between neuroscientists and computer scientists, to push forward.

Venkat Ramaswamy, NCBS, Bengaluru, presented his work on creating an Axiomatic Theory for neural computation. He started with some preliminary axioms and proceeded to show that the theorems derived from these axioms put neurosciences on a firm theoretical footing.

Manoj Gopalkrishnan, Indian Institute of Technology Bombay, pointed out that a chemical reaction is equivalent to a computation. For example, a reaction proceeding to equilibrium is equivalent to an optimization programme for free energy. He proposed an algorithmic biology that can form the basis for explaining the evolution from molecules to intelligence.

A panel discussion at the end of the meeting dealt with questions such as how to keep the interface between biology and theoretical computer sciences going, what kind of curriculum is needed to build up the manpower that is required to build the bridges between the two disciplines, how can such a curriculum be practically imparted, etc... And that tied up the points that Mukund Thattai had initiated at the end of the first day.

Though the birds that assembled were of different feathers and they all had their own songs, both the colours and the sounds somehow harmonized. And it became a fugue where mathematics, information sciences, computer sciences, genetics, developmental physiology, neurosciences, ethology and ecology merged. Some notes from theoretical linguistics could have made the music richer and merrier, one could not help thinking.

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OPINION

Groundwater management and achieving equity by direct transfer of electricity subsidy: a workable option

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The policy decision to provide free or subsidized electricity has been a key driver for widespread groundwater exploitation in India. Groundwater utilization has immensely enhanced crop productivity and employment generation, which has led to poverty reduction and rural prosperity. To boost rural development in the 1970s, state government, initially began unmetered electricity supply for irrigation, which is still being continued in different states as part of their rural development policy. Policy planners and administrators are now faced with the challenge to design and implement a workable mechanism to manage the ever-growing complexity of groundwater – energy nexus. Groundwater extraction has already surpassed sustainable utilization limits in most parts of India. Also, the water table is going down at an alarming rate, with continuous deterioration in quality. Consequently, chasing rapidly declining water table has become too costly for small and marginal farmers, thus aggravating disparity among the farming groups.

In Karnataka, groundwater depletion has forced farmers to drill up to depths of 200 to 300 m, costing about Rs 2.5–3.0 lakhs for a successful bore-well. Moreover, due to increasing interferences between wells, now bore-wells last only for 2–6 years. Bore-well failures cause huge economic setbacks for small and marginal farmers with no resources to drill another bore-well. Incurring loans for drilling another bore-well may backfire if the attempts are unsuccessful.

In Karnataka, there are 2.26 million electrically operated irrigation pump sets (EOIP). The numbers are increasing at an annual growth rate of 4.3%. This means an addition of 70,000 new pump sets per year, which also increases electricity demand. Presently, the agriculture sector in Karnataka is the largest consumer of electricity with 16,788 million units, which is 35.83% of total consumption of the state[1]. Electricity consumption for irrigation is increasing at a rate of 8% per annum, posing stiff challenges in an electricity-deficient state. Karnataka meets 20% of its demand by short-term power purchases. Marginal and small farmers constitute 76.4% of the total farm families in the state, among whom 17.8% use EOIP sets. Medium and large farmers constitute 23.6%, among whom 26% use EOIP sets. Further, marginal and small farmers own 64%, and medium and large farmers have 36% of total EOIP sets in Karnataka. Skewed ownership of irrigation facility is evident from the fact that every irrigated small farm-holder (<2 ha) and large farm-holder (>4 ha) uses 1.36 and 1.90 units of EOIP respectively. On an average, per irrigation pump set, every small and large farm-holder irrigates 0.7 and 7.3 ha respectively.

Assuming that all farmers own pump sets of the same horse power, draw water from the same depth and follow the same cropping pattern, the inequality among farmers can be understood using the extent of irrigated area as a proxy for estimating the amount of electricity consumed by small and large farm holders. Total area irrigated by small farm-holder is, on an average, 1.4 ha whereas it is 9.1 ha for the large farm-holder. This implies that every large farm-holder uses nearly seven times more power than the small farm-holder. Yet this may be a conservative estimate ignoring the fact that most plantations are owned by large farm-holders, who require continuous irrigation at specific intervals. Therefore, the resource-rich farmers enjoy greater

power subsidy benefits than do the resource-poor farmers. A similar concern has been voiced in the Economic Survey 2015–16 regarding the concentration of subsidy benefits to the rich.

Presently, the electricity subsidy in Karnataka is Rs 5460 crores (triennium ending, 2013–14), which is more than three times than that was in 2008–09, and is about 1.07% of the state's GDP[1]. It is expected to reach Rs 8000 crores in the next three years if the present trend continues. The burgeoning subsidy is not only a burden on the state exchequer, but also affects the performance of electricity supplies, with farmers getting power for only 3–6 h per day, that too, mostly during night. The subsidy per irrigation pump set is estimated at Rs 25,473 per annum or Rs 29,563 per ha, given the net irrigated area using EOIP sets is 1.90 m ha (ref. 2). The quantum of subsidy per family is Rs 31,726, which reaches 1.54 million farmers owning EOIP sets in the state. If the same quantum of subsidy is transferred directly to all the 7.83 million farm families of the state, then every farm family can avail subsidy to the tune of Rs 7155 per annum (excluding the transaction cost). In reality, the existing subsidy provision is targeted to only 19.7% of the farmers who have irrigation pump sets, leaving 88.3% of the farm families out of the purview of electricity subsidy. Implementation of pricing mechanism or metering of irrigation pump sets for groundwater management is considered as a tough political decision, given the repercussions in terms of losing power or elections, as categorically highlighted by Gulati and Pahuja[3], '…dynamics of electoral politics made it difficult to increase tariffs; instead, the political parties adopted competitive populist policies to increase subsidies and many states shifted to free and unmetered supply.' Therefore, we suggest a win–win mechanism for the political class as well as farmers, which is easy to implement without withdrawing the existing benefits and also provide incentives to encourage judicious use of groundwater resources. Similar to the direct transfer of AADHAR-linked LPG subsidy to millions of consumers by the government, the electricity subsidy may also be directly provided to the farmers, thereby rationalizing power subsidy for groundwater management based upon farm sizes (medium to large farmers may be excluded) and canal command areas. The resultant savings in power subsidy can be utilized for helping 66% of rainfed farmers who are more vulnerable but virtually made to share the burden of power subsidy without actually using subsidized power. Even if the government were to follow direct transfer of subsidy, then Rs 7155 per farm family can be directly transferred to the farming community. With this, rain-dependent farmers can at least support their livestock in drought years by purchasing fodder. Further incentives can be extended to irrigating farmers for encouraging judicious use of electricity and groundwater. Other stakeholders could also get incentives to improve their performance in terms of upgradation of infrastructure and for ensuring electricity supply to all households to fulfil the dream of 'electricity to every household'. It will also help in achieving financial inclusion linking all to banking facilities, which is considered to be essential in view of the rapidly changing socio-political compulsions to provide relief to the vulnerable sections of society.

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2. Government of India, Department of Agriculture and Cooperation, Division of Agricultural Census, 2011; http://agcensus.dacnet.nic.in
3. Gulati, M. and Pahuja, S., *Aquat. Procedia*, 2015, **5**, 22–30.

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