actual construction times are much larger than those assumed in projections. In Olkiluoto, Finland, an ~3 year delay resulted in ~50% increase in costs; there were problems due to poor-quality concrete and welds, delays in design completion and problems with contractors.

Ramana explored two possibilities to lower the costs: (i) technological learning, and (ii) new competition or economies of manufacturing scale. The learning rate is related to the percentage reduction of costs for each doubling of the cumulative volume of production. But data from the Organisation for Economic Co-operation and Development show, for example, that the learning rate for wind technology is 17%, whereas for nuclear technology it is 6%. Though there is a lot of competition amongst vendors of certain kinds of nuclear reactors, no manufacturer has full order books. If many orders are not available, there cannot be economies of scale. This makes it difficult for vendors to lower the costs, in turn making nuclear power expensive and unattractive.

Ramana then briefly discussed the economics of dealing with spent fuel. The two ways of managing spent fuel are through direct disposal (for example, long-term storage in geological repositories) and reprocessing. It is more expensive to reprocess. Using plutonium to produce mixed oxide (MOX) fuel and utilizing it in reactors makes the electricity generated more expensive than that from uranium fuel-based reactors, until the uranium prices rise multiple times. At the Kalpakkam plant in India, the cost of reprocessing spent fuel is ~Rs 26,000/kg (http://www.princeton.edu/~ramana/IJGEI_Vol27_No4_Reprocessing.pdf).

A comparison of the electricity generated by the fast breeder reactor (FBR; which uses reprocessed fuel) and that generated by the heavy water reactor (HWR) shows that the former is 80% more expensive (Figure 3; see also http://www.princeton.edu/~ramana/IJGEI-Volume35-Number01-2011.pdf). So, why are FBRs being constructed? The argument is that since India has limited uranium reserves, in order to increase the capacity, spent fuel has to be used. But Ramana says that if people are willing to pay higher prices (to meet the cost of extracting poorer quality uranium, which is available), then the obtainable uranium in future may be 300 times that available today.

In conclusion, Ramana pointed out that today, nuclear power is not an economically competitive choice (http://web.mit.edu/nuclearpower/pdf/nuclearpower_summary.pdf). There is high capital cost and large financial risk, with slow build-up in most countries.

1. Sovacool, B. K., *Energy Policy*, 2008, **36**, 2950–2963.

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Tiger estimate, 2010

Monitoring of tiger populations is done at regular intervals of four years and is a crucial component of evaluating the efficacy of tiger conservation efforts. The Ministry of Environment and Forests (MoEF), Government of India (GoI) published a booklet containing the results of the All-India Tiger Estimation exercise for the year 2010. This estimation was carried out between December 2009 and December 2010. The National Tiger Conservation Authority and independent technical experts and institutions have evaluated the population status of tigers in all the tiger reserve states using robust scientific techniques.

The Project Tiger is a centrally sponsored wildlife conservation movement initiated in India in 1973, launched under the personal leadership of the then Prime Minister of India, late Mrs Indira Gandhi to protect tigers. The project aims at tiger conservation in specially constituted tiger reserves representative of various regions throughout India and strives to maintain viable populations of Bengal tigers in their natural environment. At the same time it is meant to identify limiting factors and to mitigate them by suitable management. The damages done to the habitat were to be rectified so as to facilitate the recovery of the ecosystem to the maximum possible extent.

The potential tiger habitats being covered are Sivalik–Terai Conservation Unit (Uttaranchal, Uttar Pradesh, Bihar, West Bengal) and in Nepal, North East Conservation Unit, Sunderbans Conservation Unit, Central Indian Conservation Unit, Eastern Ghats Conservation Unit and Western Ghats Conservation Unit[1].

At the end of the 19th century, the tiger population in India was approximately 45,000. In 1972, the first tiger estimation was done, which showed the presence of only 1827 tigers. Hence in 1973, the Tiger Conservation Project was launched in Palamau Tiger Reserve, now in Jharkhand, and various tiger reserves were created in the country based on a 'core-buffer' strategy.

Today 39 tiger reserves (Table 1) exist in India, which represent around one-third of India's high-density forest area. More than 350 Indian rivers originate from these reserves. These tiger reserves help in sequestering carbon as well as provide oxygen and slowly release groundwater to regulate floods. Tigers shape the community structure of ecosystem as top predators. They prevent overgrazing of the ecosystem by limiting herbivore numbers and maintain ecological integrity and hence it has become necessary to save the tigers.

The Project Tiger is administered by the National Tiger Conservation Authority, which was established in December 2005 following a recommendation of the Tiger Task Force, constituted by the Prime Minister of India for reorganized management of Project Tiger and the many tiger reserves in India. The National Tiger Conservation Authority was set up under the Chairmanship of MOEF. The Authority has eight experts or professionals having qualifications and experience in wildlife conservation and welfare of people, including tribals, apart from three Members of Parliament, two elected by the House of the People and

Table 1. Tiger reserves in India

1	Bandipur	11	Periyar	21	Bandhavgarh	31	Satkosia
2	Buxa	12	Sariska	22	Panna	32	Kaziranga
3	Corbett	13	Indravati	23	Dampa	33	Achanakmar
4	Kanha	14	Nagarjunsagar	24	Bhadra	34	Dandeli–Anshi
5	Manas	15	Namdhapha	25	Pench	35	Sanjay Dubri
6	Melghat	16	Dudhwa	26	Pakke	36	Mudumalai
7	Palamau	17	Kalakkad–Mundanthurai	27	Nameri	37	Nagarhole (Rajiv Gandhi)
8	Ranthambore	18	Valmiki	28	Satpura	38	Parambikulam
9	Simlipal	19	Pench-MP	29	Anamalai (Indira Gandhi)	39	Sahyadri
10	Sunderban	20	Tadoba Andheri	30	Udanti–Sitanadi		

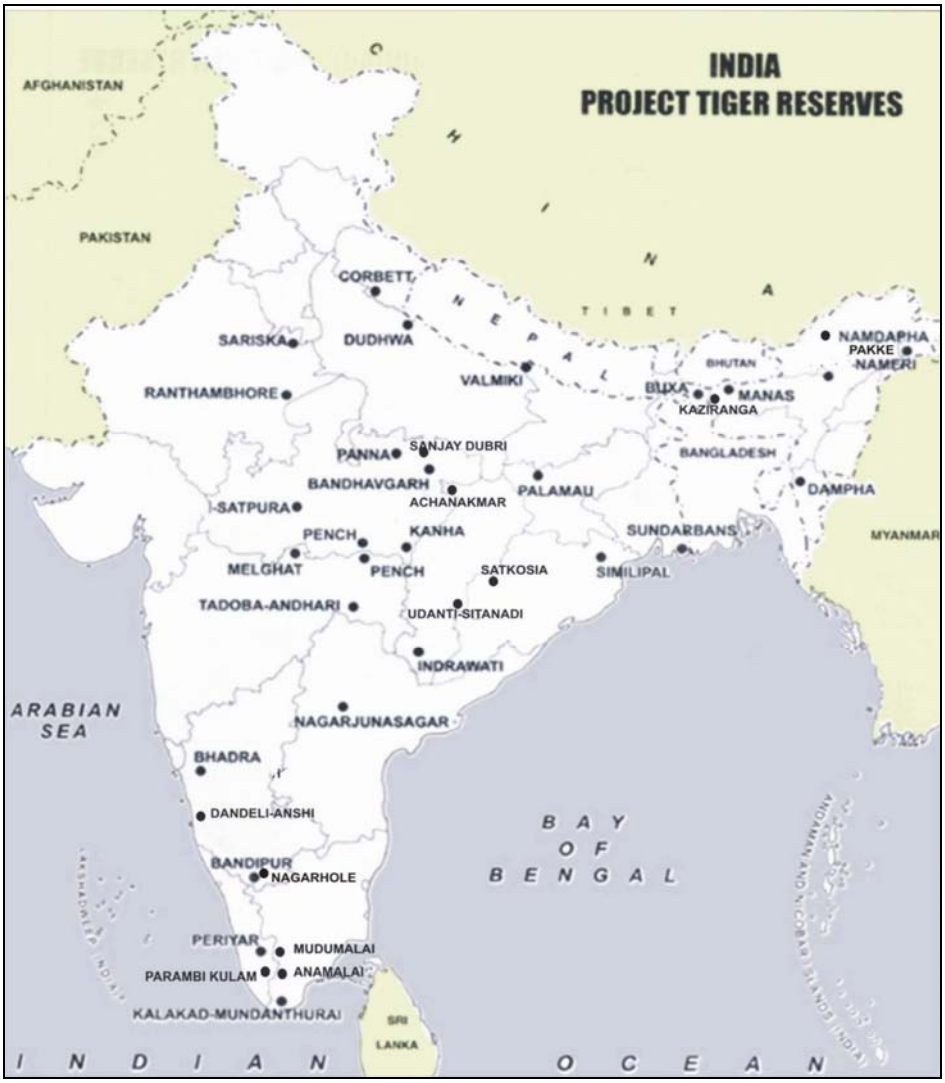

Figure 1. State wise Tiger Reserves in India (http://projecttiger.nic.in/map.htm).

one by the Council of States. The Inspector General of Forests, in-charge of Project Tiger, is the ex-officio Member Secretary[2]. The overall administration of the project is monitored by a Steering Committee. A Field Director has been appointed for each reserve, who is assisted by the field and technical personnel. At the Centre, a full-fledged Director of the project coordinates the work for the country.

The Project Tiger helped increase the population of tigers from approximately 1827 in the 1970s to 3500 in the 1990s. However, according to the 2006 census, the tiger population had dropped to 1411. Since then, the Indian Government has assured US$ 153 million to further fund the project. A Tiger Protection Force was set up to combat poachers, and for the relocation of up to 200,000 villagers, especially from core areas to minimize human–tiger conflicts. To restrict poaching in these tiger reserves, wireless

communication system and outstation patrol camps have been developed, which have helped to control poaching considerably. Fire protection engineering is carried out by suitable preventive and control measures. Also, livestock grazing has been controlled to a great extent in the tiger reserves. To increase the animal density, various compensatory developmental works were undertaken that have improved the water regime, and the ground and field-level vegetation.

The All-India Tiger Estimation Report presents India's current tiger population and a broader assessment of tiger landscapes. This estimation was carried out between December 2009 and December 2010 in three phases. In phase I, field data were collected at the beat-level, i.e. the primary patrolling unit by trained personnel using a standardized protocol. Analysis of habitat status of tiger forests using satellite data was done in phase II and in phase III, camera trapping was the primary method used, where individual tigers were identified from photographs based on their unique stripe patterns. This information was analysed using a well-established scientific framework. Camera trapping was carried out by teams of wildlife biologists and local forest personnel. Based on the tiger numbers recorded in sampled sites, an estimate for other contiguous tiger-occupied landscapes was made.

About 476,000 forest personnel were involved in data collection who sampled 29,772 forest beats and walked approximately 625,000 km in phase I. Approximately 800 cameras were used to trap 10,500 sq. km forest areas. This entire estimation costed Rs 9.1 crores.

Compared to the last tiger estimation carried out in 2006, the 2010 tiger assessment has several innovations such as partnerships with civil society organizations such as the Wildlife Trust of India and Aaranyakand World Wildlife Fund for Nature-India. Additional technical expertise was provided by the Centre for Cellular and Molecular Biology (CCMB), Hyderabad. Local communities were involved in data collection and analysis. Genetic analysis was done to estimate tiger populations from faecal samples. Along with tigers, co-predators prey and habitat quality were also assessed. Pioneering attempt to estimate tiger populations in Sunderbans Tiger Reserve, West Bengal using satellite telemetry and sign surveys was made and the first estimation of tiger population in the Sahyadri Tiger Reserve, Maharashtra was carried out in this assessment.

The 2010 national tiger assessment has shown two important findings. First, most tiger source sites continue to maintain viable tiger populations. Second, there is evidence of new forest areas populated by tigers, like the Kuno-Palpur Wildlife Sanctuary and Shivpuri National Park, Madhya Pradesh. The total number of tigers estimated for 2010 is 1706, which is comparatively better than the presence of 1411 tigers in 2006 (ref. 3).

1. Project Tiger Reserves, Project Tiger, National Tiger Conservation Authority, Ministry of Environment and Forests, Government of India.
2. Tiger Conservation Authority Set Up, Press release, National Tiger Conservation Authority, Ministry of Environment and Forests, Government of India, 19 December 2005.
3. India-Tiger Estimate 2011, Ministry of Environment and Forests, Government of India, March 2011.

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IN CONVERSATION

Chemistry at the helm

Goverdhan Mehta is an organic chemist presently at the School of Chemistry in the University of Hyderabad. He is a Fellow of the Royal Society of London. He has served as the Vice-Chancellor of the University of Hyderabad and as the Director of the Indian Institute of Science, Bangalore. Son of an agricultural scientist, Mehta's interest in chemistry was kindled at the age of six, when he saw his father's co-workers carry out titrations and the colours in the flasks disappear. He admits that he faced plenty of failures and disappointments in his research career, particularly during the projects dealing with synthesis of complex molecules. But eventually when he succeeded, it acted as elixir to keep him going. Mehta says that such cycles of success and failure continue to enrich his life. *Current Science* interviewed him about the development of organic chemistry in its endeavour to celebrate the International Year of Chemistry (IYC), 2011.

Courtesy: Shamseer Mambra

Goverdhan Mehta.