

Current Science Reports

Drought and Resilience *Indian river basins*

Drought occurrence, duration and severity vary from one river basin to the other. Basin resilience is determined by drought severity and duration. Yet these are apparently random. So, to be prepared, we can only do probabilistic modelling to fit available data.

Vibhuti Bhushan Jha and colleagues from ISRO's Space Application Centre, Ahmedabad collected monthly precipitation data from 1901 to 2013 for 28 Indian river basins. From the time series data, they calculated the deviation of cumulative rainfall from the climatological average, over a 12-month moving average scale, to identify drought events.

Drought severity and duration are random variables. They are not totally independent. Probability analysis using copula models can couple such variables. But which one to use?

Researchers have used the Gumbel copula to model drought in Rajasthan. Can it manage all 28 basins?

Goodness of fit tests, using different criteria, threw up a strange result: for some river basins, the Frank copula captures the dependence structure between duration and severity but, for others, the Gumbel copula is better.

The team found that the Godavari, Kaveri, Krishna, and smaller river basins in between, had the most droughts between 1901 and 2013. The Damodar, Mahanadi and Subarnarekha basins also had many droughts. However, duration and severity were lower. River basins in the western region had more severe and longer droughts, though not as frequent as those in the east and south. Drought return period in southern and eastern India was two years while, in western India, it was more than three.

The Damodar, Subarnarekha and Brahmani basins are least resilient, followed by the Narmada and Mahanadi. Those in South and Central India are not resilient if drought lasts long.

Now we can be better prepared for drought in each river basin.

DOI: 10.1002/joc.6758

Chilika Lagoon *Submarine groundwater*

Chilika lagoon, between the Eastern Ghats and the Bay of Bengal, is a large brackish water lagoon. Freshwater, from Mahanadi distributaries, mixes with salty water from the Bay of Bengal due to tidal flows. And much water is lost by evaporation during non-monsoon periods. The lagoon water's constitution is further complicated by submarine groundwater discharge between lagoon and sea.

This discharge can be fresh groundwater, re-circulated seawater or a combination. While other water input and output can be estimated, groundwater discharge is not easy to estimate.

For Gyana Ranjan Tripathy, IISER Pune and Waliur Rahaman, NCPOR, Goa, the Chilika Lagoon provided a case study to tackle an entirely different problem: in seas, why is the ratio of strontium's radiogenic isotope and its non-radiogenic cousin, strontium 86, in imbalance with a missing sink?

As with other strontium isotopes, the radiogenic strontium-87 is derived from the decay of radiogenic rubidium-87, enriched in the earth's crustal rocks. But strontium traces in oceans cannot be explained by crustal rock erosion alone. Is the additional radiogenic strontium from the crustal rocks of submarine aquifers?

They posed the problem to Mohd Danish, research scholar at IISER Pune. He collected water samples and sediment from different parts of the lagoon at different times and seasons to analyse the composition, especially $87\text{Sr}/86\text{Sr}$ ratios.

The team found that strontium concentrations co-vary with salinities seasonally, indicating conservative mixing between river and seawater due to tidal flows. However, mixing was non-conservative in the case of strontium isotopes. Based on sediment and water chemistry, the team attribute this to the additional supply of 87Sr via subsurface ion-exchange – submarine groundwater discharge to the lagoon.

'Strontium fluxes from submarine groundwater discharges and those from river systems may have minimal or even opposite impact on reducing oceanic imbalance', says Gyana Ranjan Tripathy, IISER Pune, happy with the clue to one of the problems.

'Approximately 20% of water input to the lagoon, during the pre-monsoon season, is from submarine groundwater discharge', says Mohd Danish, as answer to the other problem.

DOI: 10.1016/j.marchem.2020.103816

Mapping Groundwater Potential *Geospatial technique*

The Savitri and Vashishti river basins, in western Maharashtra, face water scarcity in summer. Both basins have high agricultural activity. So, groundwater withdrawal is high. But groundwater availability is low in such hard rock terrain.

Researchers from the Baburaoji Gholap College and Savitribai Phule University, Pune recently used two different methods to identify groundwater potential zones there. In influencing factor modelling, all factors that influence groundwater – rainfall, slope, drainage, etc. – are considered. The frequency ratio model, on the other hand, looks at wells and assumes a relationship between well frequency and area of influencing factors.

Using data from remote sensing and other sources, they created eight thematic layers on the geographic information system of the Savitri and Vashishti river basins: geology, lineament, drainage density, slope, rainfall, soil texture and depth, and well density. As per the influencing factor technique, they attributed weight and ranks to influencing variables in the overlay-based model to identify the groundwater potential zones.

For the frequency ratio modelling, they used 70 per cent of the wells in the basins and validated both models using the remaining 30 per cent. The frequency ratio model assessed groundwater potential more efficiently.

'In the high lineament's density area, there is very little groundwater

occurrence due to high gradients and impermeable rock and soil. Both basins have high potential zones in low-lying areas and poor groundwater zones in hilly terrain', says Arjun Doke, Baburaoji Gholap College, Pune.

'From the different morphometric parameters, we find that the Savitri and Vashishti river basins are at a mature stage of drainage development', says Sudhakar Pardeshi, Savitribai Phule Pune University.

'The frequency ratio model can be applied to other rocky terrain and the results can help manage available groundwater resources', says Sumit Das, his colleague.

DOI: 10.1007/s12665-020-09137-6

Deweeding, Mulching, Herbicides *Promoting pea production*

Pea production is plagued by high yield loss due to weeds. Mulching and manual weeding help remove weeds but at a cost. Mechanical devices like cono-weeders reduce manual labour but are time-consuming and tedious to use.

Spraying pendimethalin, a broad-spectrum herbicide, kills weeds before they emerge. However, some weeds emerge later. These are handled by imazethapyr or quizalofop-p-ethyl herbicides. But herbicides to control weeds can pollute the environment and enter the food chain. So what do we do?

Ramanjit Kaur and her team from the ICAR-Indian Agricultural Research Institute, New Delhi tried an integrated and cost-effective approach.

For two consecutive years, they grew maize in the rainy season. In winter, they sowed peas in plots.



Image: Ramanjit Kaur

In one plot, weeds were allowed to grow while, in another, they were picked manually. The team used other

plots to test combinations of weed management practices – mulching using maize residue, mechanical weeding and herbicides such as pendimethalin, imazethapyr, and quizalofop-p-ethyl.

Sixty days after sowing, they estimated weed density. The plot with uncontrolled weed growth obviously had the most weeds. In the manual weeding plot, weed control was 100 per cent and crop quality parameters were the highest.

In the experimental plots, the best results came from using a combination of maize residue mulching, pendimethalin at 50% the recommended dose after two days of sowing, followed by imazethapyr at 75% the recommended dose. Though weed control efficiency was 70%, the results were comparable to the weed-free plot in all parameters. This sequence and combination gave nearly 40% more pods than harvested from the plot with uncontrolled weed growth.

Though herbicide use was lower than recommended limits, the team analysed herbicide residue in pea crop and soil and found it below detectable levels.

Farmer acceptance of the practice will depend on cost. So, the team estimated the method's cost and compared it with other treatments.

'The combination gives nearly 18 per cent higher net benefit than manual weeding', says Ramanjit Kaur, ICAR-IARI, New Delhi.

'We hope it will be adopted by farmers in the northwest Gangetic Plains and similar agro-ecologies', says T. K. Das, her colleague.

DOI: 10.1016/j.scienta.2020.109456

Mapping Field Crops *Sentinel-2 satellite*

Monitoring crops can ensure good yield. But crop insurance and management require high resolution maps of large areas. To generate them, researchers use remote sensing. Data from different parts of the spectrum help identify crop type, developmental stage and even health. However, this technique fails when multiple crops are cultivated in small plots.

Recently, Murali Krishna Gumma and team from the ICARISAT, Hyderabad in collaboration with researchers from Switzerland came up with a strategy for crop mapping in such areas.

They selected three dryland districts – Jhansi, Chitrakoot and Panna – in the Bundelkhand region where most farmers have small and marginal land holdings. The main agricultural activity there is in the *rabi* season with wheat, chickpea, bean and mustard as major crops.

The team travelled over 4000 kilometres in January 2019 to gather data of crop type and details of agricultural practices at a total of 732 ground control points. One part of the sample data sets was used for training and the other for validation, later.

The researchers collected Sentinel-2 images of the area with ten metre spatial resolution and six day surface reflectance from January to March, 2019. Using another set of data of 15-day intervals, they got rid of the problem of cloud cover.

With a map creation tool, MAP-Scape, they combined all the satellite images and prepared a single image of the districts. The satellite data contained blue, green, red, near-infrared and mid-infrared bands. To identify crop classes from the time series satellite data, the team turned to spectral matching.

The researchers combined time series data from the satellite and data from the field to create ideal vegetation indices as temporal signatures for each of the four crops.

Then they used k means classification to train the satellite data with the monthly maximum value composite of the vegetation indices. This generated 70 classes representing four crops and all developmental stages.

Using more than 400 ground control points for validation, the researchers assessed accuracy. They also checked the accuracy of district wise maps using the field plot and national statistical data. The maps showed an accuracy of 84 per cent.

'Field crop mapping based on Sentinel-2 data can differentiate between the four crops accurately. However, mixed cropping, tree cover and shrubs generate inaccuracies', says Murali

Krishna Gumma, ICRISAT, Hyderabad.

The researchers believe that fusing Sentinel-2 data with the hyperspectral images from other satellites may help overcome this in the near future.

'The method cannot be used during *kharif* because of cloud cover. But crop insurance companies can now deal with *rabi* crops, at least, with more confidence', says N. Rao Kolli, International Reinsurance and Insurance Consultancy and Broking Services Private Limited, Mumbai.

DOI: 10.1080/10106049.2020.1805029

Murrah Buffalo Fertility *Fermented yeast fortifies feed*

Murrah buffalo is a high yielding breed originating in Haryana. There are now more than 20 million Murrah buffaloes in India. Optimally, the buffaloes should give birth every year so that the farmers have a good yield of milk. In field situations, however, this is rare.

When the buffaloes give milk, if the nutrient intake is not adequate, their metabolic process breaks down the body molecules to produce adequate milk. After the milk production stage, therefore, the fertility reduces.

Many supplements have been tried during pregnancy and lactation to improve nutrition so that fertility is restored after lactation. But costly or complicated feed regimes are not easily adopted by farmers.

Researchers from the Indian Veterinary Research Institute, Bareilly, the G.B. Pant University of Agriculture and Technology and NDRI Karnal examined the use of fermented yeast culture as a feed supplement in the transition period. It is a simple intervention and not costly. And there was some evidence that fermented yeast culture improves the dietary intake and lactation in cattle. But will it help the buffaloes to get oestrous sooner after lactation?

The researchers used 14 pregnant buffaloes for their experiments. They added 24 grams of fermented yeast culture to the feed of seven buffaloes every day from the 15th day prepartum till about three months after delivery.

The postpartum health of the buffaloes that received the supplement was significantly better. Higher plasma levels of glucose, lower levels of non-esterified fatty acids and beta-hydroxybutyric acid confirmed better metabolic status. And what is more, the buffaloes attained the pregnancy stage in a shorter time. They had the first postpartum heat earlier, had better response to inseminations and higher fertilization rate.

So now we have a simple, cheap intervention that farmers can use to keep buffaloes yielding milk.

DOI: 10.1080/09291016.2018.155783

Arsenic in Rice *Dynamics during cooking*

In the Ganga–Brahmaputra plains, paddy is a major crop. The soils in some areas and groundwater in others here are contaminated with arsenic. And paddy can absorb up to ten times more arsenic than other crops like wheat. So a large population is under arsenic health risk. How can we reduce this risk?

Researchers from the Jadavpur University, Kolkata collaborated with others from Singapore and Australia to evaluate arsenic in cooked raw and steamed rice and the dynamics of arsenic between water and rice during cooking.



Image Credit: Tarit Roychowdhury

The researchers collected samples of different varieties of raw and steamed rice grains, groundwater, cooked rice and excess water drained after rice cooking – from rural and urban areas of West Bengal. And they measured arsenic in precooked and post cooked rice as well as in the excess water drained from cooked rice.

In arsenic-contaminated regions, all varieties had high arsenic. Steamed rice grains had higher amounts.

The researchers found that water which is arsenic-free or moderately contaminated can reduce up to 89 per cent of arsenic in cooked rice. Cooking with arsenic-contaminated water increased arsenic by more than 300 per cent in cooked rice.

Arsenic concentration in excess water that is drained after cooking rice had a higher concentration of arsenic than the water used for cooking.

The researchers found that selenium and zinc, in both raw and steamed rice grains, have a negative correlation with arsenic. This suggests that the micronutrients may help arsenic remediation in rice. Steaming altered arsenic concentration and micronutrient balance.

'The risk of arsenic toxicity can be reduced by using raw rice, cooking in excess water that is not contaminated and discarding the excess water', says T. Roychowdhury, Jadavpur University.

DOI: 10.1016/j.scitotenv.2020.138937

Fever of Unknown Origin *Investigating aetiology*

Fever is a common symptom for many kinds of illnesses. Often, doctors cannot do a differential diagnosis to identify the cause. The common practice, then, is to diagnose it as pyrexia of unknown origin. The aetiology of fevers of unknown origin differs from place to place. What are the possible causes behind such fevers in North India?

Ashok Kumar Pannu and colleagues examined all such cases in the records of PGIMER, Chandigarh, a tertiary care hospital catering to the northern states. They used the older classical definition: fever for more than three weeks with no cause attributed even after one week's hospitalisation. They enrolled more than 150 such patients from three years of data.

Using whole body CAT scan and contrast-enhanced computed tomography, they identified the causes. Two-thirds had pyrexia of unknown origin due to tuberculosis – extra pulmonary tuberculosis is especially difficult to diagnose. The scans helped

locate infection sites in 85% of these cases.

Cancers of the lymph often defy diagnosis – there were 19 such cases in the sample. Adult-onset Still's disease, a non-infectious inflammatory disease, came next. To diagnose these cases, the researchers had to use not only the scans, but also invasive biopsies.

A few cases each of typhoid, infective endocarditis, bacterial pneumonia, *Trichosporon* fungal infection, brucellosis, histoplasmosis and visceral leishmaniasis also defied correct diagnosis earlier.

One case each of leptospirosis, pyelonephritis and viral encephalitis as well as acute vitamin B12 deficiency baffled doctors who diagnosed them as pyrexia of unknown origin. Then there were a few cases of metabolic and inherited diseases that caused fever and stumped doctors till elaborate tests could be done.

Out of a total of 152 cases, there were 19 where researchers failed to identify the aetiology. The fever in 12 such cases remitted spontaneously during hospitalisation.

Doctors in North India now have a list that they can use to eliminate potential causes before writing PUO as diagnosis.

DOI: 10.1177/0049475520947907

Enhancing Images Dehazing outdoor scenes

In IIT Kanpur, it is often hazy outside. Industrial pollution, heavy traffic and fog in winter make outdoor images hazy.



Image: Lalujbad via Wikimedia Commons

Hazy pictures pose problems in computer vision-based applications such as object classification, autonomous driving and remote sensing.

Nishchal K. Verma, IIT Kanpur set the problem to his PhD scholar, Teena Sharma. She found that existing dehazing models are expensive to compute and the processes are time consuming. So, they cannot be synchronised with fast, vision-based computer applications. Some methods also introduced colour distortions, especially in the sky areas of images.

The researchers used two earlier tricks as starting points. First, assuming that pixels of at least one colour channel within a local patch always have low pixel intensity values in the non-sky region, they extracted the dark channel. Second, they converted the RGB channel or the colour channel to a form of luminance channel. These two factors play roles in the patterns of haze.

Following earlier protocols, they preactivated the hazy input features and added a dropout layer to reduce chances of overfitting. Besides the activation layer and the batch normalisation layer, they had a convolutional network with three layers for deep learning.

'To train the network, we randomly selected two hundred hazy outdoor images from a dataset with thousands of computer-based synthetic and real-world hazy images', says Teena Sharma, IIT Kanpur.

'And it took only 30 minutes. Other dehazing networks needed many more images and took hours to train', adds Isha Agrawal, IIIT Jabalpur, her co-laborator.

The team compared dehazing results from their own network with those from earlier dehazing methods. Though the method used fewer resources and was more compact, dehazing was superior – clearer pictures without colour artefacts.

'For real time applications, our dehazing network is the fastest so far', says Nishchal K. Verma, IIT Kanpur.

DOI: 10.1007/s11042-020-09496-z

Flexible Supercapacitor Paper polymer nanocomposite

The race for light, low-cost, flexible energy storage devices keeps many scientists on their toes. The perform-

ance of electrodes made of conducting polymer with silver or gold nanoparticles on a paper base has raised the pitch. But gold and silver are costly.

Recently, researchers from the NIT and the Pt Ravishankar Shukla University, Raipur and from the Government Lochan Prasad Pandey College, Raigarh developed a nickel nanoparticle-based flexible supercapacitor. Nickel, though less costly, is prone to attack by acidic electrolytes. This problem is overcome by making a composite of nickel with polypyrrole, a conductive polymer.

The researchers prepared nickel nanoparticles by reducing a nickel chloride solution. When the nanoparticles were being formed, they dipped a piece of ordinary paper into the solution. The paper, soaked in nickel nanoparticles, was dried and dipped into a pyrrole solution under polymerisation conditions. The paper-nickel-polymer composite was then dried and used as electrode.

To create the electrolytic separator, the researchers used Whatman filter paper. They dipped the filter paper in a polyvinyl alcohol and sulphuric acid solution. This filter paper electrolyte was sandwiched between two pieces of paper with the nickel-polymer to make the supercapacitor.

The capacitor has a specific power of 400 watts per kilogram and a specific energy of 48 watts per kilogram, claim the researchers. The storage device has a long life – even after 3000 cycles it performs with more than 70% efficiency.

'It is better value than most flexible nanocomposite materials made so far for the purpose', says Tungabidya Maharana, NIT Raipur.

DOI: 10.1039/d0nj02158j

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ACKNOWLEDGEMENT: IISER Pune for access to scientific databases.

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