In this issue

Wheat production in India

Climate induced risks

The agro-climatic regions of India will need to be resilient to any changes in climate, if its billion plus people are to be fed. To prepare for climate adaptation, we will need to foresee the future.

The Climate Analogues Tool is a web-based application that can be used to identify locations with similar climate, based on the distribution of current and future climatic data, for any reference location. Researchers from the National Institute of Advanced Studies used this tool to examine wheat production, in four of the six agro-climatic zones that produce 95% of wheat in India. They collected past data on wheat production in sample locations in these areas and used MarkSim, a third-order Markov rainfall generator, to understand shifts in climatic conditions as well as ECHAM 5.0, a general circulation model to predict temperature changes. Using available digital and modelling tools as well as available data, they tried to foresee the status of wheat production in four of the six agro-climatic zones, in the year 2030.

The Delhi region, they find, has negligible risks. But the Patna region has high risk for wheat production. Ludhiana and Ranchi have moderate risks. In a Research Article on **page 264** in this issue, they provide the details of the crystal ball used to divine the future.

Though the model has not taken into consideration other parameters that may influence wheat production, and, hence, may provide an incomplete picture, it is a first step towards preparedness for future climate risks.

Biogas Technology

Holistic, sustainable approach

Though biogas technology has many advantages in principle, the status of the technology that has been deployed shows the practical issue of sustainability. In a Research Article in this issue, the researchers at the SVERI's College of Engineering, Pandharpur and the Bhabha Atomic Research Center, Mumbai argue that a holistic approach can indeed make biogas a sustainable technology. The solution lies in backward and forward integration and product diversification.

For example, consider the use of food waste as raw material for biogas generation. The productivity of the biogas plants can increase many fold just by installing a predigester for anaerobic digestion of the waste. Similarly, by adding an extra process of scrubbing the gas output to extract carbon dioxide and using that water for improving the carbon content of soils, the output from biogas plants can be diversified.

The researchers show that modifying existing technologies and including allied technologies can, in fact, improve the productivity and sustainability of biogas plants. Turn to **page 249** for more.

Chaturangi Glacier

Retreating rate

The Chaturangi glacier in the Uttarkashi district was once connected to the Gangotri glacier. Now it lies separate as a valley type glacier covering an area of nearly 45 sq. km. Unlike the other Himalayan glaciers, the temporal changes in the snout position, areal extent and volume loss of the Chaturangi glacier are not well studied.

Researchers from the G.B. Pant National Institute of Himalayan Environment and Sustainable Development, Almora in collaboration with a researcher from the IISc Bengaluru set out to fill this lacuna. They examined the problem from two perspectives: from satellite imageries as well as from ground-based GPS surveys.

Satellite imageries of the glacier from four sources with four different resolutions have to be registered and then the year-to-year variation can be visualised. The analysis of the satellite-based remote sensing study suggests that the Chaturangi glacier has retreated more than 1000 m from 1989 to 2016.

A Kinematic GPS survey during 2015 and 2016 showed that the average annual retreating rate of the glacier was a little more than 22 m per year. But the satellite data showed that it was nearly 60 m per year for the same duration. This, the researchers suggest, is due to inherent errors: even with a resolution of 2.5 m, the uncertainties go up to 10 m. Moreover, the debris on the glacier can also add to errors. The ice blocks that lie in front of the glacier snout further exacerbate the problem.

But from the kinematic GPS surveys, it is clear that the retreating rate of the Chaturangi glacier is higher than that of the Gangotri glacier. This could be because of its smaller size and fast response time to climatic variability.

By comparing the two methods, the researchers conclude that the remote sensing method is suitable for large areas and long-term study, while the kinematic GPS is more appropriate for annual monitoring. See **page 304**.

Prof. E. C. G. Sudarshan

In memorium

Prof. E. C. G. Sudarshan passed away in May last year. A life of path-breaking contributions to many areas of theoretical physics including the famous V – A theory on weak interaction that later led to the electro-weak interactions, quantum the Zeno effect that promises applications in quantum information processing, quantitative measures of quantumness of a state, the theory of open quantum systems...

On **pages 177–231** in this issue, his students, colleagues, peers and friends come together to pay homage to a giant in the physical sciences in the form of a special section.

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