic regression analysis and machine learning models. As independent variables, the team selected twelve factors that determine deforestation. Using the variance inflation factor

and tolerance, they determined the collinearity status of the independent variables.

Though all twelve factors were found to impact deforestation, forest density, and distance from river, slope and forest edges were the main natural factors. Proximity to agricultural land and distance from settlement and population density were the main anthropogenic factors reducing forest cover. Binary logistic regression predicted that nearly 60 out of about 195 square kilometres of forest are under threat of deforestation.

To create machine learning models, the team chose the random forest, and ensemble of rotational forest with reduced error pruning algorithms. In the case of the ensemble, the reduced error pruning tree was used as base classifier and rotational forest was used as metaclassifier. They used the same dependent and independent variables.

After randomly selecting 1000 sampling sites, the team used 70% of the related data to train the models. The remaining 30% were used for validating the models. The researchers also double checked the results with site surveys and Google maps.

All the models could predict deforestation. The machine learning algorithms outperformed the binary logistic regression model. Among the machine learning models, the ensemble model performed best.

'Even with limited data, the model performs well to predict zones susceptible to deforestation', says Sunil, University of Gour Banga.

The model can now help planners and decision makers take steps to mitigate forest cover loss.

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Classifying Precipitation *A multiresolution technique*

Convective clouds grow due to the upward displacement of air and produce large raindrops. Stratiform clouds are layered and produce smaller drops. The intensity of radar signals

reflected from clouds helps identify these rain types approximately.

From the mid 90s, the Steiner-Houze-Yuter algorithm improved the classification by adding horizontal heterogeneity as an additional criterion to identify convective regions. However, the classification did not capture the range of precipitation and the raindrop size spectra.

Recently, Bhupendra A. Raut and his team from the IITM, Pune collaborated with researchers in Australia to propose a new algorithm. Where the Steiner-Houze-Yuter algorithm takes reflectance intensity as the primary criterion, the team considered the scale of the fluctuation of rainfall intensity as the only criteria. Convective precipitation is confined to the wavelet scale smaller than 20 kilometres. Stratiform precipitation can extend to a hundred kilometres or more.

Since rain clouds are of irregular shapes, they used wavelet scale analysis, a computationally efficient algorithm, to separate convective and stratiform regions. Here, the radar signal is decomposed into successively coarser resolutions. The difference between successive approximations of these two signals gives the wavelet coefficients. The magnitude of the wavelet coefficient is much higher in convective than in stratiform clouds.

To test the method's utility, the team used the dual-polarization Doppler radar at Darwin, Australia. The radar scan data of reflectivity at the height of 3 kilometres were first processed at 2.5, 5, 10 and 20 kilometres horizontal resolutions and then combined to get final images.

In the processed images, the team found regions that could not be classified as either stratiform or convective. So they proposed a new classification. Regions with the largest wavelet coefficient are convective; those below the significant level are stratiform; the intermediate region with moderate but significant wavelet coefficient is a transition zone, where convection is growing or decaying.

The researchers compared the new algorithm on a point by point basis with the Steiner-Houze-Yuter algorithm over Darwin, Australia. They found the

new algorithm more accurate than the Steiner-Houze-Yuter algorithm.

To further validate the new classification, they used the C-band dual-polarization radar at Solapur to gather data for monsoon clouds. They compared it with raindrop size distribution data from the disdrometer installed at Tuljapur.

'Stratiform precipitation has a low density of raindrops – smaller than two millimetres. Convective precipitation has a high drop density of all sizes and larger raindrops. The intermediate precipitation has a high density of small and medium-sized drops, but large drops are rarer. We believe that this is an improved classification of precipitation in the radar data', says Bhupendra Raut.

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Lake Water Quality Analysis

Prediction and precaution

Lake water pollution is threatening drinking water quality. Can data from water monitoring predict lake water quality for present and future use?

Researchers from the Sri Sivasubramaniya Nadar College of Engineering, Chennai decided to carry out lake water analysis. They assessed data on various water quality parameters of the Korattur Lake, one of the lifelines of Chennai. There were more than 5000 records on nine parameters from 2010 to 2019.

To predict the water quality index of the lake, the team used 80% of the data to train deep learning algorithms such as the artificial neural network, the recurrent neural network and long-short term memory for both binary and multi-class classification.

Then they tested the models with 20% of the long-term time series data and found that the long-short term memory model predicts water quality best. The highest accuracy was 94%. Moreover, execution time was lower than with other deep learning models.

The researchers then used the new model to predict the water quality of the Korattur Lake from 2020 to 2022. They found it unsuitable and recommend protecting the lake from further contamination.

The lake, spread over 4 square kilometres, to the north of Chennai, is subject to sewage inputs besides seasonal rains. Sediments reduce the depth and affect percolation to groundwater.

The long-short term memory model is equipped to take into account any administrative steps to improve water quality to change predictions according to consequent data. It can also be applied to other lakes.

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Classifying Breast Cancer

Using machine learning

According to the WHO, breast cancer impacts more than two million women each year, causing the greatest number of cancer-related deaths among women. Breast cancer can be benign or malignant and the diagnosis is done by analysing microscopic images of biopsies. However, it is difficult to manually analyse images of these irregular cells.

Recently, researchers from the Noorul Islam Centre for Higher Education, Tamil Nadu proposed a machine learning technique for breast cancer classification¹. They employed a feature extraction method using principal component analysis and linear discriminant analysis. They reduced the computational load by reducing the features needed, using a combination of artificial neural network and fuzzy logic.

To train and test the system, the researchers used images from three most popular benchmark datasets of breast cancer. When they compared the accuracy of their model with three different classifiers, they found it performing better with more than 98% accuracy.

Meanwhile, scientists from NIT Bhopal proposed a breast cancer classification based on a kernelized weighted extreme learning machine². They analysed the performance of their model on two different datasets using different magnifications of the image datasets.

The scientists say that the model gives more than 92% accuracy with the BreakHis dataset even with images magnified 40 times. The accuracy was

lower when tested on BisQue datasets.

Automatic feature extraction and classifying images using machine learning techniques can reduce the drudgery and speed up the initiation of treatment in malignant cases. There is an urgent need to evaluate the different algorithms that have been used in research for the purpose and to evaluate them for their potential incorporation into clinical practice.

¹DOI: 10.1007/s12652-020-02395-z

²DOI: 10.1002/ima.22465

Targeting Diabetic Cardiomyopathy *Bauhinia variegata* leaf extract



Image: H. Zel via Wikimedia Commons

Patients with diabetes are prone to cardiomyopathy – improper functioning of heart muscles. There is no cure for the condition. Symptomatic treatment of heart anomalies and hyperglycaemia are the only recourse – often with side effects.

Yogesh Anant Kulkarni of the Shobhaben Pratapbhai Patel School of Pharmacy and Technology Management, Mumbai has been exploring the antidiabetic potential of *Bauhinia variegata* over the last 5 years. This time, his team evaluated its effect against diabetes-induced cardiomyopathy.

His student, Ankit Laddha, induced diabetes in rats by administering a single dose of streptozotocin. The team divided the diabetic rats into four groups and non-diabetic rats were taken as control.

Six weeks after diabetes induction, three groups of diabetic rats were fed different doses of the alcoholic extract of *B. variegata*.

After 28 days, the researchers found that the body weight of rats treated with higher doses of the extract im-

proved when compared with the diabetic control. And blood glucose levels decreased as expected.

Electrocardiography revealed that the heart condition was also better than in the diabetic control. There were improvements in arterial blood pressure and heart rate.

The levels of enzymes which affect the heart in this condition were also reduced.

The team observed an increase in antioxidant enzymes and reduction in heart tissue membrane lipid peroxidation. This, they say, could be due to quercetin, a polyphenolic flavonoid known to have antioxidant properties, found in the alcoholic extract of *B. variegata* leaves.

A histopathological study of the heart revealed that the number of infiltrating lymphocytes and the formation of vacuoles in heart tissues also reduced.

These results suggest that *Bauhinia* leaf extract might help manage diabetic cardiomyopathy. However, before the extract is used in clinical practice, we need to identify other active ingredients and conduct human trials.

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Plant Defence Proteins *Allergic to humans?*

Plants defend themselves against biotic stresses, such as viruses, bacteria, fungi, nematodes and insect pests, by producing proteins to counteract pathogenesis. These proteins can cause allergic symptoms: sneezing, asthma, itching, gastrointestinal distress, etc. in humans upon consuming plant-based diets or inhaling pollen grains.

Currently, 19 different classes of pathogenesis-related proteins are identified. However, only 8 classes are characterized for their allergic potential in humans.

Recently, researchers from the University of Delhi collaborated with the University College London to characterize the remaining 11 classes of pathogenesis-related proteins.

Allergens trigger immune responses by interacting with immunoglobulins on the surface of B-cells.

These cells release powerful inflammatory chemicals such as histamines, cytokines and leukotrienes which cause the symptoms of an allergic reaction. So the researchers examined the potential of the pathogenesis-related proteins from plants to interact with immunoglobulins on the surface of B-cells.

Because of the difficulty in getting pure protein crystals for structural characterization, they modelled the structure of the proteins *in silico*. Using molecular docking, they examined the interaction of B-cell epitope-binding residues with the immunoglobulin IgE molecule.

Four models are used for predicting the potential for generating allergy, each using a different algorithm. The researchers used all four to predict B-cell epitope-binding residues for the pathogenesis-related proteins. All the 19 classes of the proteins possessed B-cell epitope-binding residues.

Allergies due to plant defensins are driven by several environmental factors and the severity of symptoms depends on their cross-reactivity with other proteins.

Besides identifying immunoglobulin E epitopes on the allergen, we need to understand the mechanisms of cross-reactivity among homologous proteins to develop effective immunotherapy strategies, say the researchers.

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Lung Cancer Risk *Taking the next step*

Lung cancer is one of the most common cancers in India. It records a higher death rate than most other forms of cancer. Steps taken by the government to control the sale, advertising and use of tobacco in the country have reduced the main risk factors – smoking and second-hand smoke.

But are the steps adequate? What follow-up is needed?

Manas Pratim Roy from the Safdarjung Hospital, New Delhi collected state-wise data for tobacco consumption from the Global Adult Tobacco Survey and lung cancer cases from

the report, India: Health of the Nation's States.

Putting both datasets together, he found that the highest death rates from lung cancer are in the states with highest consumption of tobacco: Mizoram, Manipur and Kerala. Mizoram also has the highest second-hand smoking rates in India.

Smoking is not the only cause of lung cancer. Pollution, nutritional status and stress also impact incidence. The data also showed that lung cancer cases are more prevalent in the lower economic section of society.

'Locally targeted awareness programmes in areas with higher incidence, with focus on low per-capita income social groups, can help reduce lung cancer deaths', says the author.

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Increasing Solar Panel Efficiency *Keeping it cool*

When temperatures go up, solar panel efficiency goes down. In a tropical country like India, where temperatures go above 40 degrees, this poses a problem.

Cooling the panels using water circulation or water spray involves energy consumption. So, passive methods such as natural ventilation and heat sink are preferable. But the rate of heat transfer is slow.

K. S. Reddy and Vijay Mudgal tried a different approach. If a material that changes its phase is used, a large amount of heat energy would be absorbed as latent heat needed for melting. And, if it conducts heat, it can reduce the impact of heat on solar panels, they reasoned. They chose calcium chloride hexahydrate – it has a melting point at 30°C and the latent heat of fusion is high.

To extract heat from the back of the panels, they chose aluminium, a good conductor of heat. Aluminium containers packed with the phase change material should do the trick. But what should be the optimum dimensions of the containers?

Preeti Singh at IIT Kanpur did simulations and showed that the height of the containers should be less than one-sixth of a metre. Experiments by

the team showed that 10 centimetres is optimum. So they made eleven containers of that height, to fit the back of a standard solar panel.

They bought two solar panels and ensured that there were no significant day-to-day performance variations between them. Behind one, they fixed containers with calcium chloride hexahydrate. In between the back of the solar panel and the aluminium containers, they filled a thermal conductive paste.

When they tested differences in panel performance at IIT Madras, the power output and open circuit voltage of the panel with phase change material were higher than those of the reference panel, both during January and June. While the maximum power output of the reference solar panel hovered around 100 and 110 Watts, the panels with phase change material went up to 127 Watts in June and 143 Watts in January.

Does the higher efficiency and output recover the cost of the aluminium containers and the phase change material?

'We found that costs will be recovered in 23 years', says K. S. Reddy, IIT Madras.

'But if the heat extracted is applied to heating water, cost recovery can be faster', explains Vijay Mudgal, IIT Madras.

It appears that younger researchers in the team have the last bit of work remaining: to convince the solar energy industry in India.

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Eco-friendly Metal Recovery *Processing and reusing e-waste*

India produced more than five million metric tonnes of e-waste in 2020. E-waste contains copper, gold, silver, nickel and zinc. These precious metals can be extracted using pyrolysis at more than 1000°C. But that is energy intensive. It can also be extracted using chemicals. But the process is slow and pollutes the environment.

There is yet another method which converts the metals to metal chlorides using roasting in the presence of ammonium chloride. Though the process is well-known in metallurgy, it has not

been used to extract metals from e-waste.

Kamal Kumar Pant, IIT Delhi, challenged his student Ramdayal Panda to try it out and optimise the process. Ramdayal and his colleague, Prashant Ram Jadhao, went around collecting discarded mobile phones, took out the printed circuit boards, crushed and powdered them. They pyrolysed the printed circuit boards at different temperatures and durations to find out the optimum. About 400 degrees for 30 minutes created a solid residue enriched in metals and, as a secondary product, they collected energy rich oils and gases.

The solid residue was then roasted with ammonium chloride. At more than 200 degrees, ammonium chloride decomposes to hydrochloric acid gas and ammonia. Hydrochloric acid gas reacts with metals to form metal chlorides. By tweaking the parameters, the researchers found that the optimum was to use 3 grams of ammonium chloride per gram of the residue and to roast the residue at 300 degrees for four hours. About 93% copper, 100% nickel, zinc and lead could be extracted under these optimum conditions.

'Less than 50% of silver and gold are extracted but, since they are precious metals, the process is still attractive', says Ramdayal, IIT Delhi.

'Ammonium chloride is easily available and cheap. And the temperatures used for pyrolysis and roasting are lower than those used for pyrometallurgy', says his mentor, Kamal Kumar Pant.

'This is an eco-friendly and cheap way to convert e-waste to wealth', says Satya Narayan Naik, his colleague.

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